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Addition of Waste Glass to Self-Compacted Concrete: Critical Review

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Abstract

Utilization of waste glass at optimum amounts in concrete production not only provides significant environmental benefits such as reducing carbon dioxide emissions generated during the production process of cement but also enhances performance of the concrete and cement. The aim of this work was to review the effect of addition of waste glass on cement and concrete. The review showed that addition of glass powder enhances the compressive strength properties of the concrete product while using waste glass as aggregate showed that the slump flow increased with the increase of recycled glass content. On the other hand, the compressive strength, splitting tensile strength and flexural strength of the concrete were decreased with the increase in the recycled glass content.

Keywords: waste glass, self-compacted concrete, fiber, cement

1. Introduction

Nowadays, cement and glass industries face serious problems such as increasing environmental pressure resulting from high greenhouse gases emissions and overcapacity (Ali et al., 2011; Mikulčić et al. 2013). Due to non-biodegradable nature of waste glass, discarding it to landfill is not an environmental friendly practice (Cassar et al., 2012; Liu, 2011). However, waste glass chemical composition and pozzolanic properties encourage its use in the cement and concrete industries providing practical and an environmental friendly solution for both of glass and cement industries (Dhirendra et al., 2012; Khmiri et al., 2012).

In this review we will shed some light on the latest practices of using waste glass in cement and concrete industry including optimum ratio between waste glass and cement/concrete, and the effect of the glass properties on the performance and durability of the produced cement and concrete (Ganjigatti et al, 2015; Khatib et al., 2012; Federico and Chidiac, 2009; Jani and Hogland, 2014). The review will be divided into three sections: the first section reviews the glass additive as aggregate, in the second section the partial replacement of cement with waste glass will be reviewed, while in the third section the addition of waste glass as fiber will be reviewed.

2. Addition of Waste Glass as Aggregate

A number of studies were carried out to investigate the properties of fresh and hardened self-compacted concrete when waste glass was added as aggregate. Tan and Du (2013) studied the properties of self-compacting glass concrete (SCGC) which consist of liquid crystal display (LCD) glass added to the cement to replace the aggregate in the following percentages: (0, 10, 20, 30)% by applying standard tests such as slump flow, compressive and flexural strength on the produced concrete. Tan et al. observed that increasing replacement by LCD glass, decreases the compressive and flexural strengths. On the other hand, the slump flow increased with increasing glass replacement but reduced when glass percentage reaches 30%.

Ali and Al-Tersawy (2012) studied the effect of using recycled glass waste as a partial replacement of fine aggregate by (0, 10, 20, 30, 40, 50)%, on the fresh such as slump flow and hardened properties of self-compacting concrete (SCC). Ali and Al-Tersawy used 18 concrete mixes that were produced with different cement contents (350, 400, 450)kg/m^3 at W/C ratio of 0.4. Ali and Al-Tersawy had observed that the slump flow increased with the increase of recycled glass content. On the other hand, the compressive strength, splitting tensile strength and flexural strength were decreased with the increase in the recycled glass content (Idir et al.,

2009, 2010).

Gautam et al. (2012) studied the mechanical properties of self-compacted concrete with glass as a replacement of fine aggregate by (10 – 40)%. Strength is found increase up to 20% replacement level. On the other hand, decrease in strength is observed at 30 to 40% replacement level of waste glass with fine aggregate. Also the optimum replacement level of waste glass as fine aggregate is 10% (Mageswari and Vidivelli, 2010).

Malik et al. (2013) studied the effect of using waste glass as a partial replacement of aggregate in self-compacted concrete on fresh properties, compressive strength and tensile by (15, 30, 45)%. Malik, et al. showed that the slump flow increased with the increase of recycled glass. On the other hand, compressive strength and tensile strength of SCC decreased due to the weak bonding between the cement paste and the glass aggregate. In addition, the resistance to chloride ion penetrability and drying shrinkage were improved. The absorption and porosity to water for the glass were very low.

Ling, et al. (2012) studied the performance of self-compacted concrete as a partial replacement of fine aggregate by (0, 25, 50, 75, 100)% after exposure to four elevated temperatures of (300, 500, 600, 800) °C. The influence of curing conditions on the high temperature performance of SCC were studied (Patel et al., 2012). Ling et al. conclude that when concrete is exposed to temperature, all the water cured specimens had higher residual strengths and mass losses, while the water porosity and absorption values were lower as compared to the corresponding air cured specimens (Mardani-Aghabaglou et al., 2015). Thereafter, Ling et al. (2013) studied the management and recycling of waste glass in concrete products.

De Castro and de Brito (2013) studied the mechanical properties of concrete such as durability made with glass as a replacement of natural aggregates (NA) by (0, 5, 10, 20)% (Bajad et al. 2011. De Castro and de Brito found that the particle size strongly affects the workability of concrete due to the lower density of the glass aggregates. The mixes made with glass had a lighter fresh density than the standard concrete. Although there is a decrease in the compressive strength when the replacement rate increases. They found that, in most cases, the GA does not significantly alter the durability related properties of concrete.

3. Addition of Waste Glass as a Partial Replacement of Cement

A number of studies were carried out to investigate the fresh and hardened of self-compacted concrete by adding waste glass as a partial replacement of cement. Kim et al. (2014) studied the strength and durability properties of concrete with waste glass sludge (WGS) as a partial replacement of cement by (0, 10, 20, 30, 40, 50)% under an environmental condition of freezing and thawing with the existence of de-icing salts (Matos and Sousa-Coutinho, 2012). Kim et al. showed that the compressive strengths of concrete with (5 – 10)% WGS are higher than the control mixture (Ergün, 2011). The resistance of concrete was improved to freezing and thawing cycles with and without de-icing salt (Degirmenci et al., 2011; Ling et al., 2011).

Tejaswi et al. (2015) studied the feasibility of using ground glass in self-compacting concrete (SCC) as a partial replacement for both the cement and fine aggregate on fresh and hardened concrete with replacing about 10% cement and 10% sand (Saccani et al., 2010; Aly et al., 2012). Tejaswi et al. conclude that the strength was reduced with ground glass increase. The ground glass would require a small increase in water/powder ratio and the reduction in superplasticizer dosage in addition to saving landfill and reducing CO_2 emissions by the use of less cement and sand (Vasudevan and Pillay, 2013).

Idir et al. (2011) studied the performance of concrete containing glass powder as partial replacement of Portland cement by (0 – 40)% glass powder. They have done tests such as; ultrasonic pulse velocity, compressive strength and absorption (Neithalath, 2011). The results indicated that the maximum strength of concrete occurs at around 10% glass powder. Beyond 10% glass powder, the strength of concrete reduces and is lower than that of the control concrete (Vijayakumar et al., 2013).

Chikhalikar and Tande (2012) observed that manufacturing process of cement produces large amount of carbon dioxide that it cause global warming and they oriented to replace a part of cement by (0%, 10%, 20%, 30%, 40%) of glass to reduce the consumption of cement and the environmental pollution (Vandhiyan et al., 2013), also studied the workability and strength properties of concrete. Chikhalikar and Tande concluded that the 20% replacement of cement by waste glass powder will result in higher strengths, better workability, initial setting time and final setting time increased for concrete.

Soroushian (2012) studied the improvement in properties of construction materials by using waste glass as a powder by (5, 10, 15)% of cement in concrete. The compressive strength, split tensile strength, consistency and flexural strength are measured. The result showed glass powder improves the mechanical properties and is economical.

Vaitkevičius et al. (2014) prepared glass powder of various types of recycled bottles that was used in ultra-high performance concrete (UHPC) as a partial replacement of cement by (0 – 40)%. The result showed that adding glass lead to a decrease porosity of UHPC which is beneficial for mechanical and durability properties. Workability of concrete decreases when percentage of glass powder increases and bulk dry density of specimens decreases with the increase in percentage of glass powder.

Bhat and Rao (2014) studied the influence of glass powder on the properties of concrete and finding cost effective materials for increasing the strength of concrete structures with replacement of cement by waste glass powder by (5, 10, 15, 20)% (Sangeetha et al., 2015). Bhat and Rao found that replacement 20% of cement by glass powder lead to increase compressive strength of 27%. The slump was found to be 70 to 72mm. The water absorption decreases and with increase in glass content percentage. The use of waste glass in concrete produced economical concrete, reduced the disposal problem of waste glass and proved to be environmental friendly (Liu et al., 2015).

Altaf et al. (2013) studied the development of alternative binders to achieve better concrete by adding waste glass (10, 20, 30, 40)% as a partial replacement of cement (Mobasher, 2011; Kaur, 2011) and tested that compressive and flexural strength up to 28 days of age. Jhala and Goliya found that after 28 days compressive strength of modified concrete is increased 17.11% for M30 grade and 12.51% for M40 grade of controlled concrete at the 20% replacement of cement by glass powder. Flexural strength is increased 12.23% for M30 grade and 7.11% for M40 grade of controlled concrete at the 20% replacement of cement by glass powder (Course and Theor, 2012).

Taha and Nounu (2009) studied the effect of partial replacement of cement by different pozzolanic materials such as glass on heat of hydration, setting time and compressive strength of concrete. Taha and Nounu conclude that adding glass by (5, 10, 15, 20)% of cement achieved high compressive strength, low heat of hydration and increased initial and final setting time of concrete.

Meena (2012) studied the waste glass powder as pozzolanic material in concrete, the percentage of replacement cement by (15, 30)% of glass powder on laboratory tests were normal consistency, compressive strength test and capillary absorption test were conducted (Jang, 2015). The result indicated that glass powder replacement produces higher strength.

Kumarappan (2013) studied the effect of glass powder as a partial replacement of cement in concrete. The global warming is caused by the emission of greenhouse gases such as CO_2 to the atmosphere. CO_2 contributes about 65% of global warming. The glass powder was partially replaced as (10, 20, 30, 40)%. Tests of compressive, tensile and flexural strength up to 60 days of age as well as durability test, workability test and alkalinity test were conducted. The results of replacement of glass powder in cement by 40% increase the split tensile strength by 4.4% and by (20, 30, 40)% increase the flexural strength by (83.07, 99.07, 100)%.

Amen (2011) studied the replacement of cement by glass powder. Three mixes by (5, 10, 15)% of cement replaced by glass powder in weight and laboratory tests like plastic state tests, split tensile strength of concrete, compressive strength of concrete and flexural strength of concrete were conducted. The results show improvement in the split tensile strength and that the 10% replacement of cement by glass powder is the best proportion.

4. Addition of Waste Glass as a Fiber

A number of studies carried out to investigate the fresh and hardened of self-compacted concrete by adding waste plastic a fiber. Yu et al. (2014) studied the impact resistance and mechanical properties of self-compacting concrete reinforced with recycled glass fiber reinforced polymers (GFRP) by (0.25, 0.75, 1.25)% of fiber volume fractions (Chira et al. 2016; Kumar et al, 2015). The results showed that adding recycled glass fiber reinforced polymers improving the impact resistance (Chandramouli et al., 2010) and the mechanical properties of the reinforced self-compacting concrete with glass fiber reinforced polymers (Rabadiya and Vaniya, 2015; Chandramouli, 2010).

Mastali et al., 2016 studied the SCC made by usual ingredients such as cement, fine aggregate, coarse aggregate, water, mineral admixture fly ash (Yang et al., 2015; Tobbi, et al., 2012) and demolished concrete at various replacement percentage (5, 10, 15, 20)% (Moustafa and El Gawady, 2016; Baena et al., 2016). To enhance the property of SCC made with the use of demolish concrete and fly ash, glass fiber has been added to the mix (Phani et al., 2015; Baena Muñoz et al., 2016). Glass fiber in various (0.15, 0.20, 0.30)% of Wt. of cement has been added in the mix which contain demolish concrete and gave the highest strength (Maranan et al., 2015).

5. Conclusion

The review showed that waste glass can be used in concrete as a partial replacement of cement or aggregates. However, the particle size of the glass waste plays a vital role in the ASR destructive reaction and the performance of concrete. Increasing the percentage of waste glass aggregate reduces the maintenance of concrete. Replacement of cement by glass powder lead to increase in compressive strength, the workability and the water absorption decreases, the resistance of concrete to freezing and thawing cycles were improved with and without de-icing salt. When used as a fine aggregate, the slump flow increased; the compressive strength, splitting tensile strength and flexural strength were decreased with the increase in the recycled glass content due to the weak bonding between the cement paste and the glass aggregate. The resistance to chloride ion penetrability and drying shrinkage was improved – the absorption and porosity of water for the glass was very low. In most studies the optimum percentage of waste glass (as aggregate or cement replacement) was 20%, when they used waste glass in concrete to produce economical concrete that proved to be environmental friendly.

Acknowledgments

References

Ali, E. E., & Al-Tersawy, S. H. (2012). Recycled glass as a partial replacement for fine aggregate in self compacting concrete. *Construction and Building Materials, 35*, 785-791.

Ali, M., Saidur, R., & Hossain M. (2011). A review on emission analysis in cement industries. *Renewable and Sustainable Energy Reviews, 15*(5), 2252-2261.

Altaf, S. N., Asmat, K., M., Seemab, G. M., Aalan, K., M., & Azim, K, F. (2013). Suitability of glass powder as a partial replaceemnt of cement in concrete. *A project report submitted in partial fulfillment for Diploma* In Civil Engineering. A.I.A.R. Kalsekar Polytechnic, New Panvel 410 206, Navi Mumbai.

Aly, M., et al. (2012). Effect of colloidal nano-silica on the mechanical and physical behaviour of waste-glass cement mortar. *Materials & Design*, *33*, 127-135.

Amen, D. K. (2011). Degree of hydration and strength development of low water-to-cement ratios in silica fume cement system. *International Journal of Civil and Environment Engineering*, *11*(5), 10-16.

Baena, M. M., et al. (2016). Bond behaviour between recycled aggregate concrete and glass fibre reinforced polymer bars. *Construction and Building Materials*, *106*, 449-460.

Bajad, M., Modhera, C., & Desai, A. (2011). Effect of glass on strength of concrete subjected to sulphate attack. *International journal of civil engineering research and development, 1*(2), 01-13.

Bhat, V.V., & Rao, N.B. (2014). Influence of glass powder on the properties of concrete. *International Journal of Engineering Trrend and Technology (IJETT), 16*(5), 196- 199.

Cassar, J., & Camilleri, J. (2012). Utilisation of imploded glass in structural concrete. *Construction and Building Materials, 29*, 299-307.

Chandramouli, K., et al. (2010). Rapid chloride permeability test for durability studies on glass fibre reinforced concrete. *ARPN Journal of engineering and applied sciences, 5*(3), 67-71.

Chandramouli, K., et al. (2010). Strength properties of glass fiber concrete. *ARPN journal of* Engineering *and Applied sciences, 5*(4), 1-6.

Chikhalikar, S., & Tande, S. (2012). An Experimental Investigation On Characteristics Properties of Fibre Reinforced Concrete Containing Waste Glass Powder as Pozzolona. in *37th Conference on Our World in Concrete and Structures,* Singapore.

Chira, A., et al. (2016). Property improvements of alkali resistant glass fibres/epoxy composite with nanosilica for textile reinforced concrete applications. *Materials & Design, 89*, 146-155.

Course, S.N. & Theor, L. (2012). Scheme of studies & examination. *B. Tech. 1st Year (Semester–I) (Common for all branches) Credit Based Scheme wef.* ETHICS*, 1*(50), 50.

De Castro, S., & De Brito, J. (2013). Evaluation of the durability of concrete made with crushed glass aggregates. *Journal of Cleaner Production*, *41*, 7-14.

Degirmenci, N., Yilmaz, A., & Cakir, O.A. (2011). Utilization of waste glass as sand replacement in cement mortar. *Indian Journal of Engineering & Materials Sciences, 18*(4), 303-308.

Dhirendra, P., Yadav, R., & Chandak R. (2012). Strength Characteristics of Pre Cast Concrete Blocks Incorporating Waste Glass Powder. *ISCA J. Engineering Sci., 1*(1), 68-70.

Ergün, A. (2011). Effects of the usage of diatomite and waste marble powder as partial replacement of cement on the mechanical properties of concrete. *Construction and Building Materials, 25*(2), 806-812.

Federico, L., & Chidiac, S. (2009). Waste glass as a supplementary cementitious material in concrete–critical review of treatment methods. *Cement and concrete composites, 31*(8), 606-610.

Ganjigatti, M., Kashinath, B., & Prakash, K. (2015). Effect of Replacement of Cement by Different Pozzolanic Materials on Heat of Hydration and Setting Time of Concrete. *International Journal of Enviromental & Argriculture Research, 1*(4), 24-29.

Gautam, S., Srivastava, V., & Agarwal, V. (2012). Use of glass wastes as fine aggregate in Concrete. *J. Acad. Indus. Res., 1*(6), 320-322.

Idir, R., Cyr, M., & Tagnit-Hamou, A. (2009). Use of waste glass as powder and aggregate in cement-based materials. in *Proc., SBEIDCO-1st Int. Conf. on Sustainable Built Environment Infrastructures in Developing Countries, Algeria*.

Idir, R., Cyr, M., & Tagnit-Hamou, A. (2010). Use of fine glass as ASR inhibitor in glass aggregate mortars. *Construction and Building Materials*, *24*(7), 1309-1312.

Idir, R., Cyr, M., & Tagnit-Hamou, A. (2011). Pozzolanic properties of fine and coarse color-mixed glass cullet. *Cement and Concrete Composites, 33*(1), 19-29.

Jang, H., et al., (2015). Properties of different particle size of recycled TFT-LCD waste glass powder as a cement concrete binder. *International Journal of Precision Engineering and Manufacturing, 16*(12), 2591-2597.

Jani, Y., & Hogland, W. (2014). Waste glass in the production of cement and concrete–A review. *Journal of* Environmental *Chemical Engineering, 2*(3), 1767-1775.

Kaur, N. P. (2011). Active protection of corroded steel steel bar embedded in FRP wrpped concrete. Thapar University.

Khatib, J., et al. (2012). Glass powder utilisation in concrete production. *European Journal of Applied Sciences, 4*(4), 173-176.

Khmiri, A., Samet, B., & Chaabouni, M. (2012). Assessement of the waste glass powder pozzolanic activity by different methods. *International Journal of Research and Reviews in Applied Sciences*, *10*(2), 322-328.

Kim, J., et al. (2014). Durability properties of a concrete with waste glass sludge exposed to freeze-and-thaw condition and de-icing salt. *Construction and building materials, 66*, 398-402.

Kumar, A., Kn, V. K., & Anadinni, S. (2015). *Suitability of Steel Slag and E-Sand in Glass Fiber Fly Ash Based Concrete.*

Kumarappan, N. (2013). Partial Replacement Cement in Concrete Using Waste Glass. in *International Journal of Engineering Research and Technology*. ESRSA Publications.

Ling, T. C., Poon, C. S., & Kou, S. C. (2011). Feasibility of using recycled glass in architectural cement mortars. *Cement and Concrete Composites, 33*(8), 848-854.

Ling, T. C., Poon, C. S., & Kou, S. C. (2012). Influence of recycled glass content and curing conditions on the properties of self-compacting concrete after exposure to elevated temperatures. *Cement and Concrete Composites, 34*(2), 265-272.

Ling, T. C., Poon, C. S., & Wong, H. W. (2013). Management and recycling of waste glass in concrete products: Current situations in Hong Kong. *Resources, Conservation and Recycling, 70*, 25-31.

Liu, M. (2011). Incorporating ground glass in self-compacting concrete. *Construction and Building* Materials, *25*(2), 919-925.

Liu, S., Xie, G., & Wang, S. (2015). Effect of curing temperature on hydration properties of waste glass powder in cement-based materials. *Journal of Thermal Analysis and Calorimetry, 119*(1), 47-55.

Mageswari, M. & Vidivelli, B. (2010). The use of sheet glass powder as fine aggregate replacement in concrete. *Open Civil Engineering Journal, 4*, 65-71.

Malik, M. I., et al. (2013). Study of concrete involving use of waste glass as partial replacement of fine aggregates. *IOSR Journal of Engineering, 3*(7), 08-13.

Maranan, G., et al. (2015). Evaluation of the flexural strength and serviceability of geopolymer concrete beams reinforced with glass-fibre-reinforced polymer (GFRP) bars. *Engineering Structures, 101*, 529-541.

Mardani-Aghabaglou, A., Tuyan, M., & Ramyar, K. (2015). Mechanical and durability performance of concrete incorporating fine recycled concrete and glass aggregates. *Materials and Structures, 48*(8), 2629-2640.

Mastali, M., Dalvand, A., & Sattarifard, A. (2016). The impact resistance and mechanical properties of reinforced self-compacting concrete with recycled glass fibre reinforced polymers. *Journal of Cleaner Production*.

Matos, A. M., & Sousa-Coutinho, J. (2012). Durability of mortar using waste glass powder as cement replacement. *Construction and Building Materials, 36*, 205-215.

Meena, A. (2012). Comparative study of waste glass powder as pozzolanic material in concrete. Departemtn of Civil Engineering. A thesis submitted for the partial requirements for the bachelor of Science in Civil Engineeting. National Institute of Technology, Rourkela.

Mikulčić, H., Vujanović, M., & Duić N. (2013). Reducing the CO2 emissions in croatian cement industry. Applied energy*, 101*, 41-48.

Mobasher, B. (2011). Mechanics of fiber and textile reinforced cement composites. 2011: CRC press.

Moustafa, A., & El Gawady, M. A. (2016). Strain Rate Effect on Properties of Rubberized Concrete Confined with Glass Fiber–Reinforced Polymers. *Journal of Composites for Construction*, p. 04016014.

Neithalath, N. (2011). An overview of the benef its of using glass powder as a partial cement replacement material in concretes. *Indian Concrete Journal, 85*(2), 9-18.

Patel, D., Yadav, R., & Chandak, R. (2012). Strength Characteristics of Cement Mortar Paste Containing Coarse and Fine Waste Glass Powder. *International Journal of Engineering Sciences Research*, *2*, 683-686.

Phani, S.S., Sekhar, T.S., & Rao, P.S. (2015). High Strength Self Compacting Concrete Beams Under Flexure. *i-Manager's Journal on Structural Engineering, 4*(2), 10.

Rabadiya, S., & Vaniya, S. (2015). Effect of Recycled Aggregate with Glass Fiber on Concrete Properties. *International Journal for Innovative Research in Science and Technology, 2*(1), 257-265.

Saccani, A., & Bignozzi, M. C. (2010). ASR expansion behavior of recycled glass fine aggregates in concrete. *Cement and Concrete Research, 40*(4), 531-536.

Sangeetha, R., Suji, D., & Raghuraman, S. (2015). Comparative Study on Strength of Concrete by Partial *Replacement* of Fine Aggregate by Using M-Sand and Crushed Spent Fire Bricks. *Journal of Civil and Construction Engineering, 1*(2).

Soroushian, P. (2012). Strength and durability of recycled aggregate concrete containing milled glass as partial replacement for cement. *Construction and Building Materials, 29*, 368-377.

Taha, B., & Nounu, G. (2009). Utilizing waste recycled glass as sand/cement replacement in concrete. *Journal of Materials in Civil Engineering, 21*(12), 709-721.

Tan, K. H., & Du, H. (2013). Use of waste glass as sand in mortar: Part I–Fresh, mechanical and durability properties. *Cement and Concrete Composites, 35*(1), 109-117.

Tejaswi, S. S., et al. (2015). Experimental Investigation of Waste Glass Powder as Partial Replacement of Cement and Sand in Concrete. *IUP Journal of Structural Engineering, 8*(4), 14.

Tobbi, H., Farghaly, A. S., & Benmokrane, B. (2012). Concrete columns reinforced longitudinally and transversally with glass fiber-reinforced polymer bars. *ACI Structural Journal, 109*(4), 551.

Vaitkevičius, V., Šerelis, E., & Hilbig, H. (2014). The effect of glass powder on the microstructure of ultra high performance concrete. *Construction and Building Materials, 68*, 102-109.

Vandhiyan, R., Ramkumar, K., & Ramya, R. (2013). Experimental study on replacement of cement by glass powder. in *International Journal of Engineering Research and Technology*. ESRSA Publications.

Vasudevan, G., & Pillay, S. G. K. (2013). Performance of using waste glass powder in concrete as replacement of cement. *American Journal of Engineering Research, 2*(12), 175-181.

Vijayakumar, G., Vishaliny, M. H., & Govindarajulu, D. (2013). Studies on glass powder as partial replacement of cement in concrete production. *International Journal of Emerging Technology and Advanced Engineering, 3*(2), 153-157.

Yang, W., et al. (2015). Effect of interfacial strength on the flexural behavior of glass fiber reinforced polymer (GFRP) reinforced concrete beam. *Journal of Wuhan University of Technology-Mater. Sci. Ed., 30*(5), 1001-1007.

Yu, R., et al. (2016). Development of Ultra-Lightweight Fibre Reinforced Concrete applying expanded waste glass. *Journal of Cleaner Production, 112*, 690-701.

Evapotranspiration and Yield of Eggplant under Salinity and Water Deficit: A Comparison between Greenhouse and Outdoor Cultivation

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Abstract

Cultivation environment can be effective on the degree of limitations in crop evapotranspiration and yield, as a result of water shortage and salinity. The purpose of this study was to determine and compare the impact of different irrigation regimes (daily, weekly and every two weeks) combined with different water salinities (0.8, 2.5, 5.0 and, 7.0 dS m^{-1}) on eggplant yield (Y) and evapotranspiration (ETc) in outdoor and greenhouse cultivation. Daily ETc values were measured by diurnal weighting of microlysimeters throughout the growing season (from May 19th to September 5th, 2012 and June 1st to September 22nd, 2013) placed in a plastic greenhouse and outdoor basins. Measurements showed apparent variations between different irrigation regimes×water salinity treatments, during the early growing season in both years. Both water deficit and salinity factors had significant effects on ETc, ECe, Y, fruit diameter and shoot dry weight in both environments. The applicability of Doorenbos-Kassam linear crop-water production function along with Maas-Hoffman salt tolerance model was investigated in the greenhouse and outdoor conditions. The Ky coefficient obtained for outdoor and greenhouse eggplants treatments were 0.97 and 1.03 in the first year and 0.91 and 0.93 in the second year, respectively. Higher sensitivity of greenhouse eggplants to salinity was later demonstrated for both years, obtaining higher values of b and lower values of ECe$_{threshold}$ in the greenhouse eggplants.

Keywords: evapotranspiration, water deficit, salinity, greenhouse

1. Introduction

One necessity for efficient irrigation, with minimum percolation, runoff losses and environmental pollution, is the knowledge of consumption use of crops or their evapotranspiration. Yet several methods for calculating ET$_c$ have been used and evaluated for outdoor cultivation while the precision of such methods in greenhouses are not that perspicuous.

Soil water shortage and salinity lowers the potential energy of water and bounds it by capillary and absorptive forces to the soil matrix. This may result in scanty plant growth, reduction of water uptake and therewith significant ET$_c$ and yield limitations. Diminishing available water resources would cause critical water shortage problems. Consequently, the studies for accurate estimations of water consumption to save water, gain importance (Oweis et al., 2000; Li et al., 2001; Fabeiro et al., 2001). However, more studies are still needed for deficit irrigation of vegetables (Chartzoulakis and Drosos, 1995; Mendezr, 1987, Mannini and Gallina, 1996).

On the other hand incorporation of saline water in irrigation leads to a decrease in transpiration (Dudley et al., 2008),which subsequently results in reduced ET$_c$. Linear decreases in ET$_c$ with different irrigation water salinity, have been observed for a number of crops including: corn, alfalfa date palm (Tripler et al., 2007), tomato (Ben-Gal et al., 2003; Shani et al., 2007), grapevine (Shani & Ben-Gal, 2005; Shani et al., 2007), tall wheat grass (Skaggs et al., 2006), melon (Shani and Dudley, 2001; Skaggs et al., 2006), onion, bell pepper and sunflower (Shani et al., 2007; Ben-Gal et al., 2008). A good correlation was met between relative decrease in yield and relative decrease in evapotranspiration with the aforesaid crops under different levels of salinity. Blanco and Folegatti (2003) showed a 4.6% decrease in ET per unit increase of water salinity for cucumber.

Despite the considerable research on predicting the effects of irrigation regimes or saline water on crop yield and ET$_c$ in outdoor cultivation (Doorenbos and Kassam, 1986; Ouda et al. 2006 and Katerji et al., 1998), only a few

studies have spotted the combination of salinity and drought stresses especially in greenhouse cultivation.

Eggplant is an economically important vegetable crop, produced as 35.3 million tons from 1.9 million ha worldwide. 93% of the eggplant production takes place in Asia, while 7% is produced in Africa, Europe and America. Eggplant is ranked fourth within the greenhouse products, after tomato, pepper and cucumber (Boyaci, 2007). There has been conflicting results on eggplant tolerance to drought stress and soil salinity. For example, eggplant is classified as a moderately sensitive vegetable crop (Maas, 1984), whereas Bresler et al. (1982) classified it as salt sensitive.

This investigation aims to compare the impact of salinity and drought stresses, besides environmental parameters, on eggplant yield and evapotranspiration of eggplant in greenhouse and outdoor environments.

2. Materials and Methods

2.1 Area Descriptions

Experiments were carried out on eggplant (Solanum melongena L.) crops in an unheated plastic greenhouse (with dimensions: height 4.0m, length 12.0 m, width 10 m and 120 m^2 area) and the adjacent field with an area of 1500 m^2 located in Badjgah (29°36'N, 52°32'E), College of Agriculture, Shiraz University, Shiraz, Iran. An automatic weather station was installed in the central part of the greenhouse to measure net radiation (Rn), air temperature (Ta) and relative humidity (RH). The Same system was utilized in the nearby college weather station for monitoring the outdoor data.

Anamur RZ cultivar of eggplant, which is commonly grown in either fields or greenhouses, was utilized. Eggplant seeds were sown on March 18th and April 9th in the first and second year, respectively. On May 5th, 2012 and May 18th, 2013, uniform seedlings (about 15 cm in height with four leaves) were transplanted to both the field ground and plastic pots and were filled with the same ground soil from the same depth. Some physical and chemical soil features are presented in Table 1. According to the chemical properties of the soil, 1g mono ammonium phosphate was implemented for each soil pot before transplanting, and 2 g potassium nitrate was applied to each pot as 50%, 25% and 25% in three stages during growth period (i.e. transplant, beginning of the flowering and the start of harvest respectively).

After the establishment of plants (14 days after transplanting), drought and salinity treatments were initiated on May 19th, 2012 and June 1st, 2013.

Table 1. Some physical and chemical of the soil

Soil Depth (m)	Field Capacity (Mass Percent)	Wilting Point (Mass Percent)	Bulk Density (gr cm^{-3})	pH	ECe (ds m^{-1})	N$_{total}$ (%)	K (mg Kg^{-1}$_{soil}$)	P (mg Kg^{-1}$_{soil}$)
0-0.3	30.5	11	1.03	7.72	0.55	0.2	600	12.5

2.2 Treatments

The experiment was carried out according to a completely randomized design with three replicates per treatment. Irrigation frequency treatments consisted of: I$_1$, daily irrigation; I$_2$, irrigation at pot capacity level per every week interval; I$_3$, irrigation at pot capacity level per two weeks interval. Four saline irrigation waters with electrical conductivities of J$_1$, 0.8 (tap water); J$_2$, 2.5; J$_3$, 5.0 and J$_4$, 7.0 dS m^{-1} were utilized as saline water treatments. The I$_1$J$_1$ treatment (daily irrigation with tab water) was assigned as control treatment. Same 12 combinational drought/salinity treatments were utilized for greenhouse and outdoor experiments. In the greenhouse, plastic pots with 35 cm diameters and 60 cm heights were utilized for each treatment as microlysimeters. In outdoor cultivation a block was allocated to each treatment, in which 9 crops were grown. A similar pot, used as each treatment microlysimeter was installed on the ground in the center of each block.

2.3 Irrigation

Pots were irrigated up to field capacity throughout the experiment. The field capacity of each pot was determined at the beginning of the experiment by saturating pots with tap water. The water content of the covered pots after the drainage stopped was assumed to be field capacity (W_{FC}). Before each irrigation event, pots were weighed and the weight of irrigation water amount (W_I) was calculated as

$$W_I = \frac{W_{FC} - W}{1 - LF} \tag{1}$$

In which, W and W_{FC} are the pot weight (g) just before irrigation and at field capacity respectively and LF is leaching fraction, which was set to a target of 0.15 as suggested by Ayers and Westcot (1985) for efficient irrigation. Leachate was collected and measured after irrigation using empty pots placed underneath each pot.

2.4 Evapotranspiration

Since there was no capillary water entrance from the water table, runoff loss, and no precipitation during the experiment, the final equation obtained from water balance method (James, 1988) to measure daily evapotranspiration was:

$$ET = \frac{\left[\frac{(W_n - W_{n+1}) + (W_I - W_{Dp})}{\rho_w} \right]}{A} \tag{2}$$

Where, ET is the daily evapotranspiration (cm), W_I and W_{Dp} are the amounts of applied and drainage water (g), W_n and W_{n+1} are pot weights in two consecutive days (g), r_W is water bulk density (1 g cm^{-3}) and A is the top area of the cylindrical pots (cm^2). As the weights of the pots were taken daily and weight loss from each day was calculated using their preceding weights only, possible error due to the plant weight increase was indeed very little and negligible.

2.5 Harvest

Fruits were hand-harvested occasionally in August and September. Number of fruits and fruit weight per plant and some quality characteristics of eggplants such as mean fruit weight, diameter and length were determined. The plants were cut at 1 cm above the soil surface, at the end of the experiment (on September 5th, 2012 and September 22nd, 2013), and the stem diameter and dry weight (oven-dried at 70°C to a constant weight) were obtained for each replication. The plant root lengths and dry weight from each pot were measured.

In the end, soil samples taken from each pot, were air dried and passed through a 2-mm screen. Saturated soil pastes were prepared, and saturation extracts were taken after 24h and their electrical conductivities (ECe) were measured.

2.6 Modeling Yield Response

According to the theory of de Wit (1958) crop yield (Y) is a linear function of its transpiration (T). This theory was the basis for several models to predict yield from evapotranspiration (Rijtema and Endrodi, 1970; Hanks, 1974).

A simple, linear crop-water production function introduced in the FAO Irrigation and Drainage Paper No33 (Doorenbos, J. and Kassam, A. H., 1979) was evaluated to predict the reduction in crop yield when crop stress was caused by a shortage of soil water and salinity:

$$\left(1 - \frac{Y_a}{Y_m} \right) = Ky \left(1 - \frac{ETc}{ETc_{std}} \right) \tag{3}$$

Where, Y_a and Y_m are the actual and maximum (for no stress conditions) crop yield respectively, Ky is the yield response factor, ET_c is the actual crop evapotranspiration and ET_{cstd} is the crop evapotranspiration for standard conditions (I_1J_1 treatment).

The salt tolerance model suggested by Maas and Hoffman (1977) was evaluated by the computer program developed by van Genuchten (1983) for fruit yield and the threshold soil salinity value and slope value beyond the threshold value were calculated. The salt tolerance model suggested by Maas and Hoffman (1977) is:

$$\frac{Y_a}{Y_m} = 1 - (ECe - ECe_{threshold}) \frac{b}{100} \tag{4}$$

Where, $ECe_{threshold}$ is threshold soil salinity (dSm^{-1}) beyond which yield decreases, ECe is either the soil salinity of the extract or ECe threshold, whichever is greater (dSm^{-1}) and b is the slope value which is the percentage yield loss per unit increase in electrical conductivity of the saturated soil extract beyond the threshold value.

2.7 Statistical Analysis

The experimental data were analyzed using the SAS statistical analysis software package. Simple analysis of variance was applied to determine the effects of different levels of watering and salinity on the studied parameters in each environment separately. A compound analysis of variance was also used to compare the

effects of such factors in greenhouse with outdoor conditions. All statistical tests were performed at the 0.05 level of significance. Duncan's test was applied to determine the differences between the averages of the groups.

3. Results

3.1 Climatic Data

The meteorological data of the outdoor and greenhouse stations covering the experiment period from were analyzed for purposes of calculating evapotranspiration. Figure 1 shows daily temperature, relative humidity, daily pan evaporation and net radiation data for greenhouse and outdoor conditions respectively.

3.2 Irrigation

Irrigation was carried out in fixed intervals to provide field capacity moisture in the 0 to 30 cm soil depth of each pot. Total irrigation water amount and number of irrigations utilized in each treatment in outdoor and greenhouse cultivations, are indicated in Table 2. The lowest and highest irrigation waters were applied to I_1J_1 and I_3J_4 in both outdoor and greenhouse treatments.

3.3 Daily ETc

Daily evapotranspiration measurements for outdoor and greenhouse conditions are shown in Figure 2, respectively. Each Figure contains the ET_c variations during the growing season for daily (a), weekly (b) and two weeks (c) irrigation treatments during the first and second cultivation. Peak values of daily ET_c measured in outdoor pots for I_1 treatments ranged from 14 to 7.4 mm for I_1J_1 and I_1J_4, respectively, while the highest daily ET_c values for I_2 changed from 12.2 to 5.8 mm for I_2J_1 and I_2J_4, respectively. Such values were 6.6 and 3 mm for I_3J_1 and I_3J_4 treatments, respectively. Daily ET_c peak values measured in greenhouse pot changed from 10.2 to 5.9 mm in I_1 treatments for I_1J_1 and I_1J_4, respectively. In I_2 treatments such values were between 7.9 and 4.1 mm for I_2J_1 and I_2J_4, respectively, while in I_3 treatment pot 5.0 and 2.6 mm were met for extreme daily ET_c values for I_3J_1 and I_3J_4, respectively.
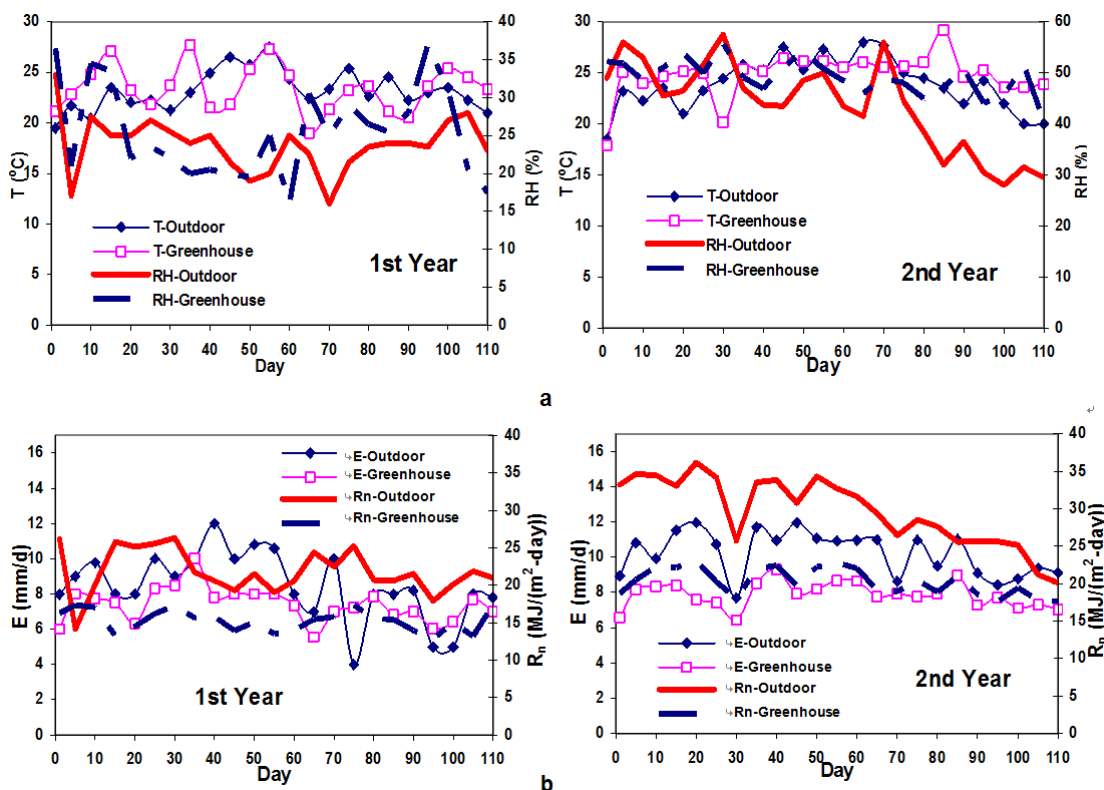
Figure 1. Daily variations of a) temperature (T) and relative humidity (RH) and b) net radiation (R_n) and pan evaporation (E)

Table 2. Number of irrigation and total amounts of irrigation water applied (mm) in outdoor and greenhouse treatments

Treatment		I_1J_1	I_1J_2	I_1J_3	I_1J_4	I_2J_1	I_2J_2	I_2J_3	I_2J_4	I_3J_1	I_3J_2	I_3J_3	I_3J_4
Number of Irrigation		110	110	110	110	16	16	16	16	8	8	8	8
Outdoor Irrigation Water Applied	1st Year	924.3	758.6	682.1	610.4	662.8	539.1	482.5	447.1	481.5	356.6	308.8	277.6
	2nd Year	1036.3	870.8	756.9	634.5	769.3	630.0	548.0	471.0	531.2	401.3	323.2	271.8
Greenhouse Irrigation Water Applied	1st Year	676.2	573.7	521.0	463.5	460.8	363.7	345.7	313.1	293.1	236.2	235.4	213.8
	2nd Year	738.9	670.3	575.6	513.2	541.4	448.0	393.8	374.2	375.2	308.6	282.8	256.9

3.4 ECe Values

The changes of measured soil extract salinity, with different watering frequencies and levels of water salinity for outdoor and greenhouse treatments are given in Table 3. In outdoor conditions, the maximum ECe value measured in I_1 treatments were 11.4 ds/m (in the first year) while such value reached 18.8 ds/m in I_3 treatments (in the second year). A similar trend was met in ECe variations in greenhouse for both years, however the effect of irrigation water salinity was more evident in each treatment, while the intensity of water deficit was less effective in the ECe values. The ECe values ranged from 1.6 (I_1J_1) to 13.9 (I_1J_4) ds/m in I_1 treatments, while in I_3 an increase from 2.7 to 16.4 ds/m was observed.
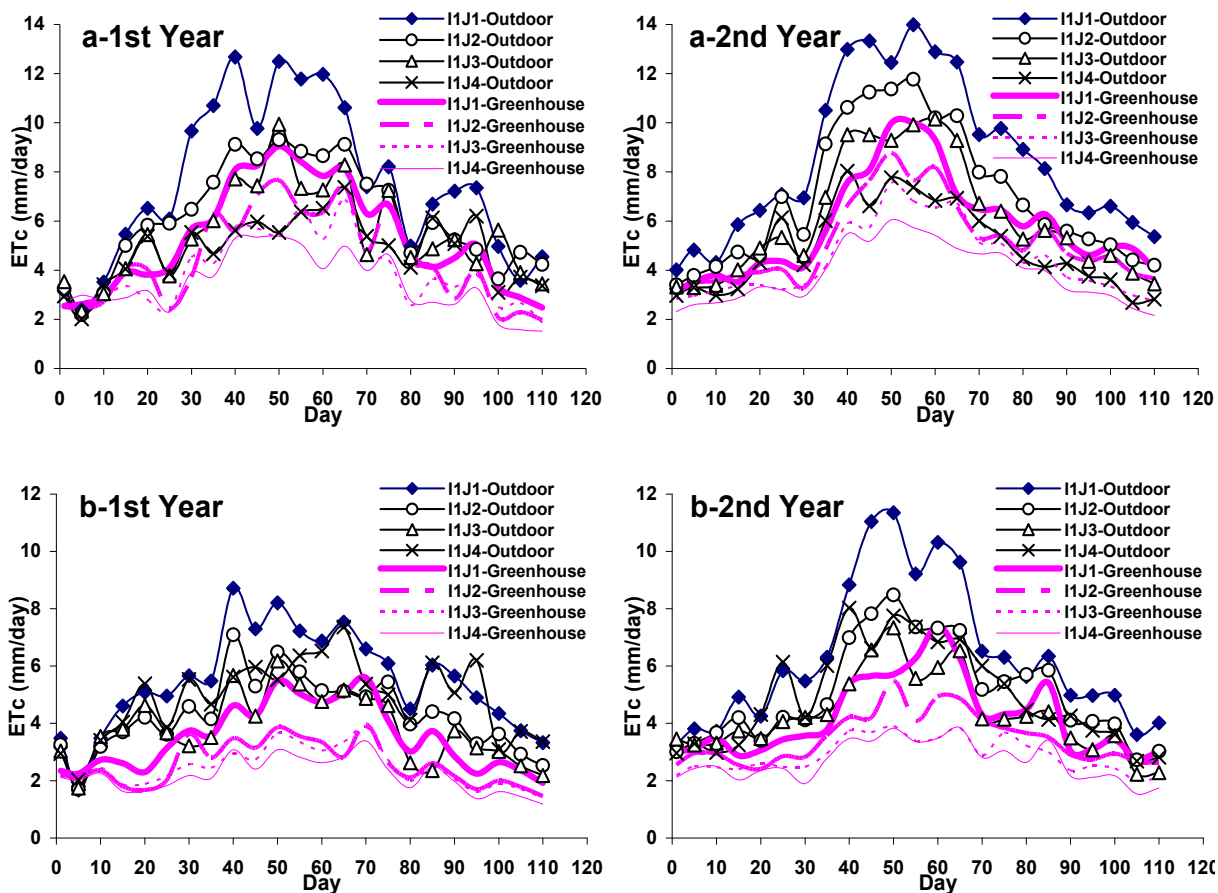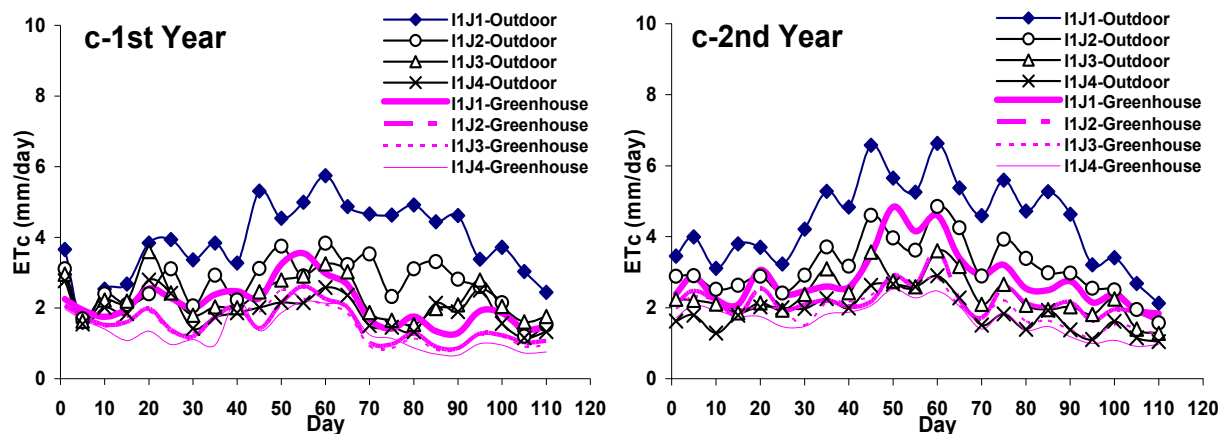
Figure 2. Daily ET_c variations for a)I_1, b)I_2 and c)I_3 irrigation treatments applying water with different salinity in outdoor and greenhouse eggplants

Table 3. Effect of different levels of water deficit and salinity on the experimental soil and plant properties in outdoor and greenhouse conditions*

Treatment	ETc (mm)		Ece (ds/m)		Y (gr/plant)		Fruit Diameter (cm)		Shoot DW (g/plant)	
	1st Year	2nd Year	1st Year	2nd Year	1st Year	2nd Year	1st Year	2nd Year	1st Year	2nd Year
Outdoor										
I_1J_1	846.6 a	954.6 a	2.7 e	3.1 g	2490.1 ab	2587.4 a	6.5 a	7.1 a	38.7 a	43.5 a
I_1J_2	680.9 b	789.0 b	8.5 d	7.2 ef	1713.2 cd	1748.2 bc	5.9 ab	6.0 abc	34.1 ab	36.6 a
I_1J_3	604.4 bc	675.1 c	10.6 cd	9.3 d	1690.8 cd	1714.1 bc	5.2 abc	5.2 abcd	29.4 bc	27.7 bc
I_1J_4	532.7 cd	552.8 d	11.4 cd	9.5 d	1536.4 cde	1429.7 cd	3.8 cde	4.9 bcd	26.0 bc	28.0 b
I_2J_1	604.7 bc	707.5 c	3.2 e	6.7 f	2720.3 a	2019.3 b	6.1 a	6.5 ab	41.0 a	41.7 a
I_2J_2	476.6 cde	564.2 d	9.8 d	9.9 d	1723.2 cd	1658.4 bc	5.5 ab	6.1 abc	38.4 a	39.2 a
I_2J_3	417.9 def	478.5 e	12.8 bc	13.2 c	1282.4 cdef	1351.6 cd	5.0 abcd	6.0 abc	28.0 bc	26.5 bc
I_2J_4	380.3 efg	400.1 f	15.2 ab	15.7 b	806.8 def	993.4 de	3.5 de	4.2 cd	25.0 bcd	24.4 bc
I_3J_1	439.2 de	482.6 e	4.3 e	7.9 e	1909.9 bc	1878.2 bc	4.4 bcd	5.1 abcd	27.9 bc	25.5 bc
I_3J_2	299.6 fgh	344.7 f	14.4 b	14.7 b	1165.4 cdef	1376.7 cd	3.8 cde	3.8 d	20.6 cd	22.0 bc
I_3J_3	251.4 gh	261.0 g	14.4 b	15.2 b	956.2 def	963.7 de	3.3 de	4.2 cd	22.3 cd	23.4 bc
I_3J_4	215.7 h	205.0 g	17.4 a	18.8 a	527.9 f	598.9 e	2.7 e	3.5 d	16.6 d	19.7 c
Greenhouse										
I_1J_1	598.5 a	657.2 a	1.6 d	2.0 h	2405.3 ab	2510.0 a	6.0 a	6.6 a	36.7 a	40.8 a
I_1J_2	495.9 b	588.6 b	9.9 c	6.8 f	1849.7 c	1869.1 b	5.2 ab	5.6 abc	31.2 ab	32.0 bc
I_1J_3	443.3 bc	493.8 c	11.6 bc	10.6 c	1141.5 de	1424.5 d	4.5 bc	5.0 bcd	28.1 bc	28.5 bcd
I_1J_4	385.8 cd	431.4 de	13.9 ab	11.0 c	1006.4 def	1210.2 de	4.2 bc	4.5 cde	25.7 bcd	31.3 bc
I_2J_1	394.2 cd	475.0 cd	2.1 d	3.3 g	2679.0 a	2290.3 a	6.0 a	6.4 a	37.2 a	39.3 a
I_2J_2	294.3 de	379.7 e	11.7 bc	8.4 e	1590.0 cd	1516.7 cd	5.5 ab	6.2 ab	32.1 ab	34.8 ab
I_2J_3	275.9 e	323.0 f	11.6 bc	10.3 cd	962.1 ef	1411.1 d	5.2 ab	5.5 abc	29.3 ab	27.4 bcd
I_2J_4	242.2 ef	301.2 fg	14.0 ab	12.6 b	779.3 ef	1184.7 de	3.0 cd	3.6 de	26.8 bcd	28.2 bcd
I_3J_1	233.4 ef	318.0 f	2.7 d	5.5 f	2080.6 bc	1781.6 bc	4.3 bc	4.8 bcde	31.1 ab	21.4 d
I_3J_2	171.4 f	249.1 gh	11.9 bc	9.0 de	914.0 ef	1212.0 d	3.2 cd	3.4 e	23.9 bcd	24.5 cd
I_3J_3	169.3 f	217.4 hi	12.5 bc	12.7 b	779.3 ef	893.0 ef	3.6 cd	3.9 de	20.9 bcd	25.6 cd
I_3J_4	145.3 f	187.3 i	16.4 a	16.3 a	497.9 f	789.0 f	2.7 d	3.3 e	19.1 d	22.0 d

NS: non-significant.

*values followed by the same letter are not significantly different according to Duncan's multiple range test at 0.05 significance level

3.5 Yield and Vegetative Growth

Values regarding eggplant total evapotranspiratoin and mean yield parameters in outdoor and greenhouse conditions are presented in Table 3. It is mentionable that some vegetative growth parameters such as number of fruits, fruit height, plant height, root length and stem diameter were not significantly affected by the treatments applied and therefore not indicated in the Table. The average values obtained for these parameters were 10, 20

cm, 11 gr/plant, 61 cm, 31 cm and 11 mm, respectively. These parameters were not significantly different, neither in outdoor and greenhouse conditions nor in the first and second cultivation. The differences of the treatments were indicated with the Latin letters in the Duncan's test result. During the two year experiments, the highest yield was obtained from J_1 while the lowest yields were observed in J_4 treatments, in outdoor eggplants. Similarly, J_1 treatments obtained the highest yield in greenhouse eggplants, while the lowest yields belonged to I_3J_3 and I_3J_4.

The relationships between relative decrease in yield (1- Y/Ym) and relative decrease in evapotranspiration (1-ET_c/ ET_m) in outdoor and greenhouse conditions are shown in Figure 3. The K_y coefficient obtained for irrigation and water salinity treatments in the first year were 0.97 and 1.03 for outdoor and greenhouse eggplants, respectively. Such values were 0.91 and 0.92 in the second year of experiment. The K_y values obtained for both years indicate that eggplant is moderately sensitive to water deficit and salinity stresses interaction.
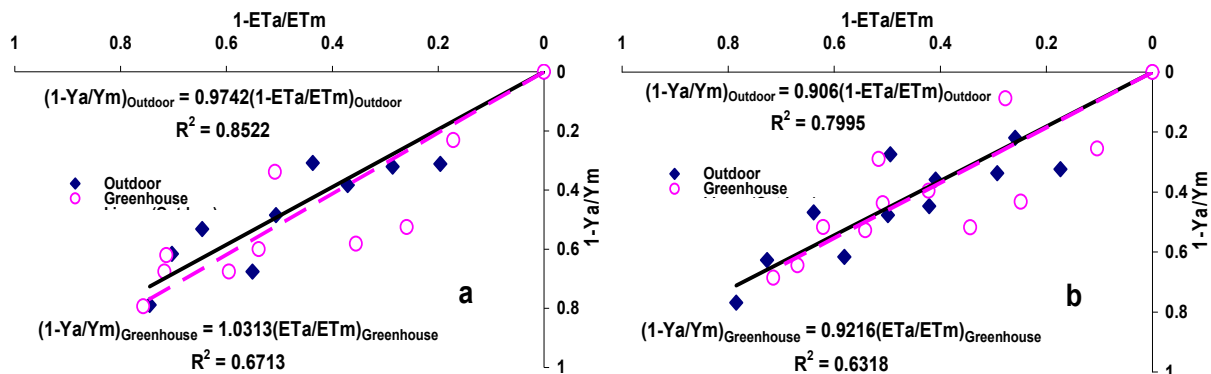
Figure 3. Relationships between relative yield decrease and relative evapotranspiration deficit for eggplant in outdoor and greenhouse conditions for the 1st (a) and 2nd (b) year of the experiment

The salt tolerance model suggested by Maas and Hoffman (1977) was also applied to study salinity effects on yield in each environment. The results for both years of the experiment are shown in Figure 4. The $ECe_{threshold}$ and b values obtained in outdoor and greenhouse conditions were 1.98 ds/m and 4.6% and 1.08 ds/m and 4.95% respectively. Values proposed by Maas (1984) for eggplant $ECe_{threshold}$ and b are 1.1 ds/m and 6.4%, respectively. However, as expressed by Maas (1984), such values are considered as initial leading ones and absolute values of these parameters vary with different weather, soil and farming conditions. For example Unlukara et al (2010) obtained 1.5 ds/m and 4.4% for eggplant $ECe_{threshold}$ and b, respectively; which are partly close to those obtained in this study. For both years of experiment, outdoor b values were smaller than those of greenhouse and larger $ECe_{threshold}$ values were obtained in outdoor conditions; which show the greenhouse eggplants being more sensitive to salinity in compare with the outdoor conditions.
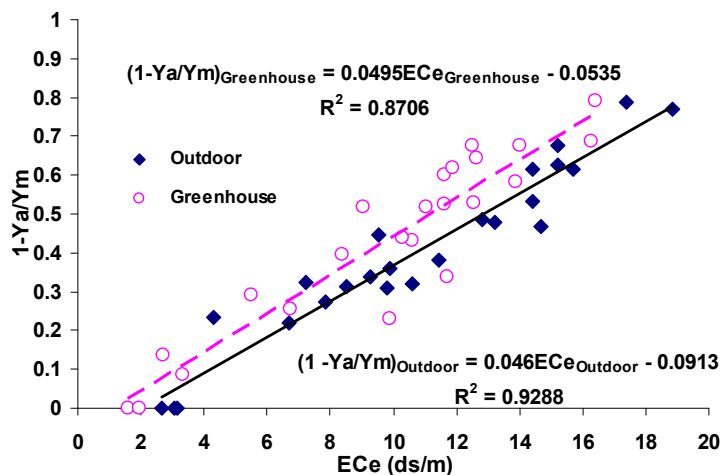
Figure. 4. Salt tolerance model for outdoor and greenhouse treatment

4. Discussion

In both environments, the relative water loss was nearly similar during the early growth stages, in all treatments. In both years of experiment, almost three weeks after the initial treatment, variations in measured daily ETc, gradually became observable due to dissimilar irrigation frequency and water salinity.

Both in greenhouse and outdoor pots, I_2 treatments showed an abrupt rise in daily ET_c values one or two days after irrigation (Figure 2-b). The rate of such sudden increase was almost the same in both environments (max. 1.7 and 1.8 mm in 2 days in greenhouse and outdoor plants respectively) during both years. In I_3 treatments, irrigation events brought about a milder increase in daily ET_c, relative to those of I_2. As shown in Figure 2-b, daily ET_c variation curves were smoother with smaller fluctuations. Such trend in daily ET_c variations can also be met in I_2 and I_3 treatments with increase of salinity, just as shown in Figures 2-a and 2-b in which the increase of irrigation water EC has led to a decrease in the amplitude of the ET_c fluctuations in daily ET_c curves. Such smoothing in the trend of daily ET_c variations toward watering frequency can be interpreted as the abatement of eggplant stomatal respond to irrigation as a result of salinity and drought stresses.

The results indicate that reductions in daily ET_c values due to salinity were more significant in outdoor conditions than greenhouse ones during both years of experiment. The outdoor daily ET_c of the J_4 (EC=0.8 ds/m) treatments were shown to be 0.5 to 0.55 that of the J_1 (EC=7 ds/m) treatments, while the ratio of the daily ET_c of the J_4 to J_1 treatments were 0.62 to 0.67 in the greenhouse eggplants.

The difference between I_1J_1 and other treatments were greater in outdoor condition than in the greenhouse. This indicates that outdoor eggplants' evapotranspiration are more sensitive to water deficiency. However, in both environments, the potential evaporative demand of eggplants decreased with lower water availability and quality. During soil moisture deficiency situations, water supply capability of the dried soil would become inadequate to meet the plant ET_c, mainly during its peak period of water use; which results in stomatal closure and total ET_c reduction from 846.6 to 377.7 mm in outdoor I_1J_1 to I_3J_1 treatments and from 598.5 to 233.4 mm in greenhouse I_1J_1 to I_3J_1 treatments, respectively. During both years of experiment, a distinct decline in total ET_c is observed versus water salinity increase. The total ET_c under the greenhouse fresh water-irrigation conditions (J_1) is around 1.5 to 1.6 times higher than those in J_4 treatments; while such ratio was between 1.6 and 1.8 in greenhouse treatments.

As indicated in the table 3, the ECe values escalated with increasing salinity levels, meanwhile, water deficit intensified soil extract salinity from I_1 to I_3 treatments in both outdoor and greenhouse environments. Results of an ANOVA analysis showed significant effects of water deficit and salinity factors on ECe values in both environments, for both years. However, the interaction of these factors revealed no significant difference in ECe values.

According to the Table 3, different watering regimes and salinity levels showed significant effects on ET_c values in both environments ($p<0.05$), however, no significant difference was observed between J_3 and J_4 treatments, in both years. Similarly, the interactive effects between irrigation and salinity treatments were not significant in both environments.

It was shown that irrigation and salinity treatments had significant effects on eggplant yield (Y). However, no significant difference was met between I_1 and I_2 treatments neither in outdoor nor in greenhouse conditions, in both years ($p<0.05$).

In both environments, despite the higher values of ET_c during the growing season, eggplants' yield in I_1J_1 treatments were lower than those in I_2J_1; however, the differences were not significant. This can be related to the excess water, applied daily in I_1 treatments especially to obtain the leaching requirements, which led to more vegetative growth of plants and negatively affected fruit yield in I_1 treatments.

The descending trend of ETc and Y with the I_1 and J_1 treatments, were not the same in the greenhouse and outdoor eggplants. The ratio of the greenhouse to outdoor ETc values ranged from 0.53 to 0.73, while the ratio of the greenhouse to outdoor Y was between 0.65 and 1.1, in different treatments.

As shown in Figure 4 a very high relation ($R^2=0.93$) was observed between ECe as well as a relative decrease in yield of outdoor treatments. In the greenhouse treatments, however, salinity showed a less positive-effect ($R^2=0.87$) on yield decrease.

4.1 Compound Analysis of Variance

A compound analysis of variance was applied for a statistical comparison of I and J effects in greenhouse with outdoor conditions. In this analysis the environment was also considered as a source of variation. The results are

presented in Table 4 for three major parameters (ET_c, ECe and Y). Environment, I and J showed a significant effect on ET_c at 5%, while their interactional effects were not significant. The effect of environment on Y and ECe was not significant, nor its interactional effects with I and J. No significant difference was met between the results of first and second years of experiment according a compound analysis of variance applied between the two years data.

Table 4. Source of variation, related F-ratios and pr-values calculated from compound ANOVA from SAS software for the ETc, Y and ECe

| Source | DF | 1st Year | | | | | | 2nd Year | | | | | |
| | | ETc | | Y | | Ece | | ETc | | Y | | Ece | |
		F	Pr>F	F	Pr>F	F	Pr>F	F	Pr>F	F	Pr>F	F	Pr>F
Environment	1	181.52	</0001*	6.04	0.0177	1.82	0.1837	330.18	</0001*	0.11	0.744	2.12	0.1521
I	2	268.66	</0001*	36.17	</0001*	34.22	</0001*	638.06	</0001*	39.54	</0001*	30.13	</0001*
Environment×I	2	2.62	0.0835	0.77	0.47	7	0.0022	18.92	</0001*	1.14	0.3281	9	0.0017
J	3	54.83	</0001*	112.87	</0001*	310.06	</0001*	175.65	</0001*	72.37	</0001*	299.01	</0001*
I×J	6	1.39	0.2388	2.46	0.0372	1.79	0.1209	3.26	0.009	0.35	0.9087	3.22	0.09743
Environment×J	3	3.93	0.0138	1.57	0.2083	1.43	0.246	15.12	</0001	0.41	0.7458	2.07	0.177
Environment×I×J	6	0.14	0.991	1.01	0.429	1.65	0.1548	0.24	0.9621	0.92	0.4917	1.99	0.1128

* Values are significant at 5%

5. Conclusions

The relationship between irrigation regimes and water salinity with eggplant evapotranspiration, yield and some plant parameters were investigated in a plastic greenhouse and in outdoor conditions, during two 110 days experiment conducted in two successive years. Daily ET_c measurements showed apparent variations between different irrigation regimes×water salinity treatments, during the early growing season. The reductions in daily ET_c values due to salinity were more noticeable in outdoor conditions than in greenhouse ones. Higher sensitivity of outdoor eggplants to salinity was later demonstrated, obtaining higher values of b and lower values of $ECe_{threshold}$ in the outdoor eggplants. In both environments, the cumulative ET_c values decreased with decreasing water availability and quality. However, the differences between total ET_c values were more obvious in the outdoor treatments than the greenhouse ones.

Both water deficit and salinity factors had significant effects on ECe values in both environments. Nonetheless, no significant difference was met between the treatments for irrigation regimes×water salinity interaction. Same results were obtained for total ET_c, Y, fruit diameter and shoot dry weight.

The K_y coefficient obtained for irrigation and water salinity treatments indicate that eggplant is moderately sensitive to water deficit and salinity stresses.

References

Allen, R. G., Pereira, L. S., Dirk, R., & Smith, M. (1998). *Crop evapotranspiration guidelines for computing crop water requirements*, FAO, Rome, Italy.

Ayers, R. S., & Westcot, D. W. (1985). *Water quality for agriculture*. FAO Irrigation and Drainage, 29, Rev. 1, Rome.

Ben-Gal, A., Ityel, E., Dudley, L., Cohen, S., Yermiyahu, U., Presnov, E., Zigmond, L., & Shani, U. (2008). Effect of irrigation water salinity on transpiration and on leaching requirements: a case study for bell peppers. *Agricultural Water Management, 95*, 587–597. http://dx.doi.org/10.1016/j.agwat.2007.12.008

Ben-Gal, A., Karlberg, L., Janson, P. K., & Shani, U. (2003). Temporal robustness of linear relationships between production and transpiration. *Plant Soil, 251*, 211–218. http://dx.doi.org/10.1023/A:1023004024653

Boyaci, H. F. (2007). *Resistance resources and its inheritance against to fusarium wilt in eggplants*, Cukurova University, Ph D Thesis, *Natural and Applied Sciences*. 108 p.

Bresler, E., McNeal, B. L., & Carter, D. L. (1982). *Saline and Sodic Soils*. Springer-Verlag: Berlin. http://dx.doi.org/10.1007/978-3-642-68324-4

Chartzoulakis, K., & Drosos, N. (1995). Water use and yield of greenhouse grown eggplant under drip irrigation.

Agricultural Water Management, 28, 113- 120. http://dx.doi.org/10.1016/0378-3774(95)01173-G

de Wit, C. T. (1958). *Transpiration and crop yields*. Versl Landbouwk. Onderz. 64.6, Pudoc, Wageningen, 88 PP.

Doorenbos, J., & Kassam, A. H. (1979). *Yield response to water*. FAO Irrigation and Drainage, 33, FAO, Rome, Italy. 193 p. http://dx.doi.org/10.1016/B978-0-08-025675-7.50021-2

Dudley, L. M., Ben-Gal, A., & Shani, U. (2008). Influence of plant, soil and water on the leaching fraction. *Vadose Zone Journal, 7*, 420–425. http://dx.doi.org/10.2136/vzj2007.0103

Fabeiro, C., Martin, S. F., & Juan, J. A. (2001). Yield and size of deficit irrigated potatoes. *Agricultural Water Management, 48*, 255–266. http://dx.doi.org/10.1016/S0378-3774(00)00129-3

Hanks, R. J. (1974). Model for predicting plant yield as influenced by water use. *Agronomy Journal, 66*, 660-665. http://dx.doi.org/10.2134/agronj1974.00021962006600050017x

James, L. G. (1988). *Principles of farm irrigation system design*. John Wiley and Sons. Inc., New York. 543 p.

Katerji, N., van Hoorn, J. W., Hamdy, A, Mastrorilli M., & Karam F. (1998). Salinity and drought, a comparison of their effects on the relationship between yield and evapotranspiration. *Agricultural Water Management, 36*, 45–54. http://dx.doi.org/10.1016/S0378-3774(97)00049-8

Li, F., Yan, X., Li, F., & Guo, A. (2001). Effects of different water supply regimes on water use and yield performance of spring wheat in a simulated semi-arid environment. *Agricultural Water Management, 47*, 25–35. http://dx.doi.org/10.1016/S0378-3774(00)00097-4

Maas, E. V. (1984). *Salt tolerance of plants.* The Handbook of Plant Science in Agriculture, Christie BR (Ed.). CEC Press: Boca Raton, Fla. http://dx.doi.org/10.1061/9780784411698.ch13

Maas, E. V., & Hoffman, G. J. (1977). Crop salt tolerance, current assessment. *Journal Irrigation and Drainage. Div. ASCE, 103*, 115-134. http://dx.doi.org/10.1.1.542.1486

Mannini, P., & Gallina, D. (1996). Effects of different irrigation regimes on two tomato cultivars grown in a cold greenhouse. *Irrigazione e drenaggio, 61*, 64-650. http://dx.doi.org/10.5897/AJB10.2574

Mendezr, F.,J. (1987). Effect of applying different irrigation frequencies into tomato production in San Juan de Lagunillas merid state. *Acta Horticulturae., 22*, 383–386.

Ouda, S. A., Khalil F. A., & Tantawy M.M. (2006). Predicting the impact of water stress on the yield of different maize hybrids. *Research Journal of Agriculture and Biological Sciences, 2*(6), 369–374.

Oweis, T., Zhang, H., & Pala, M. (2000). Water use efficiency of rainfed and irrigated bread wheat in a Mediterranean environment. *Agronomy Journal, 92*, 231–238. http://dx.doi.org/10.1007/s100870050027

Rijtema, P. E., & Endrodi, G. (1970). Calculation of production of potatoes. *Netherlands Journal of Agricultural Science, 18*, 26-36.

Shani, U., & Ben-Gal, A. (2005). Long-term response of grapevines to salinity: osmotic effects and ion toxicity. *American Journal of Enology and Viticulture, 56*(2), 148–154.

Shani, U., & Dudley, L. M. (2001). Field studies of crop response to water and salt stress. *Soil Science Society of America Journal, 65*, 1522–1528. http://dx.doi.org/10.2136/sssaj2001.6551522x

Shani, U., Ben-Gal, A., Tripler, E., & Dudley, L. M. (2007). Plant response to the soil environment: an analytical model integrating yield, water, soil type, and salinity. *Water Resources Researches, 43*, 1–12. http://dx.doi.org/10.1029/2006WR005313

Skaggs, T. H., Poss, J. A., Shouse, P. J., & Grieve, C. M. (2006). Irrigating forage crops with saline waters: 1. Volumetric lysimeter studies. *Vadose Zone Journal, 5*, 815–823. http://dx.doi.org/10.2136/vz2015.06.0088

Tripler, E., Ben-Gal, A., & Shani, U. (2007). Consequence of salinity and excess boron on growth, evapotranspiration and ion uptake in date palm (Phoenix dactylifera L., cv. Medjool). *Plant Soil, 297*, 147–155. http://dx.doi.org/10.1007/s11104-007-9328-z.

Unlukara, A., Kurunc, A., & Kesmez. G. D. (2010). Effects of salinity on eggplant (Solanum melongena L.) growth and evapotranspiration. *Irrigation and Drainage, 59*, 203-214. http://dx.doi.org/10.1002/ird.453

Van Genuchten, M. T. (1983). Analyzing crop salt tolerance data: Model description and user's manual. USDA-ARS, U. S. Salinty Lab. Res. Rep. 120. U. S. Salinty Lab. Riverside, CA.

Yaron D., & Bielorai H. (1982). Linear crop response functions to salinity with a threshold salinity level. *Water Resources Research, 18*, 101–106. http://dx.doi.org/10.1029/WR018i001p00101

The Effect of Electronic Banking on the Performance of Supply Chain Management of Small and Medium Businesses

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Abstract

In current age, e-commerce does not just imply online buying and selling, but implies an efficient business throughout business levels, in which supply chain management can be regarded as the major pillar. The aim of this survey is to study effect of use of electronic banking services and important instruments of e-banking on performance and dimensions of supply chain performance at the first level of the SCOR model in electronics businesses. The present study is an applied research type in terms of aim, which is categorized as descriptive correlation in terms of data collection. The statistical population consists of electric supplies stores in Bushehr, of which 107 stores were selected as sample group using simple random sampling method. The questionnaire has been used as data collection instrument, that its validity has been confirmed through face and content validity through Cronbach's alpha. To analyze data, structural equation modeling using software Lisrel was used. Findings of the present study indicate that the use of e-banking services has a significant effect on performance of supply chain management. Further, among all devices of e-banking services except for POS (Point of Sale) and mobile banking, rest of the devices have a significant effect on performance of supply chain management.

Keywords: E-banking, supply chain, supply chain management, small businesses, Bushehr

1. Introduction

Effect of growth of information and communication technologies and their arrival to the organizational systems on development of economic strategies causes development in traditional approach at business and market. In this regard, increasing development of e-banking has provided a suitable infrastructure to facilities making economic and commercial communications especially at modern business models (Talebzade, 2014). The main purpose in development of e-payment systems is sending electronic payments to receive electronic goods or adhering to deliver physical commodities. For this, the main focus in on design of e-payment systems in the process of supply and delivery of good through Internet portals.

In recent 20 years, companies have spent huge costs to improve the methods to distribute goods and services, especially factories have carried their early goods from long distance and distributed their products at points of sale throughout the world. Currently, complicated supply chain systems especially the systems which are based onelectronic supply chain management pave the way for the big companies for payment management. E-banking is the most important technology which provides the area for e-payment in supply chain management in Iran (Kaboutari, 2013). Information and communication technology especially the services provided in e-banking system have causes big changes in the process of supply chain. The term "e-business" is used to describe planning in supply chain by means of internet, modern communication tools and payments and online systems. This technology paves the way to integrate and implement information operations within various businesses from wholesale to computer stores. This integration paves the way for the company for a more accurate and flexible control and prediction of demand, and optimal allocation of asset together with improving quality, providing services and responding the customers with awareness from loyal customers' treatment (Mojdehi et al., 2007).

To date, with regard to the studies relating to the supply chain management, changes in consumer preferences,

global trade liberalization, internet, e-commerce, the increasing tendency towards outsourcing and even environmental issues have been entered into discussion. In other words, competitive global marketplace and change in customers' needs have caused the organizations address evaluation and investigation of effect of various factors on performance of supply chain and its improvement (fynes& wiengarten, 2011). Despite influence of e-commerce and its instruments especially e-banking system in supply chain system at small and big businesses throughout the world and importance of this technology as a logic for payment within supply chain, it can witness that various businesses especially start-up businesses in current community adjust themselves with this technology with a negligible speed and insist on use of their own traditional method. One of the most important reasons for this negative habit can be lack of practitioners' information on effect of these technologies on performance of their supply chain or lack of risk in acceptance and use of these technologies at their businesses. Hence, the present study aims to give a response to this question "whether use of e-banking services within supply chains at small businesses affects supply chain performance management at these business units?".

The present paper aims to investigate place and effect of e-banking technology on effectiveness and efficiency of supply chain performance management by investigating the structure and features of supply chain. The main purpose of the present study is to investigate effect of use of services provided in e-banking system on supply chain performance management at small businesses. Furthermore, the present paper aims to propose some suggestions to various businesses to let them to use more e-banking services for the purpose of achieving their major aim and providing services with high quality and building sense of loyalty and satisfaction in customers.

2. Literature Review and Research Background

There is no gap within organizations. Any organization including big companies, small business, and public or private companies seek to meet customers and stakeholders' expectations and needs, thus they require materials, equipment, facilities from other organizations, whereby the performance of an organization is influenced by means of activities of other organizations which develop supply chain. Efficiency and effectiveness of any organization relies on management performance and supply chain structure. The secret in survival of modern organizations relies on understanding customers' need and rapid responsiveness to these needs. To achieve supply chain competitiveness, providing services for customers is a leading factor. Nowadays, competition between companies has replaced with competition between supply chains (Boyson et al., 2013). A capability which is required to achieve supply chain competitiveness is investigation of supply chain performance and effect of various innovations and its components on supply chain performance. The present research seeks to investigate effect of one of the most effective technologies in current age within the arena of banking industry and economy (e-banking) on supply chain management performance at small businesses.

2.1 E-Banking

Indeed, it can say that e-banking is one of big achievements in e-business. With increasing development of e-business throughout the world and with regard to the need to rapid, simple and accurate banking operations to transfer financial resources, e-banking plays a major role in e-business. It should be noted that it requires representing a certain definition for e-banking and factors affecting it in order to understand e-banking. In this regard, e-banking implies paving the way for customers' access to banking services through secure mediators or direct supply of services and banking operations for customers through interactive electronic communication channels (Daniela & Octavian, 2005; Bauer & Hein, 2006). Indeed, e-banking implies optimal integration of all activities of a bank through using modern information technologies concerning banking process (Wendyet al., 2005). E-banking supplies all banking services via online systems and meets customers' needs without any need for physical presence at bank. E-banking provides the services such as account information and inquiry to it, transfers or transfer funds between accounts, deposits, currency conversion and paying bills for utilities for the customer in a list.E-banking is followed by many advantages such as increasing the number of customers and reducing cost at banking transactions, in this way banks can supply their services with more efficiency and lower costs and consider increasing market share and focusing on new distribution channels (Harris & Spence, 2002). Today, banks using e-banking can give information to the customers regarding their needs, and cause increasing loyalty and reducing costs, and also can provide new opportunities to supply suitable good and services for customers (Marianne et al., 2004). The most important e-banking services which are provided throughout the world include information about customer accounts, transfer funds between accounts, buying and selling stocks, buying and selling currencies, credit services and create a safe path for the relationship between banks and customers (Gorilas et al., 2003). E-banking encompasses the systems which enable customers to use banking services at three levels information, communication and transaction (Ding et al., 2011). A variety of services are used in e-banking, which include:

1- ATM machine: ATM machine can act as a branch of bank and fulfills most of major banking tasks during which a large portion of transactions will be fulfilled with the least intervention by manpower. Statistics indicate that installation of ATM machine has had a growth for about 45%, such that it can say that the banks throughout the world have invested on ATM machine in the communication age. Status of implementation of ATM machines within leading countries concerning e-banking indicates that an ATM machine has been considered per 750 individuals (Ibrahimi, 2004)

2- Point of sale: point of sale implies e-transfer of funds at point of sale through which the customer at any place and time transfers the fund from his account to the bank using various forms of secure identity identification.

3- Iinternet bank: use of internet as communication channel for providing banking services is called internet banking. These services include a series of old services including transfer of fund and a series of new services including supply of electronic statements. Using internet will be followed by benefits for banks and customers. The first and important factor in use of e-banking includes better access to services, better prices and higher privacy (Karjaluotoet al., 2002).

4- Telephone-banking: telephone-banking is called to a business transaction between bank and customers through telephone. The methods used in telephone-banking include Voice Response, Voice Recognition and Programmable Telephone.

5- Mobile bank: development in e-banking has started since the 1980s using mobile phones. development in e-banking together with expansion of wireless networks and mobile phones and the capability for connecting mobile phones to internet has caused the customers have an access to their accounts at bank from any point and develop a new phenomenon "e-banking".
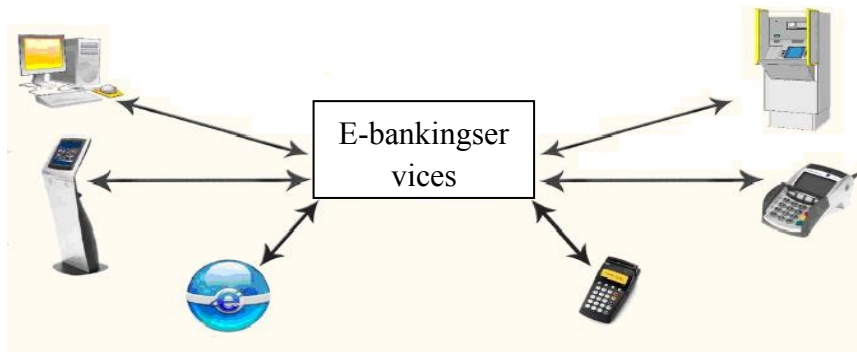
Figure 1. Various types of services provided in e-banking system

2.2 Supply Chain Management

A variety of definitions for supply chain management have been represented in the supply chain literature review, that some are as follows:

A supply chain encompasses all facilities, tasks and activities that suppliers and customers involve in it in production and delivery of a good or service, and it also encompasses planning and supply and demand management, material procurement, production and scheduling of product or service, storage, inventory control, distribution, delivery and customer service (Carmignani, 2009). Supply chain management organizes all these activities in order that it paves the way for the customers to acquire products with high quality and reliable services at minimum cost, suitable time, place, amount and conditions. Supply chain management can pave the way for the company to exploit from competitive advantage (Cirtita & Segura, 2012).

Supply chain refers to the functions that associate the supply chain of materials and distribution of final products to each other. Companies involved in supply chain are connected to each other at different stages of this process through supply and demand relations. Companies involved in a supply chain can optimize the flow of goods by exchange of information and coordination of their activities from the supplier to the consumer, reduce their costs and react to the changes at demand (Jabboura & Lopes, 2011). Supply chain encompasses all the activities associated to the flow of goods from the stage of raw materials to the final consumer and information flows associated to them. Supply chain management implies integration of these activities through improvement of supply chain relations to achieve a sustainable competitive advantage (Cirtita & Segura, 2012).

2.3 Supply Chain Operation Reference (SCOR)

Before starting a process of improvement, having a clear image and a thorough recognition from the existing supply chain structure as well as the current method, fulfillment of all activities and approaches associated to supply chain is required. After the recognition phase, there will be the need for an in-depth analysis of all activities and operations of supply chain. Hence, there will be the need for a strong instrument so as to support the phase of recognition and evaluation of supply chain. For this purpose, supply chain operation reference model can be a worthwhile instrument. This model is the first model which can be used to develop a supply chain based on business strategy (Elwan& Olayinka, 2012). This model has been included of business process reengineering approaches, benchmarking and performance measurement in an integrative framework, proposing an improved state for this model by specifying the existing status of each process, and setting operating aims for each process concerning performance measurements (Khorshidi & Hadadi, 2008). This model defines numerous standards for the supply chain performance including general indicators and in-depth operating indicators. Fundamental indicators which measure and describe general performance of chain are considered as the key indicators of performance. These indicators due tohierarchical nature of SCOR model generally encompass more operating indicators and standards (Akhavan, 2010). The aforementioned model grants support to performance measures which are used together with five performance features: reliability, responsiveness, flexibility, and cost and asset management. Definitions for each of these measures have been represented in table 1. This model has used a common language to facilitate the relationship between managers and design supply chain to achieve a favorable performance (Akhavan, 2010).

Table 1. Dimensions of supply chain performance based on SCOR model

Dimensions	Definitions	Items
Reliability	Supply chain performance is in delivery of the right product, at the right time , to the right place, and in a good condition and package, in a good size and amount, with proper documentation and the appropriate client	One hundred percent delivery of order Delivery performance to customer on time Accuracy in documentation Product delivery with perfect condition
Responsiveness	Quick delivery of products to customers in the supply chain	Sourcing cycle time Manufacturing cycle time Delivery cycle time
Agility	Agility of supply chain in reaction to the changes at market to acquire or maintain a competitive advantage	Supply Chain Flexibility Supply Chain Adaptability
Cost	Costs related to the supply chain operations	Direct and indirect costs of the supply chain Distribution and selling expenses of products
Asset management	The effectiveness of an organization in management of its property and assets to support responsiveness to demand which includes all types of assets including fixed and working assets	Cash to cash cycle time Back Supply Chain Fixed Assets Back capital accounts Supply Chain

Source: Authors' findings.

2.4 Small and Medium Businesses

Small and medium businesses are conveyed as the factors affecting economic development process of countries. Small and medium business at various countries around the world are defined based on various standards including employment size, capital size, production size, turnover rate, type of technology and export of productions. Small and medium businesses are divided into four groups concerning employment size, which can be seen in table 2.

Table 2. Classification of small and medium businesses

Various types of organizations	Number of employees
Micro enterprises	1-4
Very small organizations	5-15
Small organizations	20-99
Medium Organizations	100-500

Source: Authors' findings.

Small and medium businesses in most of developed countries receive support from states due to various reasons, of which it can refer to the necessary abilities for acquisition of existing capitals in the community and conductance of them in manufacturing and industrial activities. According to what aforementioned above, representing some approaches to facilitate active presence of small and medium businesses within economic cycle of country can lead to development and evolution of these organizations (Soughi, 2009).

2.5 Conceptual Model and Research Hypotheses

Overview of literature review in the context of e-banking instruments and data collection of the latest technologies of e-banking system in Iran including Bushehr indicated that e-banking instruments which are used in this city include ATMs, POS, mobile banking, phone banking and Internet banking. With regard to literature review of supply chain operation reference (SCOR) proposed by supply chain association, supply chain performance has been developed from five dimensions including cost, responsiveness, reliability, asset management and agility.

Hence, with regard to the literature review in the context of research subject, it can propose the hypotheses as follows, that the details and arguments associated to them have been proposed in the literature review.

Primary hypothesis:

The level of use of e-banking affects supply chain management performance at small businesses within city of Bushehr

Secondary hypotheses:

1- The level of use of e-banking affects reliability of supply chain at small businesses within city of Bushehr

2- The level of use of e-banking affects responsiveness of supply chain at small businesses within city of Bushehr

3- The level of use of e-banking affects agility of supply chain at small businesses within city of Bushehr

4- The level of use of e-banking affects cost of supply chain at small businesses within city of Bushehr

5- The level of use of e-banking affects asset management of supply chain at small businesses within city of Bushehr

According to relationships between variables in research hypotheses of the study, conceptual model has been designed (Figure 2).
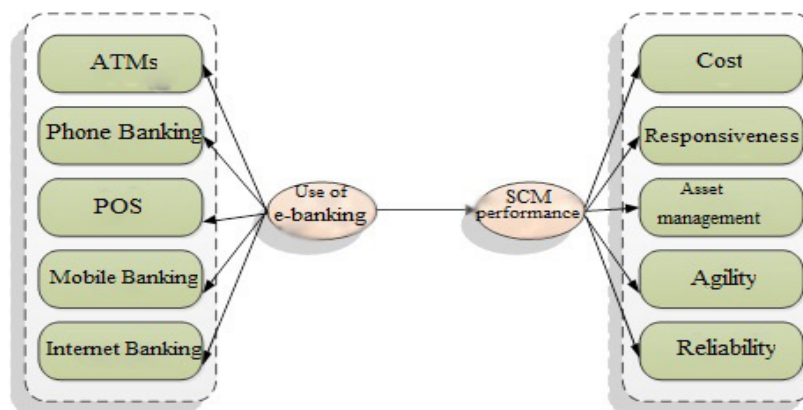

Figure 2. Conceptual model of research

3. Research Methodology

Research can be defined as an organized attempt to investigate a special problem which requires a solution, including the steps which are designed and considered to acquire the responses for the problem which is in favor of us at work environment. The present study is an applied research type in terms of aim, which is categorized as descriptive correlation in terms of data collection. The present study investigates effect of quality of e-banking services on the level of use of e-banking and its effect on supply chain management performance within electric supplies store*s* in Bushehr.

The statistical population consists of electric supplies stores in Bushehr*,* of which 107 stores were selected as sample group using simple random sampling method. The sample size (110) has been determined using Cochrane formula from finite population at confidence level (95%) and error level (5%).

In this study, two groups of latent and patent variables have been used. Latent variables refer to the variables which cannot be directly observed or measured. Patent variables refer to those variables which are used to defy the latent variables. In this study, two latent variables entitled "the level of use of e-banking" and "supply chain management performance" have been used. Five patent variables include ATMs, POS, mobile banking, phone banking and internet banking which are associated to the latent variable of the level of use of e-banking; further, five patent variables include cost, responsiveness, asset management, agility and reliability which are associate to the latent variable of supply chain management performance. Further, the latent variable "supply chain management performance" and its dimensions are considered as dependant variables and the latent variable "the level of use of e-banking" and its dimensions are considered as independent variables.

The questionnaire has been used data collection instrument. This questionnaire, in addition to demographic questions, develops from 50 questions to evaluate the variables. 24 questions have been considered to measure the variable "use of e-banking" designed by the researcher and 26 questions taken from SCOR model, have been considered as the questions to measure the supply chain management performance. To measure the variables, five-point Likret scale ranging from very low to very high has been used. To conduct this research, 110 questionnaires were distributed among electric supplies stores within city of Bushehr.

Validity of questionnaire was examined through face and content validity. For this purpose, the questionnaires were given to several professors and owners of electric supplies stores within city of Bushehr, and thereby the content validity was examined and necessary changes were applied. To measure reliability of questionnaire, Cronbach's alpha method has been used. As seen in table 3, Cronbach's alpha coefficient for all the research variables goes beyond 70%, thus it can conclude that the designed questionnaire enjoys the required reliability.

Table 3. Reliability of research variables by means of Cronbach's alpha

Latent variables	Patent variables	No of questions	Cronbach's alpha coefficient
The level of use of e-banking	POS	4	0.86
	ATMs	4	0.76
	phone banking	4	0.89
	mobile banking	4	0.90
	internet banking	8	0.96
Sum		24	0.87
Supply chain management performance	Cost	5	0.87
	Responsiveness	5	0.80
	Asset management	6	0.82
	Agility	4	0.89
	Reliability	6	0.84
Sum		24	0.84

Source: Authors' findings.

In this study, to examine and test the conceptual model proposed by the research, structural equation modeling and software Lisrel have been used. Structural equation modeling gives the researcher assistance to test and examine the theoretical model which has been developed from various components.

4. Analysis of Data and Findings

After collecting data using the questionnaire, the data were classified and analyzed using suitable statistical techniques which are relevant with the research method, type of variables and so forth, and finally the research hypotheses were tested. In this research, 110 questionnaires were distributed among statistical population and then were evaluated, that the results of demographic results are as follows in table 4.

Table 4. Demographic characteristics of respondents

Demographic variable	Levels	Frequency percent
Gender	Male	87.7
	Female	12.3
Education status	Diploma and under diploma	40.9
	Associate degree	23.8
	Bachelor degree	28.1
	Master degree	7.2
Age	Under 35 years old	23.3
	35-45 years old	47.9
	Elder than 45 years old	28.8
Work experience	Under 10 years	21.9
	10-20 years	59.2
	Above 20 years	18.9

Source: Authors' findings.

Here, we attempt to investigate effect of the level of use of e-banking services on performance and dimensions of supply chain in small and medium businesses, using structural equation modeling. Diagrams 2 and 3 indicate research models in the state of estimation of significance coefficients; all the research variables are transformed to two latent and patent classifications. Patent variables are measured in a direct way by the researcher, yet the latent variables are not measured in a direct way, but they are inferred based on the relations and correlations between measured variables.

Goodness of fit Statistics:

Chi-Square=58.06,   df=29, (χ^2/df=2.002), RMSEA=0.084, GFI=0.91, CFI=0.94, NFI=0.92, NNFI=0.96, IFI=0.94, RFI=0.91

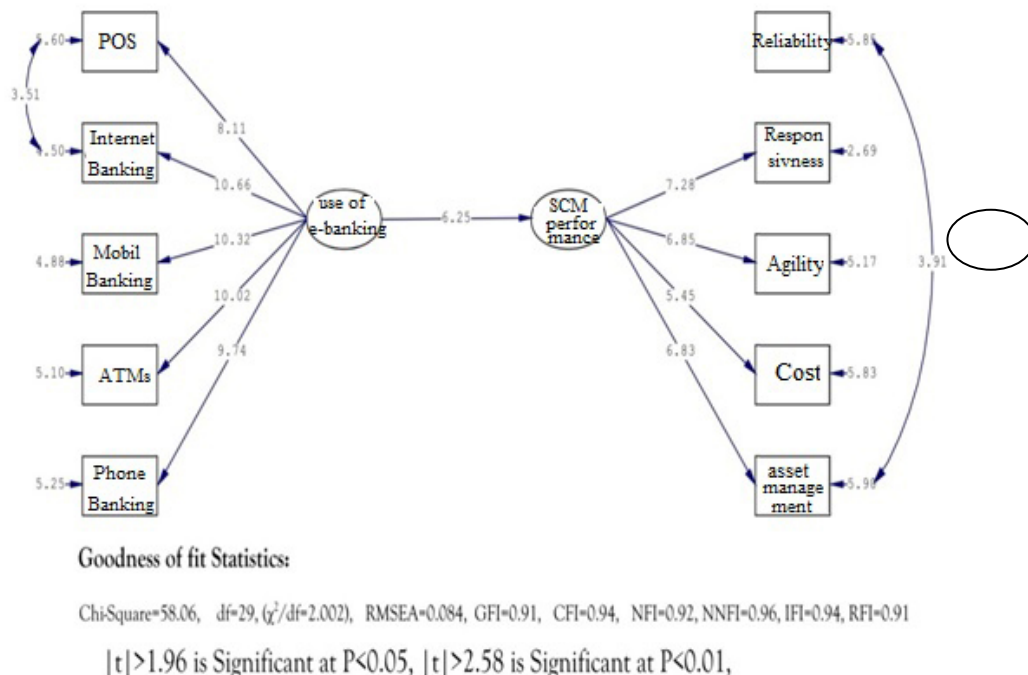$|t|>1.96$ is Significant at $P<0.05$, $|t|>2.58$ is Significant at $P<0.01$,

Figure 2. The model representing use of e-banking services in supply chain management concerning significance coefficients (t-value)
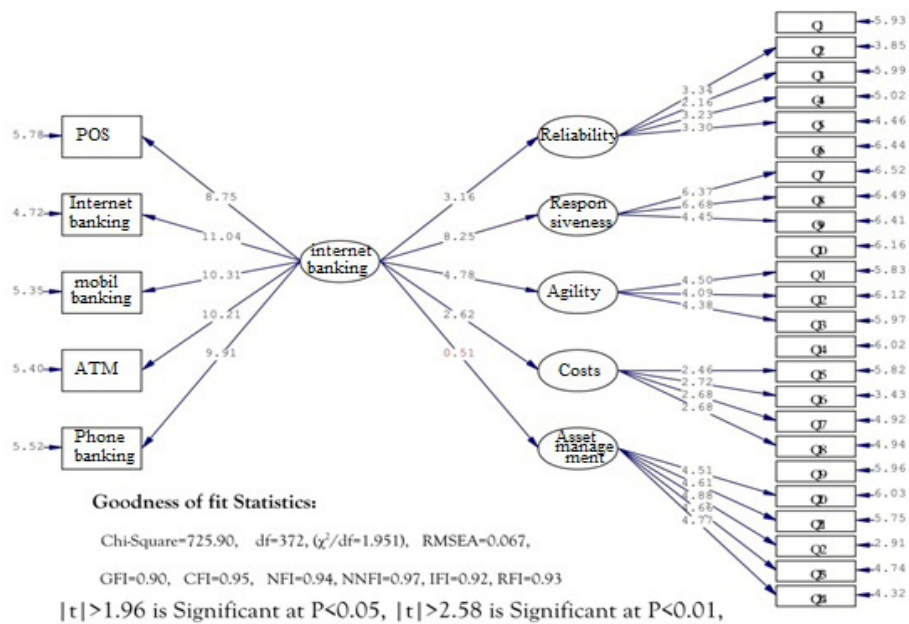
Figure 3. The model representing effect of use of e-banking services on dimensions of supply chain management concerning significance coefficients (t-value)

Table 5 represents that the conceptual model of research enjoys a suitable status for fitness and determination, that all the indicators of fitness of model indicate fitness of model with patent data, and thereby it can say that the conceptual model of research is significant.

Table 5. Indicators of fitness of model

Index	Primary model	Secondary model	Allowed limit
Chi-Square with degrees of freedom	2.002	1.951	Under 3
Goodness of Fit Index (GFI)	0.91	0.90	Above 0.9
Root Mean Square Error of Approximation (RMSEA)	0.084	0.067	Under 0.09
CFI	0.94	0.95	Above 0.9
Normed Fit Index (NFI)	0.92	0.94	Above 0.9
No Normed Fit Index (NNFI)	0.96	0.97	Above 0.9

Source: Authors' findings.

According to structural equation modeling and extraction of standard coefficients and significance, now it can investigate research hypotheses. Table 6 represents results of standard coefficients and significance coefficients of testing research hypotheses.

Table 6. Results of research hypotheses

No of hypothesis	Research hypotheses		Standard coefficient (β)	t-value	Results of hypotheses
Primary	E-banking $\rightarrow$ Supply chain management		0.77	3.16[**]	Confirmed
First hypothesis	E-banking $\rightarrow$	Reliability	0.94	8.25[**]	Confirmed
Second hypothesis	E-banking $\rightarrow$	Responsiveness	0.91	4.78[**]	Confirmed
Third hypothesis	E-banking $\rightarrow$	Agility	0.81	2.62[**]	Confirmed
Fourth hypothesis	E-banking $\rightarrow$	Costs	0.37	0.51	Confirmed
Fifth hypothesis	E-banking $\rightarrow$	Asset management	0.77	3.16[**]	Rejected

Source: Authors' findings.   **significance at 99% confidence level   * significance at 95% confidence level

According to table 6, research hypotheses' testing indicates that e-banking affects supply chain management performance at small businesses and its all dimensions except for asset management within **Bushehr.** Hence, the more e-banking services increase, supply chain performance and its dimensions will increases, and the more e-banking services decrease, supply chain performance and its dimensions will decrease.

5. Conclusion and Suggestions

The present paper has aimed to investigate effect of use of e-banking on supply chain management and its dimensions at small businesses within city of Bushehr. The major hypothesis has been proposed in this way that the level of use of e-banking affects supply chain management performance at small businesses within city of Bushehr. In other words, level of use of services provided in e-banking system and virtual facilities which this system provides for its customers affect fulfillment of payment operations in supply chain, having a positive effect on supply chain management performance and its dimensions. According to the results from research, the variable "e-banking" has a significant effect on supply chain performance at confidence level (99%). With regard to positive path coefficient, it can say that there is a positive direct relationship between these two variables. Hence, it can conclude that the more level of use of e-banking services and its facilities and use of this technology increase in the supply chain, supply chain management performance will also increase, and the more level of use of e-banking services and use of this technology decrease in supply chain, supply chain management performance will also decrease. Findings of this research indicate that e-banking has had the highest effect on supply chain management and its dimensions including responsiveness, agility, costs and reliability, but it has had no effect on asset management.

The results of this research indicate that the more level of use of e-banking services and its instruments in fulfillment of various payment operations from the early stage of supply chain to later increases, the supply chain management performance and its associated components will also increase. As the results of research indicate, applying e-banking services in an effective way especially at the current age which plays a major role in success of an organization will be also effective in success of business. Findings of this research are relevant with the results of other studies by Wever (2010), Tsenga et al. (2011), Sadeghi & Hanzaee (2010), Kima et al. (2010) and Jabbour(2011). In this regard, given the results of this research, the suggestions as follows are represented:

1- Supply chain management performance is a big concern at small and big businesses at current age. As a result, most of organizations seek to use any modern approach which has a positive effect on supply chain management performance. With regard to the results from this research, it is suggested to the small businesses to develop the preparations for more use of e-banking services (ATMs, POS, mobile banking, phone banking and internet banking), and to develop necessary infrastructures to implement e-banking system within payment management in the supply chain.

2- Among e-banking instruments, point of sale is one of the instruments in e-banking system which has reduced customers' banking queue*s*, because the customers will no longer carry their money and stand in long banking queues, but they can use point of sale for their purchase without any need to refer to the bank. Thus, firstly it is suggested to the banks to improve quality of software and hardware of this system within city of Bushehrso as to welcome various business units for acceptance of point of sale in their daily transactions, and then it is suggested to the small businesses to provide the possibility for paying the good's price or concurrent purchase of services by setting up point of sale within their business enterprises which are not in need of huge costs and time, whereby the components of responsiveness, agility, costs, asset management and reliability improve.

References

Akhavan, M. (2010). Identification of Factors affecting the performance of the supply chain. *Journal of Management Sciences, 5*, 67-87. (In Persian)

Bauer, K., &Hein, S. E. (2006). The effect of heterogeneous risk on the early adoption of Internet banking technologies. *Journal of Banking & Finance, 30*(6), 1713-1725. http://dx.doi.org/10.1016/j.jbankfin.2005.09.004

Boysona, S., Corsia, T., & Verbr, A. (2013). The e-supply chain portal: a core business model. *International Journal of Operations & Production Management, 26*(39), 175–192. http://dx.doi.org/10.1016/S1366-5545(02)00046-7

Carmignani, G. (2009). Supply chain and quality Supply chain and quality: The definition of a standard to implement a process management system in a supply chain. *Business Process Management Journal, 45*(3), 395-407. http://dx.doi.org/10.1108/14637150910960639

Cirtita, H., & A. Glaser-Segura, D. (2012). Measuring downstream supplychain performance. *Emeraldinsight, 23*(3), 299-314. http://dx.doi.org/10.1108/17410381211217380

Daniela, R., &Octavian, D. (2005). The Adoption Electronic Banking Services in Developing Countries. *International Journal of, Inforn1ationManagement, 25*(5), 396- 410.

Ding, D. X., Hu, P. J.H., &Olivia, R. L.(2011).E-SELFQUAL: A scale for measuring online self-service quality. *Journal of Business Research, 64*, 508-515. http://dx.doi.org/10.1016/j.jbusres.2010.04.007

Ebrahami, N. (2005). Barriers to electronic banking in Iran. *Tadbir journal*, No. *137,* pp. 25-32. (In Persian)

Elwan, I. S., & Olayinka, O. (2012). The effect of linkages and information sharing on supplychain and export performance: An empirical study of Egyptian textilemanufacturers. *International Journal of Information Management, 27*(5), 336–351. http://dx.doi.org/10.1108/17410381211230394

Fynes, B., & Wiengarten, F. (2011). Assessing value creation process of e-business along the supplychain. *Journal of Management, 16*(4), 207-219. http://dx.doi.org/10.1108/13598541111139035

Gorilas, S., Tambouris, E., & Boukis, G. (2003). Investigation of Electronic. Retrieved from citeseerx. *International Journal of, Inforn 1ation Management, 31*(5), 122-128.

Harris, L., & Spence, L. J. (2002). The Ethics of eBanking. *Journal of Electronic Commerce Reasearch, 3*(2), 37-53.

Hashemian, M. (2013). Concepts of e-government. *Takfa Journal, 47*, 17-23. (In Persian)

Jabboura, D., & Lopes, A.(2011). Factors affecting the adoption of supply chain management practices: Evidence from the Brazilian electro-electronic sector. *IIMB Management Review, 23*(4), 208–222. http://dx.doi.org/10.1016/j.iimb.2011.09.001

Kaboutari, J. (2013). Applying ES-QUAL and ANP model for the evaluation and ranking of factors affecting the quality of ATM machines, *Tehran, Engineering Conference*, 423-427. (In Persian)

Karjaluoto, H., Pento, T., & Mattila, M. (2002). Factors Underlying Attitude Formation Towards Online Banking in Finland. *Information Management, 20*(6), 261-272. http://dx.doi.org/10.1108/02652320210446724

Khorshidi, H., & Vahdadi, M. (2008). Evaluation of supply chain performance in pharmaceutical holding in Iran: Social Security Organization, *Journal of Industrial Management, 17*, S45-59. (In Persian)

Kima, K. S., Taoa, W., & Shinb, N. (2010). An empirical study of customers' perceptions of security and trust in e-payment systems. *Electronic Commerce Research and Applications, 9*(1), 84–95. http://dx.doi.org/10.1016/j.elerap.2009.04.014

Marianne, A., Kolodinsky, J. M., & Hogarth, J. M. (2004). The Adoption of Electronic Banking Technologies by US Consumers. *International Journal Of Bank Marketing, 22*(4), 238-25. http://dx.doi.org/10.1108/02652320410542536

Mojdehi, N., Mehraban. A., & Amini, M. (2007). Examination of the role and importance of supply chain management, electronic payments. *Bank and Finance Magazine, 109*, S43-49. (In Persian)

Sadeghi, T., & Hanzaee, K. H. (2010). Customer satisfaction factors (CSFs) with online banking services in an Islamic country Iran. *International Journal of Operations & Production Management, 21*(2), 461-75. (In Persian)

Soghi, G. (2008). A model to evaluate the performance of small and medium enterprises in the adoption of electronic commerce. *International Journal of Engineering, Iran University of Science and Technology, 19,* 79-65. (In Persian)

Stadtler, H. (2005). Supply chain management and advanced planningbasics, overview and challenges. *European Journal of Operational Research*, *16*(3), 575–588.http://dx.doi.org/10.1016/j.ejor.2004.03.00

Taleb-Zadeh, S. A. (2014). Supply chain operations reference model. Tehran: *Monthly journal of engineering and related industries*, *37*(4), 45-49. (In Persian)

Tsenga, M.L., Wub , K.J., & Nguyena, T. T. (2011). Information technology in supply chain management: A case study. *Procedia-Social and Behavioral Sciences, 25*(1), 257-272. http://dx.doi.org/10.1016/j.sbspro.2011.10.546

Van Donk, D. P. (2008). Challenges in relating supplychain management and information and communicationtechnology. *International Journal of Operations & Production Management*, *28*(4), 308-312.

http://dx.doi.org/10.1108/01443570810861534

Wendy, W., Wan, N., Luk, C. L., Cheris, W., & Chow, C. (2005). Customers' Adoption of Banking Channels In Hong Kong. *Tourism Management, 23*(4), 255-272. http://dx.doi.org/10.1108/02652320510591711

Wever, M. W. (2010). Alignment between chain quality management and chain governance in EU pork supply chains: A Transaction-Cost-Economics perspective. *Meat Science*, *28*(2), 228–237. http://dx.doi.org/10.1016/j.meatsci.2009.05.012

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Hybrid Methodology for Image Segmentation Based on Active Contour Module and Alpha-Shape Theory

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Abstract

The concept of the active contour model has been extensively utilized in the segmentation and analysis of images. This technology has been effectively employed in identifying the contours in object recognition, computer graphics and vision, biomedical processing of images that is normal images or medical images such as Magnetic Resonance Images (MRI), X-rays, plus Ultrasound imaging. Three colleagues, Kass, Witkin and Terzopoulos developed this energy, lessening "Active Contour Models" (equally identified as Snake) back in 1987. Being curved in nature, snakes are characterized in an image field and are capable of being set in motion by external and internal forces within image data and the curve itself in that order. The present study proposes the use of a hybrid image segmentation technique to acquire precise segmentation outcomes, while engaging "Alpha Shape (α-Shape)" in supposition to derive the original contour, followed by a refining process through engaging a conventional active contour model. Empirical results show high potential in the suggested computational method. Trials indicate that the primary contour is capable of being precisely set next to the objective contour and effectively have these objective contours extracted, devoid of any contour instigation. Some of the benefits associated with the novel hybrid contour include minimized cost of computation, enhanced anti-jamming capability, as well as enlarged utilization array of snake model.

Keywords: active contours models, Alpha Shape, automatic initialization, image segmentation, snake

1. Introduction

By definition, segmentation of images entails the identification and grouping together of features or regions sharing identical qualities. Segmentation exploits arithmetical categorization, threshold, detection of edges and regions, or a mixture of these approaches to resolve segmentation problems. These approaches range from edge-based, connectivity-based, threshold-based, to region-based (Pichumani, 1997). Region-based methods are dependent on general patterns in concentration values within a group of adjacent pixels. This group or cluster is identified as the region, while the objective of the segmentation technique mirrors grouping of regions, irrespective of their anatomical or functional roles. Threshold-based approach is highly dependent on the local pixel information. Its competence is witnessed when the object's intensity levels fall evenly outside the array of background levels. With the image's spatial information being overlooked, problems became evident at region boundaries that were blurred. Edge-based approaches are highly dependent on disruption in image values between different regions, while the purpose of the segmentation operation is to precisely identify the margin demarcating these regions. As for the connectivity-based approach, it is highly dependent on a curve identified as active contour created by various positions on the image. Deformable models (Terzopoulos, Witkin, & Kass, 1988), or active models (Kass, Witkin, & Terzopoulos, 1987), have been extensively employed in image segmentation (Gastaud, Fellow, Aubert, & Ý, 2004; Haud & Montanvert, 1999; McInerney & Terzopoulos, 1999; T. McInerney & Terzopoulos, 1995) as well as tracking of objects (Mansouri, Mukherjee, Member, & Acton, 2004; Paragios & Deriche, 2000; Ray, Acton, & Ley, 2002; Ray & Acton, 2004). Regardless of the various prevailing customized types of active models (Ootes, Aylor, Ooper, & Graham, 1995), the most extensively utilized models are inclusive of active surfaces and active contours (Kass et al., 1987; Terzopoulos et al., 1988). Collapsing of the active models occurs on the image domain to gain a preferred aspect by decreasing the energy operational subject to certain constrictions. The energy functional normally entails two conditions: an external energy that draws the elastic model to the interest features, as well as an internal energy model responsible for

limiting the model's rigidity and smoothness.

Back in 1987, Kass introduced active contour models identified as "Energy-Minimizing Curves" or "Snakes" (Kass et al., 1987). Nonetheless, there exist a number of considerations associated with it. To begin with, it is unable to detect high curvature edges in addition to an image's multi-objects. In addition, the position of the primary contour is needed to be adjacent to the edges; if not, there is a likelihood of arriving at erroneous results hence becoming a difficult undertaking. It was in 1997 that another approach was invented by Xu Chenyang and Prince, identified as Gradient Vector Flow (GVF) capable of broadening the dimension of the primary contour setting by efficiently broadening the GVF capturing force, hence being able to arrive to the U-shaped edges (Prince, 1997; Xu & Prince, 1998). This brings a solution to the traditional snake model's incapacity to converge to concavity, while the problems of the location of primary contours being next to the true edges. Nonetheless, active contour's capturing array is dependent on the level of GVF force field, normally arrived at by the quantity of GVF iterations. There exist a direct proportion between the number of GVF and computational cost, where several GVF iterations results in high computational cost. While computing for convergence, the active contour may be distant from the ideal edges, hence requiring additional convergence iterations. Regrettably, GVF force field entails points of local least amount of energy holding back the convergence of the initial contour.

Another fresh technique of contour, the commencement of GVF snake model was invented by Caixia L. (Caixia, Yanbin, & Houjun, 2006). Primarily, a theory of "Effective Area" was considered while "Multi-Scale Edge Detection" technique founded on wavelet transform was employed in acquiring edge points. Eventually, a connection of the edge positions on the interested region's outer layer and incessant initial contour was done. "Effective Area" is the set initial contour, in addition to being adjacent to the true contour, capable of extracting the objective contour besides minimizing the computational costs. Nonetheless, this technique also entails some setbacks. Primarily, it is only capable of exploring the edge points onward and it is unable to get rid of the hindrance caused by the burr noise. Additionally, the searching area of this method is uneven and it equally diverges from the bearing of ideal edges while identifying edge points. In the present study, we investigated an enhanced contour initialization procedure characterized with reversal of all benefits achieved in GVF Snake model and offered a solution to the two setbacks in the technique suggested by (Haud & Montanvert, 1999). Empirical trials reveal that the present approach is characterized with firm resistivity to noise, for instance, fake contours and strings, minimizing the time intricacy, effectively extracting intricate shapes and widening the utilization array greatly.

2. Original Snake Active Contour Model

2.1 Definition

Kass Witkin and Terzopoulos derived the inventive snake in 1987 (Kass et al., 1987). The term "Snake" was founded on the model's behavior on an image. As a way of lessening its energy, it slides on an image.

$$v(s) = [x(s), y(s)] \qquad s \in [0,1] \qquad \qquad (1)$$

As evident Equation (1) expresses a snake as a planar parametric curve. The considerations entail snake control points identified as "Snaxels". Such Snaxels are connected jointly to create an active contour as indicated in Figure 1 below. Arguably, the snake as a method cannot automatically be able to detect the margin of the anticipated object in an image. It needs suitable constraints, settings and primary locations of the "Snaxels" irrespective of the concerned margin. On such grounds, some prevailing information regarding the image under assessment is needed for the top level system.
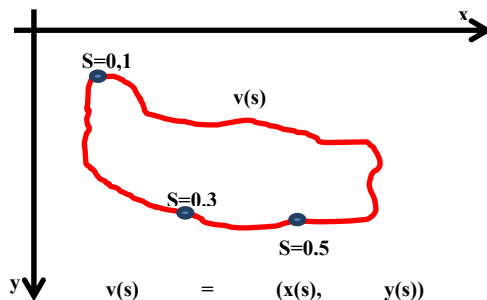

Figure 1. Parametric Curve (Al-Tamimi & Sulong, 2014)

Snake's energy function has been represented in Equation (1). With the snake being delineated as an energy decrement spline (Kass et al., 1987), it is able to achieve this by deforming itself, hence, having its energy minimized. The functionality of the energy is in a manner such that the snake arrives at the target's margin. Its behavior is identical to that of a rubber band situated outside an object, hence shirking to arrive at the target's boundary. The initial two phrases of the of snake's energy function stipulated in Equation (2) are identified as "Internal Energy". It is these forces that control the strain and inflexibility of snake model. External Energy is the other term of snake's energy function. It is a derivative of the image and it draws the snake to the target contour.

$$E_{snake} = \int_0^1 (\alpha . E_{elastic}(v(s)) + \beta . E_{bending}(v(s)) + \gamma . E_{image}(v(s)))ds \qquad (2)$$

2.2 Internal Energy

The subcomponents of the internal energy include "Bending Force" and "Elasticity Force". Therefore, internal energy is delineated as the summation of such forces with the energy function being articulated as:

$$E_{interal} = \left[\alpha(s) \left| \frac{dv(s)}{ds} \right|^2 + \beta(s) \left| \frac{dv(s)^2}{ds^2} \right|^2 \right]/2 \qquad (3)$$

Both the two contour's derivatives (first and second) delineate these energy terms and identified as "Elasticity Force" and "Bending Force", in that order. The snake's tension is controlled by the elastic force. It is able to minimize stretching of the active contour as well as being liable to shrink the contour (as shown in the red arrow of Figure 2 below). An excellent delineation of Bending Force has been termed as the "bending energy makes snake acts like a thin plate" (Kass et al., 1987). It is responsible to control the snake's rigidity. However, its control is limited to the curvature only, hence, excluding the contour's length. At its deformation procedure, a smooth curve or a straight line is maintained (Blue-dot arrow in Figure 2).
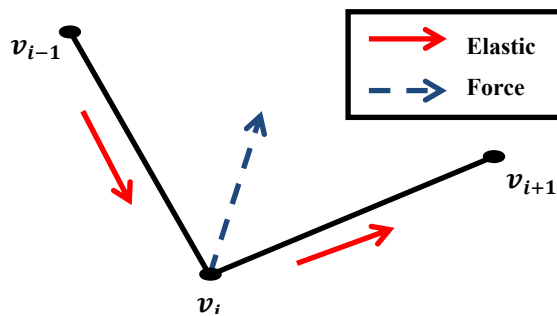

Figure 2. Internal energy (Al-Tamimi & Sulong, 2014)

Both $\alpha(s)$ and $\beta(s)$ parameters before each term delineates weighing functions. Generally, the weighing functions' values are constants for all snaxels. Considering an opposite set of such constants generates one of the setbacks in snake. These setbacks exhibit huge impacts on the behavior of the snake in addition to being totally in control of deformation process' performance. Every object within an image needs a different set of constant value in order to achieve excellent performance from the snake. One sure way of achieving a solution to this setback has enable the snake to vigorously alter these values to proper values within the process of deformation. Nonetheless, it is through a computer that topologies or shapes of an image object are automatically detected. Therefore, the way out is to consider future improvements of the snake. At present, these constraints are expected to be selected by the users during the initialization phase.

2.3 External Energy

The image data is employed in deriving external energy. The snake is drawn towards the target contour by the image-compelled force. The equations below aids in the definition of the energy term (Kass et al., 1987).

$$E_{external}(s) = -\gamma(s) . \left| \nabla(I(s)) \right|^2 \qquad (4)$$

$$E_{external}(s) = -\gamma(s) . |\nabla(G_\sigma(s) * I(s))|^2 \qquad (5)$$

∇ Denotes gradient operator while I(s) delineates the image's intensity at s. G(s), σ is Two-Dimensional (2D) Gaussian functions having a standard deviation of σ. Nonetheless, image force control is achieved by engaging the weighing function $\gamma(s)$. The snake's capture range is increased by the application of Gaussian filter to the inventive image. Blurring in images is an outcome of the application of Gaussian filters. The figure below (Figure 3) demonstrates a typical illustration of a blurring effect of an edge. The diffusion of the image force is from one edge (blue-dot line) to another edge (red lines). This result in the widening of the snake's capture array.
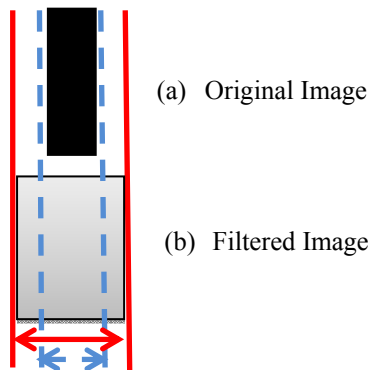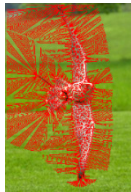

(a) Original Image

(b) Filtered Image
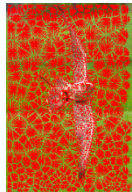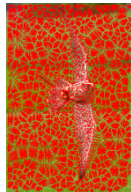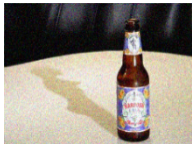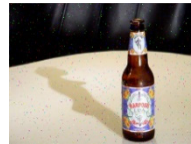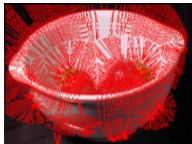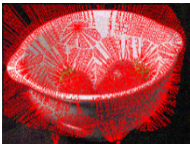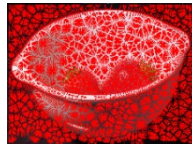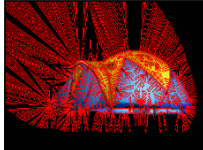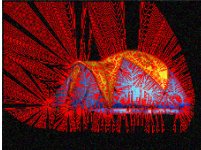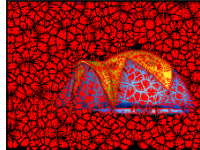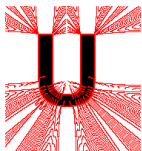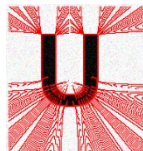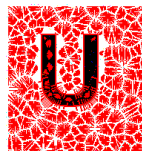
Figure 3. Image Force (Al-Tamimi & Sulong, 2014)

Normally, Equation (5) is employed in calculating the external force, given that the square of the gradient enormity of concentration itself entails a lesser capture array. In addition, the snake's capture array is highly dependent on the Standard Deviation (SD) σ. The outcome of larger SD is that the objects' margins tend to become blurry. This is occasionally vital in aiding an active contour to get drawn towards the anticipated boundary. In order to have snake's external force and GVF's sensitivity of the nose is evaluated (Xu & Prince, 2006), we incorporate impulse noise to the images and evaluate their GVF energy with the inventive image, hence endeavoring to realize the extent unto which noise can impact the GVF value as well as the active contour fragmentation algorithm. The nine images utilized have been illustrated in Table 1 together with their GVF energies as well as GVF energy computed from "Salt and Pepper Noise" and "Gaussian Noise".

Table 1. GVF energy calculated from nine original images and their "Salt and Pepper Noise" and "Gaussian Noise" images (Continue …)

Original Image	GVF Energy of original image	'Gaussian Noise'	GVF Energy of Gaussian Noise image	'Salt and Pepper Noise'	GVF Energy of Salt and Pepper Noise image

Table 2. GVF energy calculated from nine original images and their "Salt and Pepper Noise" and "Gaussian Noise" images.

Original Image	GVF Energy of original image	'Gaussian Noise'	GVF Energy of Gaussian Noise image	'Salt and Pepper Noise'	GVF Energy of Salt and Pepper Noise image

As shown in Table 1, the GVF snake offers excellent outcomes considering original images. However, becomes unable to arrive at the shape plus the object since it faces distractions from local impulse noise in "Salt and Pepper Noise" and "Gaussian Noise" images.
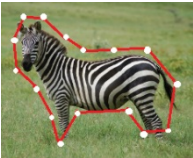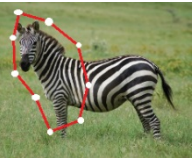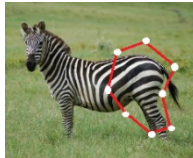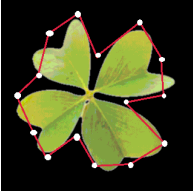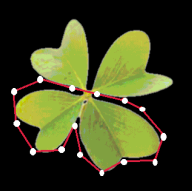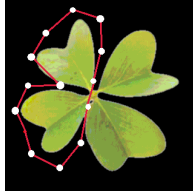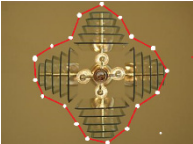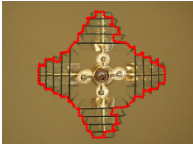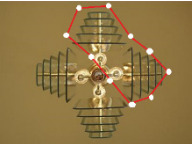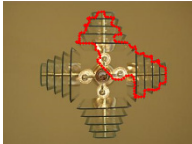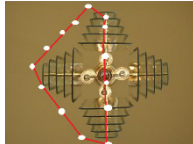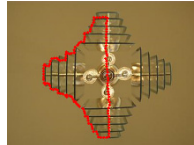
2.4 Snakes Algorithms

Several of the algorithms associated with active contour models entail the following three stages:

    a) **Initialization Process:** for the commencement process, the initial snaxels' locations around the target -object's boundary is set by the user. Concurrently, the considered set of weighing constraints includes α, β, and γ. Subsequently, it begins to deform itself towards the ideal margins of the object. It is vital that the first contour becomes situated adjacent to the subject boundary owing to the condition that the snake was capable of shifting towards the noises among other unwanted lines or edges on an image upon being situated at a distance from the ideal boundary.

Table 3 exemplifies the outcome of the inventive implementation of the active contour algorithm; three diverse initial contour assessments are depicted with their eventual smoothing to exemplify the significance of the snake's initial contour.

Table 3. Active contour segmentation result using three different initial contours (represented by red lines with white points)

	Test 1		Test 2		Test 3	
	Initial contour	Final snake	Initial contour	Final snake	Initial contour	Final snake

b) **Deformation Process:** at the deformation phase and procedure, the technique is able to deform itself as an approach of lessening the total energy terms stipulated in Equation 2, for the current process' iteration; a fresh location is searched among adjacent pixels in each snaxel. There are two options of snaxel, to either move towards a low-energy pixel or remain within the same location in case there exist none. There exist several methods to gauge new snaxels' locations.

Among the approaches employed in the realization of a fresh location for each snaxel is the "Greedy Algorithm", perceived being highly simple and unproblematic to be executed. At the iteration phase, the amount of external and internal energies is calculated at a snaxel as well as its adjacent 8 pixels.

The new location is arrived at by considering one with the least energy. For such reasons, the snaxel has the option of shifting to one of the 8 probable adjacent pixels; the red arrows illustrated in Figure 4 below, or equally remain in the same position if none of the energy is smaller compared to the current energy contained by the snaxel.
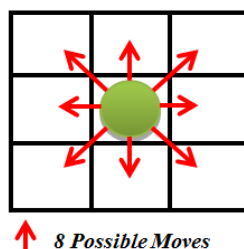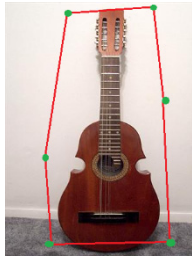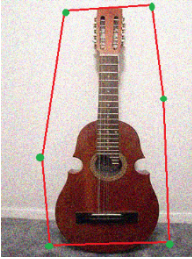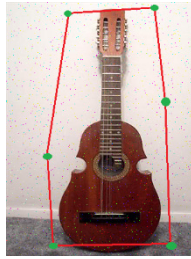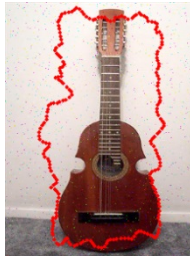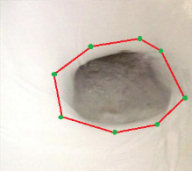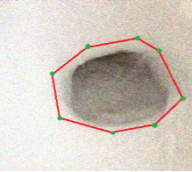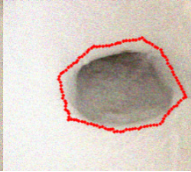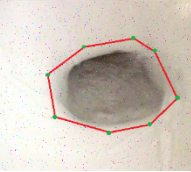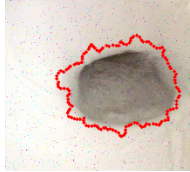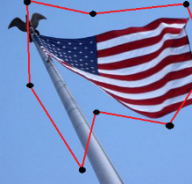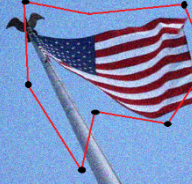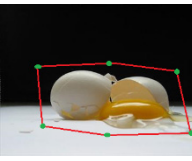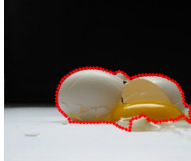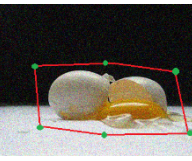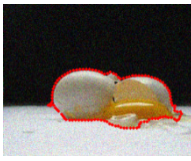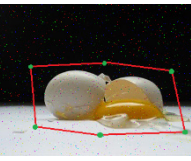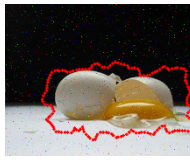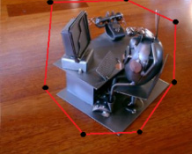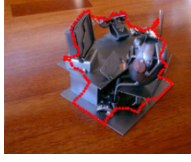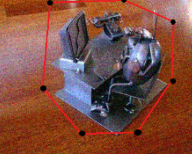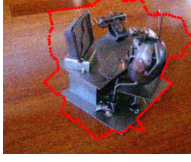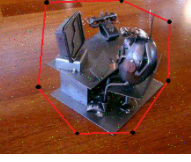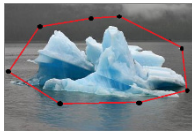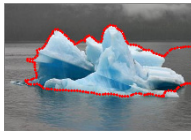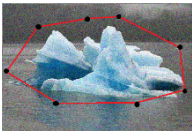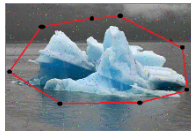
Figure 4. Greedy Algorithm for deformation process of active contour (Al-Tamimi & Sulong, 2014).

For the purposes of assessing the competence of GVF snake energy within the active contour's deformation technique, we experimented on the original snake by engaging two diverse images' impulse noises with the outcomes being assessed against those of the original images. Table 3 shows 6 noisy images degraded with a "Salt and Pepper Noise" and "Gaussian Noise" and experimented by use of the inventive snake algorithm.

Table 4. Six images segmented by original active contours using GVF energy model compare with images corrupted with a "Salt and Pepper Noise" and "Gaussian Noise".

Original image		Images corrupted by 'Gaussian noise'		Images corrupted by 'Salt and Pepper noise'	
Initial contour	Final snake	Initial contour	Final snake	Initial contour	Final snake

The process of deforming goes on up to a period when the snake is trapped in one of the lapsing techniques, the subsequent section offers a discussion of the termination processes.

C) Termination of the Snake: at some time instance, there is the need to impede the snake's deformation process.

As expected, the snake will end its deformation where the snaxels are unable to identify fresh locations in the adjacent pixels, or basically by arriving at zero and vanishes from the eight possible moves. Nonetheless, it has the option of shifting into a perpetuity loop upon oscillation or relocation along the margin by the snaxels. Based on this argument, there is the need to put in place a given technique for snake's termination. Setting a threshold on the utmost iteration quantity implemented in the deformation technique should be considered as the simplest approach.

This is an assurance that the snake is ceased and it does not shift into an infinity loop. Although it is important to note that it is highly important that the user sets the correct amount of iterations before commencing the deformation procedure. Due to the fact that the rate of iterations is variant and dependent on the object's size and shape, it is highly intricate to approximate the number of iterations required to identify the subject contour. Due to this, termination of the snake would take place prior to its destination or close to the true margin upon setting the least number of utmost iterations. Another technique is by having the threshold set respective of the rate of snaxels shifted among the iterations. For example, having the threshold set at 90 percent of the snaxels' summation would be a typical illustration. This means that the termination of deformation by the snake will occur when 90 percent of snaxels are unmoved. By so doing, the threshold is independent of the size and shape of the target object. Subsequently, the user is not expected to alter the iteration quantity on every target object.

Nonetheless, none of the terminating methods would be valuable since it is, at times, witnessed that the snaxels tend to move along the boundary, while the contour simply shifts very slightly (Choi, Lam, Siu, & Ic, 2001). For the purposes of prevailing over this setback, different approaches of automated implementations have been suggested. These initialization approaches have been engaged for diverse forms of images such as MR images, human face, as well as the heart's ultrasound images (Codon & Fristot, 1999; Jia Liang, Ding, & Wu, 2008; Pluempitiwiriyawej & Sotthivirat, 2005; Tauber, Batatia, & Ayache, 2005) plus the abdomen Computed Tomography (CT) images (Shen & Kassim, 2007). These techniques equally entail the demerits of having increased computational expenses, being employed in certain images types, as well as not being able to multitask while processing objects (Shen & Kassim, 2007; Tauber et al., 2005). In the present paper, we suggested and proposed α-Shape theory to employ in the extraction of the initial contour later refined by engaging a conventional active contour model.

3. Improved Contour Initialization Algorithm

In diverse situations, the contours of the concerned areas exhibit edge aspects, in addition to the existance of noise, for instance burr noise and Interferential points. Therefore, if the technique is capable of prevailing over the noise, setting of the initial contour can be done next to the ideal contour. In the present paper, we initially engage multi-random initialization founded on active counter to acquire edge points in the concerned areas. Subsequently, the tasks entailed progression of the technique using α-Shape supposed to prevent the setback of noise space and multi-objects, while eventually employing α-Shape point as the primary seed point for the primary contour to be employed in snake technique (Active Contour). Figure 5 has offered a summary of the proposed algorithm flowchart.
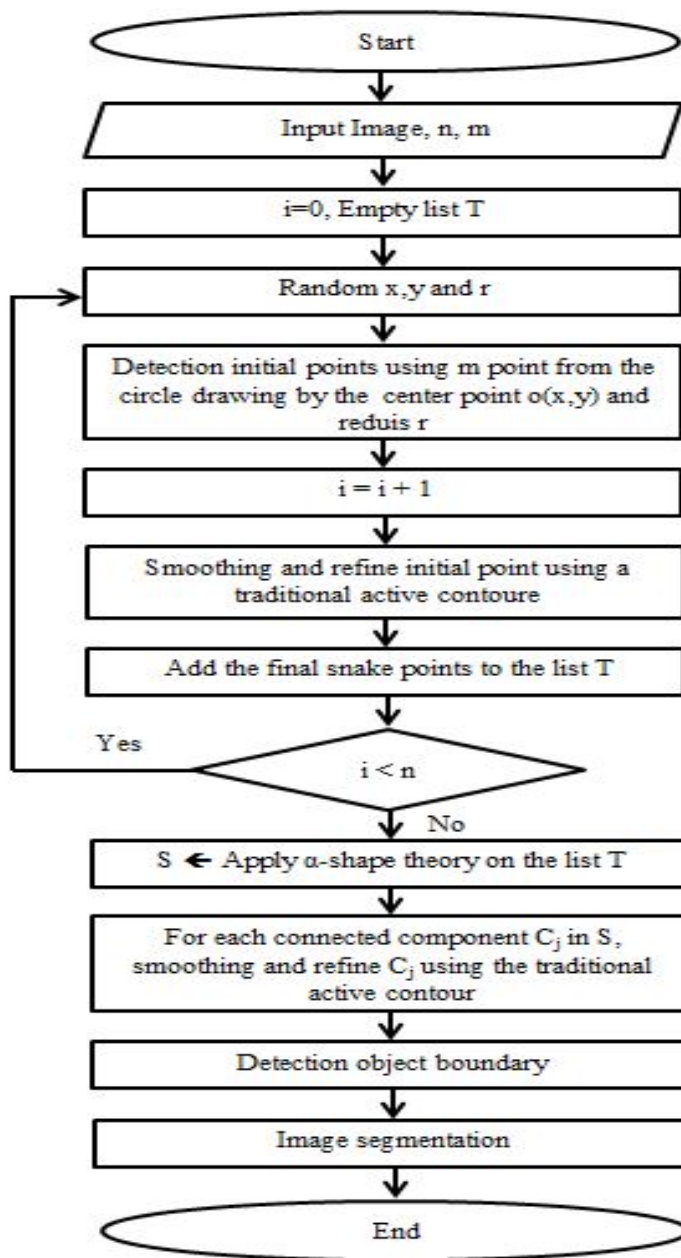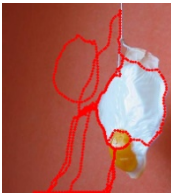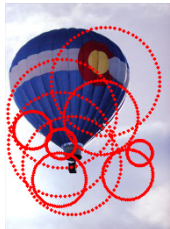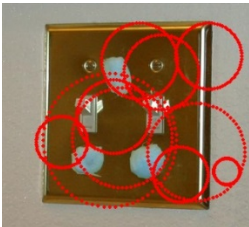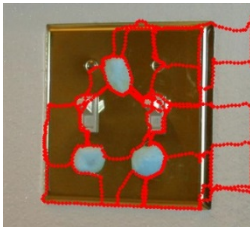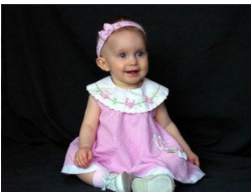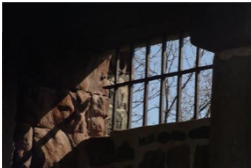
Figure 5. Flowchart of the proposed hybrid algorithm method

3.1 Multi Random Initialization Based on Active Contour

Since the adapted active contour segmentation technique is founded on curve development, we employ a circle as the first curve whose radius and center require random setting. Acquisition of edge points of concerned areas is the primary approach in the suggested method. We engage multi-random commencement founded on an active contour to detect and get rid of this point. For this phase, we identify the active contour algorithm "n" time (in the present study n=10) by engaging three random values x, y, and r in each time, to denote "Horizontal Coordinate" and "Vertical Coordinate" of the circle center and circle radius in that order. By engaging N first contours in an active contour replica, we obtained an N point list to denote "n" snakes as the edge points of concerned areas. Table 4 below denotes five-colour images availed in the outcome of this phase, while Algorithm 1 illustrates the pseudo code of this phase.

Table 5. Result of multi random initialization based on active contour

Original image	Initial 10 contours	Snakes calculated from 10 initial contours.

```
Algorithm 1: Multi Random Initialization
 1  Function Rotation(P0,P1:Tpoint;Alpha:real) : Tpoint is
 2      P:Tpoint;
 3      S,C:real;
 4      S ← sin(Alpha);
 5      C ← cos(Alpha);
 6      P.x ← ((P1.x -P0.x)*C) - ((P1.y- P0.y)*S) + P0.x;
 7      P.y ← ((P1.x -P0.x)*S) + ((P1.y- P0.y)*C) + P0.y;
 8      return P
 9  end
10  x ← random(image.height);
11  y ← random(image.width);
12  r ← random(min(image.height,image.width));
13  P0.x=x;
14  P0.y=y;
15  P.x=x;
16  P.y=y-r;
17  Alpha ← 10 * π / 180 ;
18  S ← Alpha ;
19  Add point p to result Point;
20  while  S < 360 do
21      PN ← Rotation(P0,P,S) ;
22      Add point PN to result Point;
23      S ← S + Alpha;
24  end
```

3.2 Alpha Shape (α-Shape)

α-Shape (commonly identified as Alpha Shape), is a class of piecewise linear plain curves in the Euclidean Plane linked with the shape of a limited points set within computational geometry (Al-Tamimi, Sulong, & Lut, 2015). Edelsbrunner, Kirkpatrick and Seidel (H. Edelsbrunner, Kirkpatrick, & Seidel, 1983; Herbert Edelsbrunner, 2010) were the first scholars to define α-Shape. The present study discusses α-Shape in a detailed approach as they are the study's basic tool for the hybrid algorithm. α-Shape have not been overtly employed in motion planning, regardless of being highly utilized in chemistry, biology and geometry as a universal purpose topological and geometric modeling tool. The concept of α-Shape is an officiated approach of the instinctive perception of "shape" for spatial point sets. This is arguably contrary to other techniques, just like in surfaces and obtainable surface area, typically estimating and reliant upon several meagerly delineated variables.

Hitherto, α-Shape has been engaged in several varied fields. The apparition of associations among data points in both Three Dimensional (3D) and Two Dimensional (2D) is frequently an initial phase of statistical implication. α-Shape have been utilized in the visualization of asymmetrical shape margins of 3D clusters (Lucieer & Kraak, 2004). Further scholars (Moran & Wagner, 1994) engaged α-Shape in characterizing and envisaging a number of simple Brownian motion paths qualities and realized that α-Shape are very efficient tools used in gauging a diffusing particle's   mass. Arguably, a typical use of α-Shape as delineated by several researchers is as a method for enhancing surface renovation from finitely trialed points (Giesen, Cazals, Pauly, & Zomorodian, 2006; Guo, Menon, & Willette, 1997; Park, Lee, & Kim, 2005; Teichmann & Capps, 1998). Within the area of solid mechanics, α-Shape have been engaged in enhancing the interpolation of surface via preventing linear disarticulation fields along convex margins (Teichmann & Capps, 1998).

α-Shape equally offer highly precise linear interpolation over non-convex margins (Cueto, Doblare, & Gracia, 2000). Lately, within the field of image segmentation, boundaries reconstruction from non-optimal or noisy image segmentation has been efficient, courtesy of α-Shape (Meine, Köthe, & Stelldinger, 2009). By considering trials within atomic levels, Zomorodian and colleagues (Zomorodian, Guibas, & Koehl, 2006) employed α-Shape in an attempt to enhance prediction of protein structure with statistical capabilities. These techniques are practically costly owing to huge number of atomic interfaces, as well as α-Shape being engaged to filter the list of   protein's interrelating atoms (Rohs et al., 2009; Rother, Hildebrand, Goede, Gruening, & Preissner, 2009; W. Zhou, Yan, & Hao, 2012; W. Zhou & Yan, 2010; Weiqiang Zhou & Yan, 2010, 2014). In addition, α-Shape have equally been engaged in studying structures in proteins (Cheng & Shi, 2009; De-Alarcón, Pascual-Montano, Gupta, & Carazo, 2002; Pérot, Sperandio, Miteva, Camproux, & Villoutreix, 2010; Rohs et al., 2009; Wilson, Bender, Kaya, & Clemons, 2009), surface area and volume (J Liang, Edelsbrunner, Fu, Sudhakar, & Subramaniam, 1998; Lou, Jiang, Scott, & Paul, 2013; Nikkilä, Polishchuk, & Krasnoshchekov, 2014; Pesaresi & Schwingshackl, 2014), pockets (H Edelsbrunner, Facello, & Liang, 1998; J Liang et al., 1998), as well as

packing (J Liang & Dill, 2001). With reference to existing literature characterizing voids, irregular pockets, and depressions (J Liang & Dill, 2001), Liang and colleagues (W. Zhou & Yan, 2010) assessed the idea of protein packing. They realized a huge resemblance between packed spheres and proteins as compared to that of jig-saw puzzle. They equally found out that protein voids and cavities highly contributed to non-homogenous densities. In addition, by considering proteins of different sizes, the researchers found out how larger proteins are less dense compared to smaller proteins. Therefore, the α-Shape affiliated with several points is a simplification of the notion of the convex hull, that is, each of the convex hulls is a α-Shape, but not every α-Shape is a convex hull
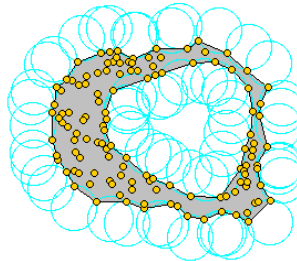
Figure 6. α-Shape representation for set of points (Al-Tamimi et al., 2015)

By taking into assumption that provision of 2D points S set is done, there is the need to have an outcome such as "the shape created by these points." By itself, this idea is highly vague with a probability of several likely interpretations, with α-Shape being amongst them. α-Shape are capable of being utilized in reconstructing shapes by engaging a dense unorganized dataset points. Actually, an α-Shape is segregated by a frontier, identified as a linear estimation of the inventive shape (Bernardini & Bajaj, 1997).
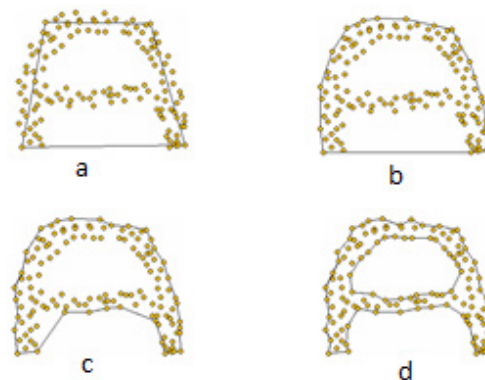
Figure 7. Identical set of point and four different frontiers, (a) Linear frontier, (b) Convex hull, (c) Concave hull, and (d) α-Shape (Al-Tamimi et al., 2015)

As stipulated in a study by Edelsbrunner (Herbert Edelsbrunner & Mucke, 1994),the approach delineates a category of shapes, known as α-Shape for any provided point set. It enhances accurate, swift and efficient volume and surface area computation.

- α-Shape are simplification of the convex hull. Taking into consideration a set point, S.
- For α = infinity, then, α-Shape is convex to hull of S.
- In case α is lesser than half the smallest distance amid two points in S, the α-Shape is S itself.

For any α in the middle, it would be perceived that α-hull is the largest polygon (polyhedron) or equally a set with vertices being in point set while edges entail a length not beyond 2α. Edge presence is indicative of a radius; α probe is not able to pass between the endpoints of the edges.
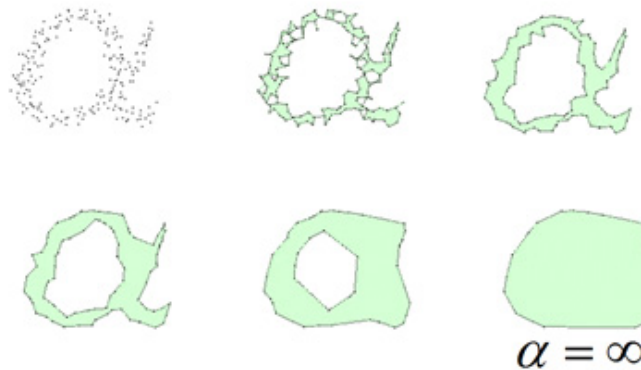
Figure 8. α control the desired level of detail in α-Shape theory (Al-Tamimi et al., 2015)

3.3 Computing the α-Shape Using Delaunay Triangulation

In computational geometry, α-Shape computation is arguably the most aptly assessed problems based on Delaunay Triangulation (DT) (O'rourke & Joseph, 1994). There is a DT for each point sets in 2D. It is highly unique provided co-circular is not met in the four points set, since it lessens the small angles and circumscribed circles. To have the algorithm implemented, there the need to consider the functions below, the primary one is to locate the closest point, as delineated in Algorithm 2.

Algorithm 2: Nearest Neighbor Algorithm

1   **Function** $Distance2Point(P1,P2:Tpoint) : real$ **is**
2   D:real;
3    $D \leftarrow \sqrt{(P1.x - P2.x)^2 + (P1.y - P2.y)^2}$;
4   return D;
5   **end**
6   **Function** $nearest\text{-}neighbor(i:int) : int$ **is**
7   D,Dmin:real;
8   j,Imin:int;
9    $Dmin \leftarrow 99999$;
10   **forall the** $Point\ List[j]\ in\ List$ **do**
11     $D \leftarrow Distance2Point(List[i],List[j])$;
12   **if** $D < Dmin$ **then**
13      $Dmin \leftarrow D$;
14      $Imin \leftarrow j$;
15   **end**
16   **end**
17   return Dmin;
18 **end**

Algorithm 3 shown above return the point vsd such as the triangle, j, vsd is DT, and the point vsd is en right of the line ij, the algorithm return (-1) if we don't find this point.

Algorithm 3: Right Next Neighbor Algorithm

---
1 **Function** *Right-next-neighbor(i,j:int) : int* **is**
2   k,v1x,v1y,v2x,v2y,neighbor-Number:int;
3   ProdScal,diski,diskj,det,coskij:real;
4   cosmin ← 1 ;
5   neighbor-Number ← -1;
6   **forall the** *Point [k] in List* $k \neq i$ *and* $k \neq j$ **do**
7   v1x ← List[j].x-List[i].x;v2x ← List[k].x-List[i].x;
8   v1y ← List[j].y-List[i].y;v2y ← List[k].y-List[i].y;
9   det ← v1x * v2y -v1y * v2x ;
10   **if** *det < 0* **then**
11   diski ← Distance2Point(List[k],List[i]);
12   diskj ← Distance2Point(List[k],List[j]);
13   ProdScal ← v1x * v2y + v1y * v2x ;
14   coskij ← $ProdScal/(diski*diskj)$;
15   **if** *coskij < cosmin* **then**
16   cosmin ← coskij ;
17   neighbor-Number ← k ;
18   **end**
19   **end**
20   **end**
21   return neighbor-Number;
22 **end**

The same algorithm we need to implement to find the point vsg such as the triangle i, j, vsg is DT, and the point vsg is en left of the line ij as shown in Algorithm 4:

Algorithm 4: Left Next Neighbor Algorithm

---
1 **Function** *Left-next-neighbor(i,j:int) : int* **is**
2   k,v1x,v1y,v2x,v2y,neighbor-Number:int;
3   ProdScal,diski,diskj,det,coskij:real;
4   cosmin ← 1 ;
5   neighbor-Number ← -1;
6   **forall the** *Point [k] in List* $k \neq i$ *and* $k \neq j$ **do**
7   v1x ← List[j].x-List[i].x;v2x ← List[k].x-List[i].x;
8   v1y ← List[j].y-List[i].y;v2y ← List[k].y-List[i].y;
9   det ← v1x * v2y -v1y * v2x ;
10   **if** *det > 0* **then**
11   diski ← Distance2Point(List[k],List[i]);
12   diskj ← Distance2Point(List[k],List[j]);
13   ProdScal ← v1x * v2y + v1y * v2x ;
14   coskij ← $ProdScal/(diski*diskj)$;
15   **if** *coskij < cosmin* **then**
16   cosmin ← coskij ;
17   neighbor-Number ← k ;
18   **end**
19   **end**
20   **end**
21   return neighbor-Number;
22 **end**

Algorithm 5 shown down resume all the steps need to calculate the DT:

Algorithm 5: Delaunay Triangulation Algorithm

---

1   Given a set of point List;
     Result: Delaunay triangles neighbor from List
2   **forall the** *Point[i] in List* **do**
3   ppv ← nearest-neighbor(i) ;
4   neighbor[i][0] ← ppv ;
5   length[i] ← 1 ;
6   kk ← 0 ;
7   **repeat**
8   vsd ← Right-next-neighbor(i,neighbor[i][kk]);
9   length[i] ← length[i] + 1 ;
10   neighbor[i][kk+1] ← vsd ;
11   kk ← kk+1 ;
12   **until** *vsd = ppv OR vsd = -1*;
13   **if** *vsd = -1* **then**
14   **repeat**
15   vsg ← Left-next-neighbor(i,neighbor[i][0]);
16   **if** *vsg ≠ -1* **then**
17   **for** *kkk = length[i]-1;* **do** kkk >= 0
18   neighbor[i][kkk+1] ← neighbor[i][kkk];
19   kkk ← kkk -1 ;
20   **end**
21   neighbor[i][0] ← vsg ;
22   length[i] ← length[i] + 1 ;
23   **end**
24   **until** *vsg = -1*;
25   **end**
26 **end**

With a point set S provided, DT (S) becomes the DT in a way that no S point is contained in the circumsphere of any d-simplexes σ_T with T ⊆ S. The association between α-Shape and DT is that α-Shape S boundary and DT subset of S, typically identified as α S ⊆ DT(S). The following are the key procedures to follow while constructing the α-Shape of S: (1) Construct DT, (2) Determine the α-extreme points of S, (3) Determine the α-neighbors of S, (4) Output the α-Shape.

Algorithm 6 delineates the shape computation engaging DT, and Table 5 portrays the α-Shape algorithm used on diverse colour images using the set of point calculated by step one of our algorithm.

Algorithm 6: α-Shape Algorithm

---

1   Given a set of point S;
2   Given radius α; Computes two lists σ_{reg},σ_{sing} of the regular facets
     and the singular facets of the boundary of the α-shape
3   σ_{k+1} ← $DelaunayTri(S)$;
4   i ← 1
5   j ← 1
6   **forall the** *elements of σ_k* **do**
7   r ← CircumSphere(σ_{k+1})
8   **if** $r < \alpha$ **then**
9   **if** *Unique(σ_k)* **then**
10   σ_{reg}(i) ← σ_k
11   i ← i + 1
12   **end**
13   **end**
14   r ← SmallCircumSphere(σ_{k+1})
15   **if** $r < \alpha$ **then**
16   **if** *IsSphereEmpty(σ_k)* **then**
17   σ_{sing}(i) ← σ_k
18   j ← j + 1
19   **end**
20   **end**
21 **end**
22 return (σ_{reg},σ_{sing})

Table 6. α-Shape algorithm applied on different colour images using the set of point calculated by step of our algorithm **(Continue …)**
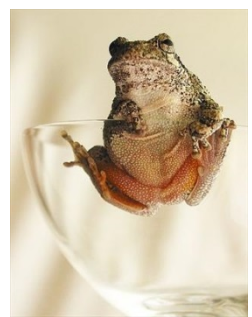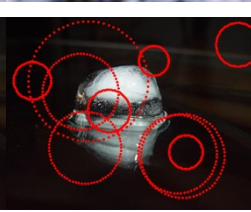
Original image	Initial 10 random contours	Refine the initial contours	Remove Point with Energy 0	Set of point α-Shape

Table 7. α-Shape algorithm applied on different colour images using the set of point calculated by step of our algorithm

Original image	Initial 10 random contours	Refine the initial contours	Remove Point with Energy 0	Set of point α-Shape

By considering Table 5, it is evident that the α-Shape algorithm enhanced the initial contour and facilitated the key point to be engaged in the initialization algorithm of active contour. Furthermore, additional benefits of engaging α-Shape cab are evident in case more than a single object is present in the image, employing the merged component algorithm, this has been deeply delineated in the subsequent section.

3.4 Hybrid Algorithm

Upon obtaining the α-Shape contour, there is the need to have the contour refined to enable it the nearly entire segmentation engaged as template contour image segmentation. There is the need to identify the perfusion location in the opted image. Employing the attached object algorithm (Algorithm 7) is capable of detecting multi-object in identical picture, with demarcation of α-shape being done by a frontier of every isolated object. Eventually, for every identified object in the preceding step, each isolated object's frontier is set as the initial contour later refined by engaging the active contour algorithm, employed as template contour image segmentation.

Algorithm 7: The Connected Object Algorithm

1　Given a set of point S;
2　Given radius α;
　　Result: connected Object extracted from S
3　Open =set of all point in S
4　**while** *open is not empty* **do**
5　　SG=$\oslash$
6　　X=first point in open
7　　Put X in SG
8　　Remove X from open
9　　Put all point with distance $< \alpha$ to X in SG
10　　Remove them from open
11　　For each point Y with distance $< \alpha$ to x in SG and remove them from open
12　　write SG
13　end

---

4. Result and Discussion

This section offers the likelihood of the use of the suggested hybrid approaches on ideal images. The trial was conducted in Delphi 7.0 by engaging prevailing natural images accessible at the segmentation evaluation database (Alpert, Galun, Brandt, & Basri, 2012), we conducted our algorithm for the images and assessed the suggest approach. The visual assessment done for the data set segmentation was excellent and offered positive outcome. Table 6 below shows the outcome of segmentation concerning 32 images.

Table 8. Segmentation Results of 32 Randomly Selected Images with one and two objects (Continue …)

RGB image	Segmentation	RGB image	Segmentation

Table 9. Segmentation Results of 32 Randomly Selected Images with one and two objects **(Continue …)**
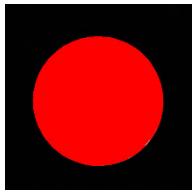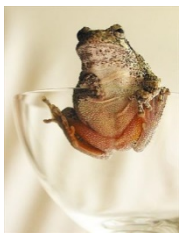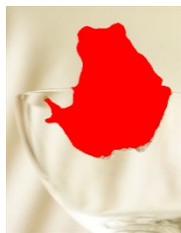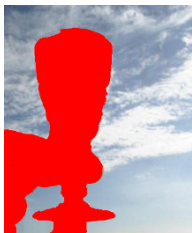
RGB image	Segmentation	RGB image	Segmentation

Table 10. Segmentation Results of 32 Randomly Selected Images with one and two objects **(Continue …)**
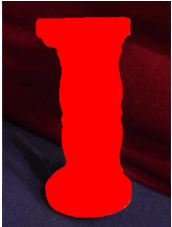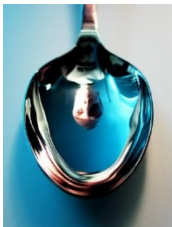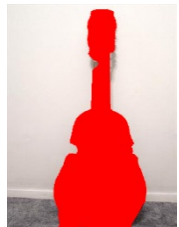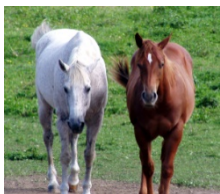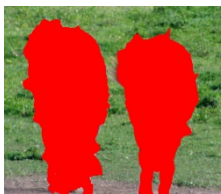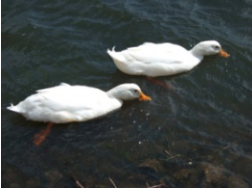
RGB image	Segmentation	RGB image	Segmentation

Table 11. Segmentation Results of 32 Randomly Selected Images with one and two objects

RGB image	Segmentation	RGB image	Segmentation

For the outcome, the edge term never highly impacted the image segmentation. The technique could engage textual image statistics instead of conjunction with intensity statistics. Nonetheless, integrating intricate region statistics is capable of exhibiting negative influence on the general algorithm's computational cost.

5. Conclusions

This paper has introduced and discussed a hybrid technique for image segmentation founded on α-Shape and active contour model. With reference to the mean curvature motion of the guardian vector flow and edge attraction term, the hybrid approach precisely and effectively segmented the natural images. The outcome of the study was highly promising. The type of statistics that could be integrated in the algorithm's region portion as well as the litheness of the parameter setting's approach could highly consider images segmentation with sharp intensity ingredients within areas of interest or weak edges in intensity homogeneity regions. The study proposes that in future there should be an experiment on other area statistics for segmentation and enhances the approach to multispectral images.

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References

Alpert, S., Galun, M., Brandt, A., & Basri, R. (2012). Image Segmentation by Probabilistic Bottom-Up Aggregation and Cue Integration. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, *34*(2), 315–326. http://dx.doi.org/10.1109/TPAMI.2011.130

Al-Tamimi, M. S. H., & Sulong, G. (2014). A Review of Snake Models in Medical MR Image Segmentation. *Jurnal Teknologi*, *2*(1), 101–106.

Al-Tamimi, M. S. H., Sulong, G., & Lut, I. (2015). Alpha Shape Theory for 3D Visualization and Volumetric Measurement of Brain Tumor Progression Using Magnetic Resonance Images. *Magnetic Resonance Imaging*, *33*, 787–803. http://dx.doi.org/10.1016/j.mri.2015.03.008

Bernardini, F., & Bajaj, C. L. (1997). Sampling and Reconstructing Manifolds Using Alpha-Shapes. *Purdue E-Pubs, a Service of the Purdue University Libraries*, 1–11.

Caixia, L., Yanbin, F., & Houjun, Y. (2006). A New Algorithm of Contour Initialization in GVF Snake Model. *Computer Application*, *26*(7), 1614–1616.

Cheng, H. L., & Shi, X. (2009). Quality Mesh Generation for Molecular Skin Surfaces Using Restricted Union of Balls. *Computational Geometry*, *42*(3), 196–206. http://dx.doi.org/10.1016/j.comgeo.2008.10.001

Choi, W., Lam, K., Siu, W., & Ic, Q. L. (2001). An Adaptive Active Contour Model for Highly Irregular Boundaries. *Pattern Recognition Society*, *34*(2), 323–331.

Codon, P. D. P. Y., & Fristot, V. (1999). Automatic Snakes for Robust Lip Boundaries Extraction. In *In Acoustics, Speech, and Signal Processing, 1999. Proceedings., 1999 IEEE International Conference* (Vol. 6, pp. 3069–3072).

Cueto, E., Doblare, M., & Gracia, L. (2000). Imposing Essential Boundary Conditions in the Natural Element Method by Means of Density-Scaled Alpha-Shapes. *International Journal for Numerical Methods in Engineering*, *49*(4), 519–546.

De-Alarcón, P. A, Pascual-Montano, A., Gupta, A., & Carazo, J. M. (2002). Modeling Shape and Topology of Low-Resolution Density Maps of Biological Macromolecules. *Biophysical Journal*, *83*(2), 619–632. http://dx.doi.org/10.1016/S0006-3495(02)75196-5

Edelsbrunner, H. (2010). Alpha Shapes - a Survey. *Tessellations in the Sciences*, 1–25.

Edelsbrunner, H., Facello, M., & Liang, J. (1998). On the Definition and the Construction of Pockets in Macromolecules. *Discrete Applied Mathematics*, *88*(1), 83–102. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/9390238

Edelsbrunner, H., Kirkpatrick, D., & Seidel, R. (1983). On the Shape of a Set of Points in the Plane. *IEEE Transactions on Information Theory*, *29*(4), 551–559. http://dx.doi.org/10.1109/TIT.1983.1056714

Edelsbrunner, H., & Mucke, E. P. (1994). Three-Dimensional Alpha Shapes. *ACM Transactions on Graphics (TOG)*, *13*(1), 43–72.

Gastaud, M., Fellow, M. B., Aubert, G., & Ý, Ü. Ý. Ü. (2004). Combining Shape Prior and Statistical Features For Active Contour Segmentation. *Circuits and Systems for Video Technology, IEEE Transactions*, 2–10.

Giesen, J., Cazals, F., Pauly, M., & Zomorodian, A. (2006). The Conformal Alpha Shape Filtration. *The Visual Computer*, *22*(8), 531–540. http://dx.doi.org/10.1007/s00371-006-0027-1

Guo, B., Menon, J., & Willette, B. (1997). Surface Reconstruction Using Alpha Shapes. *Computer Graphics Forum*, *16*(4), 177–190. http://dx.doi.org/10.1111/1467-8659.00178

Haud, J.-O. L., & Montanvert, A. (1999). Deformable Meshes With Automated Topology Changes for Coarse-to-Fine Three - Dimensional Surface Extraction. *Med. Image Anal.*, *3*, 187–207.

Kass, M., Witkin, A., & Terzopoulos, D. (1987). Snakes : Active Contour Models. *International Journal of Computer Vision*, *1*(14), 321–331.

Liang, J., & Dill, K. A. (2001). Are Proteins Well-Packed ? *Biophysical Journal*, *81*(2), 751–766. http://dx.doi.org/10.1016/S0006-3495(01)75739-6

Liang, J., Ding, G., & Wu, Y. (2008). Segmentation of the Left Ventricle from Cardiac MR Images Based on Radial GVF Snake. In *In BioMedical Engineering and Informatics, 2008. BMEI 2008. International Conference* (Vol. 2, pp. 238–242). IEEE. http://dx.doi.org/10.1109/BMEI.2008.188

Liang, J., Edelsbrunner, H., Fu, P., Sudhakar, P. V., & Subramaniam, S. (1998). Analytical Shape Computation of Macromolecules: I. Molecular Area and Volume Through Alpha Shape. *Proteins Structure Function and Genetics*, *33*(1), 1–17. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/9741840

Lou, S., Jiang, X., Scott, P. J., & Paul, J. (2013). Application of the Morphological Alpha Shape Method to the Extraction of Topographical Features from Engineering Surfaces. *Measurement*, *46*(2), 1002–1008.

Lucieer, A., & Kraak, M. (2004). α -Shapes for Visualizing Irregular Shaped Class Clusters in 3D. *Electronic Imaging 2004. International Society for Optics and Photonics,* 201–211.

Mansouri, A., Mukherjee, D. P., Member, S., & Acton, S. T. (2004). Constraining Active Contour Evolution Via Lie Groups of Transformation. *Image Processing, IEEE Transactions*, *13*(6), 853–863.

McInerney, T., & Terzopoulos, D. (1999). Topology Adaptive Deformable Surfaces for Medical Image Volume Segmentation. *IEEE Transactions on Medical Imaging*, *18*(10), 840–850. http://dx.doi.org/10.1109/42.811261

Meine, H., Köthe, U., & Stelldinger, P. (2009). A Topological Sampling Theorem for Robust Boundary Reconstruction and Image Segmentation. *Discrete Applied Mathematics*, *157*(3), 524–541. http://dx.doi.org/10.1016/j.dam.2008.05.031

Moran, P. J., & Wagner, M. (1994). Introducing Alpha Shapes for the Analysis of Path Integral Monte Carlo Results. In *Visualization'94, Proceedings., IEEE Conference on. IEEE* (pp. 52–59). IEEE Comput. Soc. Press. http://dx.doi.org/10.1109/VISUAL.1994.346337

Nikkilä, M., Polishchuk, V., & Krasnoshchekov, D. (2014). Robust Estimation of Seismic Coda Shape. *Geophysical Journal International, ggu002*, 1–18.

O'rourke, & Joseph. (1994). Computational Geometry Column 22. *International Journal of Computational Geometry & Applications*, *4*(01), 119–122.

Ootes, T. F. C., Aylor, C. J. T., Ooper, D. H. C., & Graham, J. (1995). Active Shape Models-Their Training and Application. *Computer Vision and Image Understanding*, *61*(1), 38–59.

Paragios, N., & Deriche, R. (2000). Geodesic Active Contours and Level Sets for the Detection and Tracking of Moving Objects. *Pattern Analysis and Machine Intelligence, IEEE Transactions*, *22*(3), 266–280. Retrieved

from http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=841758&tag=1

Park, S. H., Lee, S. S., & Kim, J. H. (2005). A Surface Reconstruction Algorithm Using Weighted Alpha Shapes. *In Fuzzy Systems and Knowledge Discovery. Springer Berlin Heidelberg*, 1141–1150.

Pérot, S., Sperandio, O., Miteva, M. A., Camproux, A. C., & Villoutreix, B. O. (2010). Druggable Pockets and Binding Site Centric Chemical Space: A Paradigm Shift in Drug Discovery. *Drug Discovery Today*, *15*(15), 656–667.

Pesaresi, L., & Schwingshackl, C. W. (2014). Automated Measurement Grid Generation for Scanning Laser Doppler Vibrometers. *Topics in Modal Analysis, Springer New York*, 7, 645–653.

Pichumani, R. (1997). Survey of Current Techniques. Retrieved from http://homepages.inf.ed.ac.uk/rbf/CVonline/LOCAL_COPIES/RAMANI1/node17.html

Pluempitiwiriyawej, C., & Sotthivirat, S. (2005). Active Contours With Automatic Initialization for Myocardial Perfusion Analysis. In *Conference proceedings : Annual International Conference of the IEEE Engineering in Medicine and Biology Society* (Vol. 3, pp. 3332–3335). http://dx.doi.org/10.1109/IEMBS.2005.1617190

Prince, J. L. (1997). Gradient Vector Flow: A New External Force for Snakes. In *Computer Vision and Pattern Recognition, 1997. Proceedings., 1997 IEEE Computer Society Conference on. IEEE* (pp. 66–71). IEEE Comput. Soc. http://dx.doi.org/10.1109/CVPR.1997.609299

Ray, N., & Acton, S. T. (2004). Motion Gradient Vector Flow: an External Force for Tracking Rolling Leukocytes With Shape and Size Constrained Active Contours. *IEEE Transactions on Medical Imaging*, *23*(12), 1466–1478. http://dx.doi.org/10.1109/TMI.2004.835603

Ray, N., Acton, S. T., & Ley, K. (2002). Tracking Leukocytes in Vivo With Shape and Size Constrained Active Contours. *IEEE Transactions on Medical Imaging*, *21*(10), 1222–1235. http://dx.doi.org/10.1109/TMI.2002.806291

Rohs, R., West, S. M., Sosinsky, A., Liu, P., Mann, R. S., & Honig, B. (2009). The Role of DNA Shape in Protein - DNA Recognition. *Nature*, 1248–1253.

Rother, K., Hildebrand, P. W., Goede, A., Gruening, B., & Preissner, R. (2009). Voronoia: Analyzing Packing in Protein Structures. *Nucleic Acids Research*, *37*, D393–D395. http://dx.doi.org/10.1093/nar/gkn769

Shen, W., & Kassim, A. A. (2007). A New Scheme for Automatic Initialization of Deformable Models. In *Image Processing, 2007. ICIP 2007. IEEE International Conference* (pp. 289–292).

T. McInerney, & Terzopoulos, D. (1995). A Dynamic Finite Element Surface Model for Segmentation and Tracking in Multidimensional Medical Images With Application to Cardiac 4D Image Analysis. *Comput. Med. Imag. Graph.*, *19*, 69–83.

Tauber, C., Batatia, H., & Ayache, A. (2005). A General Quais- Automatic Initialization for Snakes: Application to Ultrasound Images. In *Image Processing, 2005. ICIP 2005. IEEE International Conference* (pp. 9–12).

Teichmann, M., & Capps, M. (1998). Surface Reconstruction With Anisotropic Density-Scaled Alpha Shapes. *Visualization'98. Proceedings*, 67–72. http://dx.doi.org/10.1109/VISUAL.1998.745286

Terzopoulos, D., Witkin, A., & Kass, M. (1988). Constraints on Deformable Models: Recovering 3D Shape and Nonrigid Motion. *Artificial Intelligence*, *36*(1), 91–123.

Wilson, J. A., Bender, A., Kaya, T., & Clemons, P. A. (2009). Alpha Shapes Applied to Molecular Shape Characterization Exhibit Novel Properties Compared to Established Shape Descriptors. *Journal of Chemical Information and Modeling*, *49*(10), 2231–2241. http://dx.doi.org/10.1021/ci900190z

Xu, C., & Prince, J. L. (1998). Snakes, Shapes, and Gradient Vector Flow. *IEEE Transactions on Image Processing : A Publication of the IEEE Signal Processing Society*, *7*(3), 359–369. http://dx.doi.org/10.1109/83.661186

Xu, C., & Prince, J. L. (2006). Active Contours, Deformable Models, and Gradient Vector Flow. *Available on: Http://iacl. Ece. Jhu. Edu/projects/gvf/via the Internet.*

Zhou, W., & Yan, H. (2010). Prediction of DNA-Binding Protein Based on Alpha Shape Modeling. In *2010 IEEE International Conference on Bioinformatics and Biomedicine (BIBM)* (pp. 23–28). IEEE. http://dx.doi.org/10.1109/BIBM.2010.5706529

Zhou, W., & Yan, H. (2010). Relationship Between Periodic Dinucleotides and the Nucleosome Structure Revealed by Alpha Shape Modeling. *Chemical Physics Letters*, *489*(4), 225–228.

Zhou, W., & Yan, H. (2014). Alpha Shape and Delaunay Triangulation in Studies of Protein-Related Interactions. *Briefings in Bioinformatics*, *15*(1), 54–64. http://dx.doi.org/10.1093/bib/bbs077

Zhou, W., Yan, H., & Hao, Q. (2012). Analysis of Surface Structures of Hydrogen Bonding in Protein - Ligand Interactions Using the Alpha Shape Model. *Chemical Physics Letters*, *545*, 125–131.

Zomorodian, A., Guibas, L., & Koehl, P. (2006). Geometric Filtering of Pairwise Atomic Interactions Applied to the Design of Efficient Statistical Potentials. *Computer Aided Geometric Design*, *23*(6), 531–544.

Investigation on MDOF Bilateral Teleoperation Control System Using Geared DC-Motor

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Abstract

This paper presents the research on bilateral teleoperation control system of two link planar manipulator. The bilateral control system consists of master and slave system using geared DC-motor. Both master and slave manipulators are actuated by DC-Micromotor attached to planetary gearhead to increase the output torque. In the previous researches, the common used actuators were linear motors and direct drive DC motor. However, the application of DC motor with gearhead is vast in industry, due to the need for high output force or torque. Thus in this paper, a deeper research on bilateral teleoperation control system is proposed with implementation of gear into the DC-motor. The modelling of multi-degrees-of-freedom (MDOF) bilateral teleoperation control system is designed with the implementation of workspace observer (WOB), reaction force observer (RFOB), position controller and force controller. During the experiments, free motion and contact motion were conducted to validate the proposed setup in bilateral teleoperation control system. The position and torque responses of both master and slave manipulators were observed. The operationality and reproducibility of this proposed system were evaluated through experimental results. Ultimately, this paper focused on the performance of the proposed setup and is analysed by using reproducibility and operationality.

Keywords: haptics, MDOF bilateral teleoperation control system, geared DC-motor, operationality, reproducibility

1. Introduction

Haptic is one of the developing technology in the robotic application. Bilateral teleoperation with master and slave system is one of the haptic technology. This is to enable human to feel haptic information from the remote environment which human cannot present to. This technique is expected to apply in many situations such as space, surgery and in industrial environment. For example, development of bilateral teleoperation control system in surgery for surgical tools and instruments has been researched for the past few decades. As a result, this technology assisted in minimal invasive surgeries for mankind. Thus, K. Prasanga et al. and K. Tanida *et al*. proposed and developed haptic surgical forceps that can be used as surgery tools (Prasanga et al., 2012; Tanida et al., 2012). With the bilateral control system in this device, the surgeon can feel the stiffness of the tissues and react accordingly.

If the bilateral teleoperation control system has multi-degrees-of-freedom, disturbance observer can be designed in two kinds of domain, which is joint space and workspace. Joint space is the implementation of actuator at each joint and workspace is the implementation of end effector of the manipulator (Murakami et al., 1995). The disturbance observer implemented in workspace control is called as workspace observer. H. Tai proved that using workspace based bilateral control is better than joint space in terms of stability and transparency of equivalent mass matrix based bilateral control of MDOF (Tai & Murakami, 2010; Lasnier & Murakami, 2010). In terms of stability, the joint space which included inverse Jacobian matrix deteriorated when approaching singularity point. Indeed, the workspace control scheme is the most convenient for human because it describes the desired position and motion imposed by the human. Additionally, with the implementation of this scheme and workspace observer into MDOF bilateral control, the external forces exerted on master and slave system can be physically felt. More analysis on workspace-based bilateral control with MDOF motion system and the studies on reproducibility and operationality of the MDOF bilateral control system were also researched (Horie

& Murakami, 2011).

The acceleration-based bilateral control method was able to generate improvement in performance even in MDOF bilateral control system. A robust control based on disturbance observer approach improve the motion control system with the equivalent mass matrix determined arbitrarily and independent of configuration and inertia variation of the manipulator (Murakami et al., 1995). However, the posture change in the manipulator can cause fluctuation of cut-off frequency of the workspace observer due to the variation of the equivalent mass in workspace (Shimono & Yamashita, 2012). Moreover, further investigation in paper (Togashi et al., 2014) stated that the control performance can be improve by implementing the use of the equivalent mass matrix including the non-diagonal elements.

In particular, geared motor has been used vastly in industrial environment such as factory automation, robotics, industrial machines and medical sciences as well as laboratory technology. Geared motor also brings cutting-edge technology applications such as outer-space and underwater exploration, advanced robotics, and machinery. The advantage of geared motor is the ability to produce high torque. To produce high torque from a motor itself without gear for power transmission, the size of the motor has to be large. This in fact is not just costly, but also impractical in size. Thus, it is important to realise that the higher the torque required, the larger the size of the motor. With much different type of gears and ratio, the engineer can decide the torque output for an application.

However, in the past approaches, researches on bilateral teleoperation control system utilised linear motor. The output force is powerful but the cost is high. Moreover, it controls linear (Cartesian) positions. Nevertheless, some researches approached bilateral teleoperation control system using DC rotational motor. But the output power is very low. For instance, the implementation of geared motor in bilateral teleoperation control system is a new step in research. The outcome of the teleoperation using geared motor was able to realize a low cost teleoperation system. Unfortunately, geared motor produces large joint friction in teleoperation and affects the force/torque sensorless control. As a result, this also affects the reproducibility and operationality of a bilateral control system.

Furthermore, for industrial robots seen in automation and car manufacturing, the operation of the robots is programed based on trajectory position. The robots are usually are for pick and place or assembly task. Yet, operation area is fenced around to avoid human from accessing the operation zone. This is because the industrial robots are rigid and sensor-less to external environment, thus it will harm and injure humans when it contacts with human during operation. Consequently, these industrial robots are not safe during operation and not human friendly. In order to be safer, accessible and human friendly, the system must have external force feedback from the environment other than operation task. By all means if the system is able to track external force, the industrial robots will halt the operation immediately when it makes contact with the undesired force from the environment. Thus, this research focused on two link rotational planar manipulator for bilateral teleoperation control system. Moreover, this research also highlights the application of gearhead on the DC-motor not just to increase the output torque, but also to achieve low cost teleoperation system.

This paper is organized as follows. The first part introduces about the bilateral teleoperation control system followed by the workspace observer (WOB) and reaction force observer (RFOB) for two DOF planar bilateral teleoperation manipulator. Next the experimental setup and experimental manipulations is demonstrated. At the result and discussion section, the experiments of free and contact motions conducted were discussed. Ultimately, the performance of the proposed setup is analysed by using reproducibility and operationality.

2. Bilateral Teleoperation Control System

The dynamic modelling of workspace control for two DOF planar manipulator has been introduced in (Wei et al., 2015). In this paper, the combination of of workspace control and bilateral control system were presented. In this system, there are two MDOF manipulators. Both manipulators have the same two DOF, which are distinguished as master and slave manipulator system. Both systems are interconnected as bilateral control system. Figure 2.1 shows the block diagram of two link planar manipulator bilateral control based on acceleration control. The actuator information from joint space is transformed into human modal space and the bilateral control is implemented at each joint. Then the acceleration reference is transformed to actuator information in joint space.
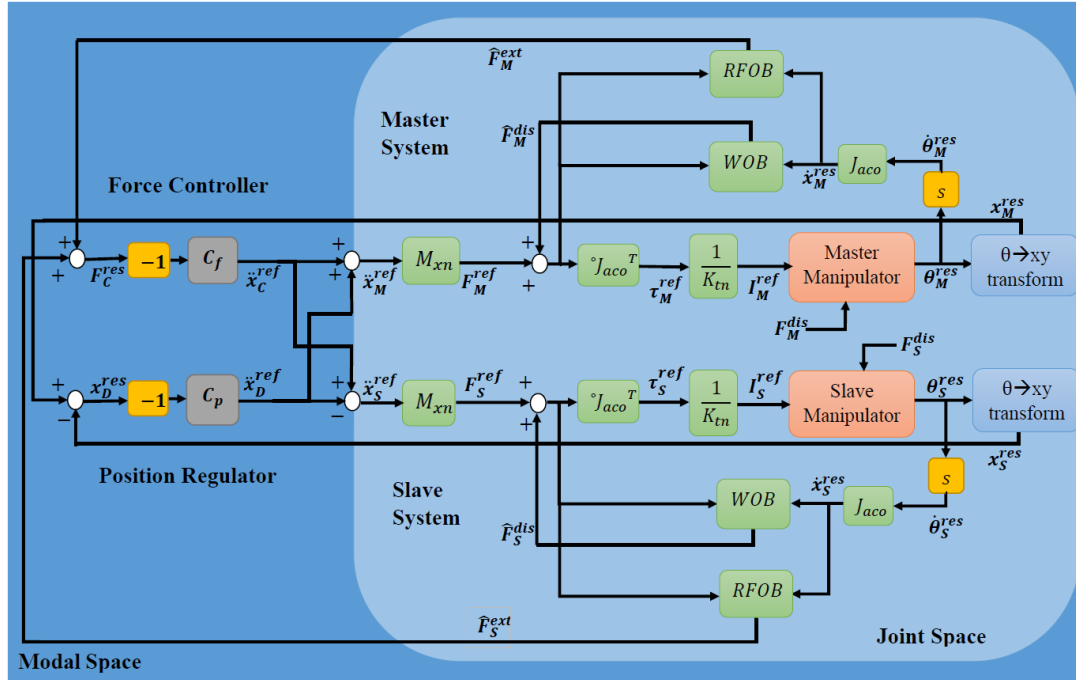
Figure 2.1. Block diagram of two link planar manipulator bilateral control based on acceleration control

In order to transfer information in haptic communication, the realization of position tracking and the law of action and reaction between master system and slave system are important. The F_M represents the force applied by human operator to the master manipulator while the F_S represents the force applied by the environment at the slave manipulator. Moreover, vector force is applied at the end effector (in x and y coordinate) of both master and slave manipulator. Thus the force on master and slave consists of F_{Mx}, F_{My} and F_{Sx}, F_{Sy}, respectively. Equation (2.1) represents the summation of the action force from human operator F_M and reaction force from environment F_S which should converge to zero. On the contrary, Equation (2.2) represents that the position error in Cartesian space between master position x_M, y_M and slave position x_S, y_S should converge to zero. $\hat{F}_M^{ext}$ and $\hat{F}_S^{ext}$ are estimated using RFOB rather than obtaining it from the force sensor. The estimated force from master and slave manipulators' end effector also in Cartesian space $\hat{F}_{Mx}^{ext}$, $\hat{F}_{My}^{ext}$, $\hat{F}_{Sx}^{ext}$ and $\hat{F}_{Sy}^{ext}$ Equations (2.2) to (2.5).

$$F_C^{res} = \hat{F}_M^{ext} + \hat{F}_S^{ext} \tag{2.1}$$

$$x_D^{res} = x_M^{res} - x_S^{res} \tag{2.2}$$

$$F_C^{res} = 0 \tag{2.3}$$

$$x_D^{res} \to 0 \tag{2.4}$$

$$x_D^{res} = 0 \tag{2.5}$$

The basic concept of bilateral motion control system on both master and slave system is required to be implemented in its total position in differential mode x_D and total force in common mode F_C, on both x and y coordinate (Ohnishi et al., 2010). The common mode and the differential mode are able to be designed independently. In order to decouple between these two modes, the second order Hadamard matrix (quarry matrix), H_2 is applied as modal decomposition as shown in Equation (2.6) ("$*$" denotes non-zero element and not taken into account for bilateral control system). Thus, position control and force control are achieved simultaneously.

$$\begin{bmatrix} F_C^{res} & * \\ * & x_D^{res} \end{bmatrix} = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \begin{bmatrix} \hat{F}_M^{ext} & x_M^{res} \\ \hat{F}_S^{ext} & x_S^{res} \end{bmatrix} \tag{2.6}$$

$$= H_2 \begin{bmatrix} \hat{F}_M^{ext} & x_M^{res} \\ \hat{F}_S^{ext} & x_S^{res} \end{bmatrix}$$

Then the system includes the force controller C_f and position controller C_p to calculate the common mode

acceleration reference, $\ddot{x}_C^{ref}$ and differential mode acceleration reference, $\ddot{x}_D^{ref}$ using the transformed force and position response as shown in Equation (2.7) and Equation (2.8), respectively;

$$\ddot{x}_C^{ref} = -C_f F_C^{res} \tag{2.7}$$

$$\ddot{x}_D^{ref} = -C_p x_D^{res} \tag{2.8}$$

The position and force information are transformed into acceleration reference so that both information can be controlled together. By using the Equation (2.7), (2.8) and second-order inverse Hadamard matrix, H_2^{-1}, the reference signal in acceleration dimension to control master and slave are shown Equation (2.9).

$$\begin{bmatrix} \ddot{x}_M^{ref} \\ \ddot{x}_S^{ref} \end{bmatrix} = \frac{1}{2} \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \begin{bmatrix} \ddot{x}_C^{ref} \\ \ddot{x}_D^{ref} \end{bmatrix} \tag{2.9}$$

$$= H_2^{-1} \begin{bmatrix} \ddot{x}_C^{ref} \\ \ddot{x}_D^{ref} \end{bmatrix}$$
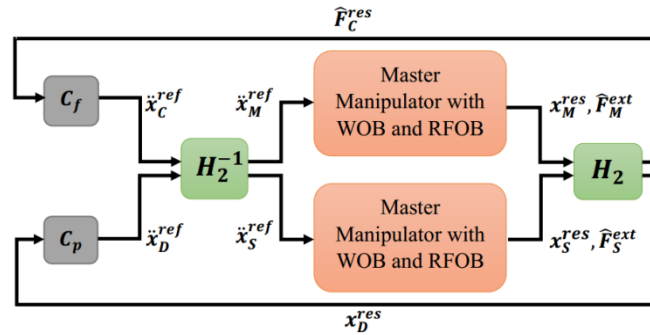
Figure 2.2. General acceleration based four channel bilateral controller

Figure 2.2 shows the block diagram of four-channel bilateral controller of this system. From the above system, high transparency is achieved between master system and slave system of bilateral control system. Human operator at master side can feel an environment in the slave side as if it is in the master side.

The function of the position controller system is to allow the tracking position system to track the desired trajectory in the critically damp response as shown in Equation (2.12). The position coefficient and velocity coefficient are set based on the natural angular frequency and a damping coefficient of the control system as show in Equation (2.10) and Equation (2.11) (Jamaluddin et al., 2014). Moreover, the force controller system has to maintain the contact stability between force at end-effectors and the force at the contact object (Leksono et al., 1996) as shown in Equation (2.13).

$$K_p = \omega_n^2 \tag{2.10}$$

$$K_d = 2\delta\omega_n \tag{2.11}$$

$$C_p = K_p + K_d s \tag{2.12}$$

$$C_f = K_f \tag{2.13}$$

2.1 Disturbance Observer (DOB) and Reaction Force Observer (RFOB)

In the previous paper has mentioned on the implementation of workspace observer into Direct Cartesian scheme and showed improvement in the workspace control (Wei et al., 2015). Although bilateral control system is used in this paper, the meaning and implementation of WOB are the same. However, reaction force observer (RFOB) is used too. Figure 2.3 shows the block diagram of the implementation of WOB and RFOB into the MDOF bilateral control system. Equation (2.17) and Equation (2.18) are the estimated disturbance $\hat{F}^{dis}$ for master and slave system and both x axis and y axis, respectively.
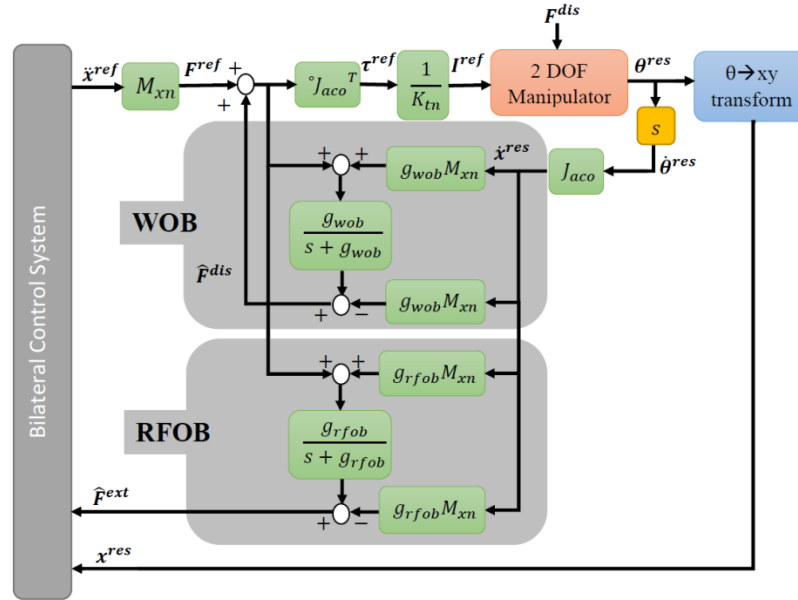
Figure 2.3. Block diagram of workspace based disturbance observer and reaction force observer

$$F = F^{ref} - F^{dis} \tag{2.14}$$

$$F^{dis} = F^{int} + F^{ext} + F^c + D\dot{\theta}^{res} \tag{2.15}$$

$$\hat{F}^{dis} = \frac{g_{wob}}{s+g_{wob}}\left(F^{ref} + \hat{F}^{dis} + g_{wob}M_{xn}\dot{x}\right) - g_{wob}M_{xn}\dot{x} \tag{2.16}$$

$$\begin{bmatrix}\hat{F}^{dis}_{Mx}\\\hat{F}^{dis}_{My}\end{bmatrix} = \frac{g_{wob}}{s+g_{wob}}\left(\begin{bmatrix}F^{ref}_{Mx}\\F^{ref}_{My}\end{bmatrix} + \begin{bmatrix}\hat{F}^{dis}_{Mx}\\\hat{F}^{dis}_{My}\end{bmatrix} + \begin{bmatrix}g_{wob} & 0\\0 & g_{wob}\end{bmatrix}\begin{bmatrix}M_{Mxn} & M_{Mxyn}\\M_{Myxn} & M_{Myn}\end{bmatrix}\begin{bmatrix}\dot{x}^{res}_{M}\\\dot{y}^{res}_{M}\end{bmatrix}\right)$$
$$- \begin{bmatrix}g_{wob} & 0\\0 & g_{wob}\end{bmatrix}\begin{bmatrix}M_{Mxn} & M_{Mxyn}\\M_{Myxn} & M_{Myn}\end{bmatrix}\begin{bmatrix}\dot{x}^{res}_{M}\\\dot{y}^{res}_{M}\end{bmatrix} \tag{2.17}$$

$$\begin{bmatrix}\hat{F}^{dis}_{Sx}\\\hat{F}^{dis}_{Sy}\end{bmatrix} = \frac{g_{wob}}{s+g_{wob}}\left(\begin{bmatrix}F^{ref}_{Sx}\\F^{ref}_{Sy}\end{bmatrix} + \begin{bmatrix}\hat{F}^{dis}_{Sx}\\\hat{F}^{dis}_{Sy}\end{bmatrix} + \begin{bmatrix}g_{wob} & 0\\0 & g_{wob}\end{bmatrix}\begin{bmatrix}M_{Mxn} & M_{Mxyn}\\M_{Myxn} & M_{Myn}\end{bmatrix}\begin{bmatrix}\dot{x}^{res}_{S}\\\dot{y}^{res}_{S}\end{bmatrix}\right)$$
$$- \begin{bmatrix}g_{wob} & 0\\0 & g_{wob}\end{bmatrix}\begin{bmatrix}M_{Mxn} & M_{Mxyn}\\M_{Myxn} & M_{Myn}\end{bmatrix}\begin{bmatrix}\dot{x}^{res}_{S}\\\dot{y}^{res}_{S}\end{bmatrix} \tag{2.18}$$

F^{dis} is the total disturbance force generated in workspace for both x axis and y axis where;

F^{int} Internal force;

F^c Coulomb friction;

$D\dot{\theta}^{res}$ Viscous force;

$$\hat{F}^{dis} = \frac{g_{wob}}{s+g_{wob}}F^{dis} \tag{2.19}$$

$$\frac{g_{wob}}{s+g_{wob}} \tag{2.20}$$

The relationship between real disturbance force and estimated disturbance force is as described in Equation (2.19). By using the workspace observer, the system was able to estimate the disturbance force through a low-pass filter as shown in Equation (2.20), where g_{wob} is a cut-off frequency. The bandwidth of the WOB low-pass filter is set as high as possible to estimate a wide frequency range of disturbance. However, it is limited by practical and robustness constraints (Ishii et al., 2007).

Furthermore, by subtracting the external disturbances and system uncertainties from input of a WOB, it can estimate the reaction force applied to the system. It is necessary to identify them as precisely as possible. This process is called as reaction force observer (RFOB) (Murakami & Ohnishi, 1993) as shown is Figure 2.3. Equation (2.21) shows that the reaction force observer is estimated through first-order LPF. RFOB can estimate external

force without force sensor because force sensor has many drawbacks. The study of comparison between force sensor and reaction force observer based on force control system has been analysed (Sarlyildiz & Ohnishi, 2014).

$$\hat{F}^{ext} = \frac{g_{rfob}}{s+g_{rfob}} F^{ext}$$
(2.21)

Where $\frac{g_{rfob}}{s+g_{rfob}}$ is the low-pass filter (LPF) and g_{rfob} is a cut-off frequency.

However, identification of frictional force is needed in advance to estimate the external torque. The friction disturbance can be compensated by DOB only if an accurate friction model is provided. Here, the frictional force is not compensated and cannot be ignored. Thus later in the experiments, the system has friction effects largely from planetary gear. The friction force largely contributed as an operational force. However, the compensation of friction force is not in the scope.

2.2 Hardware Setup

There are two sets of two link planar manipulators. Each joint is actuated by a planetary geared DC-Micromotor with incremental encoder. It has 5000ppr (pulse per revolution) before gearhead. The links are designed with a length of 0.13m each with a base attached to a platform to prevent any unwanted vibration. The link can be either used to operate the system by human operator on master side or to the environmental contact on the slave side. The links at both master and slave side are in horizontal orientation that provide zero gravitational effects. Thus, only disturbance effect and frictional force are present in the gearhead and motor. Moreover, the main purpose of this setup is to investigate the operationality torque and reproducibility of this proposed geared bilateral teleoperation control system.

Planetary gearhead is able to provide higher torque for a low torque DC-Mircomotor. Moreover, the backlash is crucial to the haptic application where it can affect the performance of the bilateral system. The output of master and slave manipulator is position measured by the encoders mounted at the back of each motor shaft. The velocity response is obtained by derivative of position response and noise from the signal is filtered away by Low Pass Filter (LPF) in the control loop in the computer software. Within the Simulink, the processed data is set to analogue voltage reference signal from the Micro-Box to the motor driver. Motors are driven by Maxon motor driver (ESCON 50/5) in current-based control mode. The reference value represents the desired current that the motor driver will inject to the motor. The motor torque is directly proportional to the motor current (Hace & Jezernik, 2010). Figure 2.4 shows the experimental setup of this research.

Nevertheless, before conducting the experiment, the position controller gains, force controller gain, bandwidth of DOB and RFOB/RTOB are stochastically tune in order to achieve the required performance of the particular system. These gains are tuned based on random trials until the overall system is logically stable and shows good performance (Wei et al., 2016).
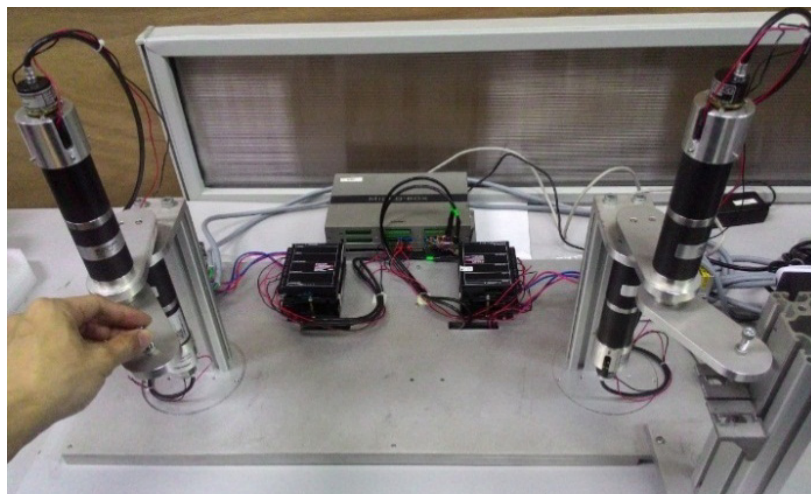
Figure 2.4 Experimental Setup

2.3 Experimental Manipulations

In this part, there are two experiments to be conducted. The first experiment is free motion and the second experiment is contact motion. During the free motion, the human operator control freely (without any obstacle) at master system while the slave system also follow freely without contact with any obstacle. During the contact motion, the initial position of the end-effector of the slave system is very near to the surface of the objects, but not touching it yet. The human operator operates the master manipulator manually in order for the slave manipulator to contact the object. During contact motion, human operator holds the master handle and moves the handle while the slave handle is constrained by a static object. The human operator then applies torque at the master handle. The hard object is an aluminium while the soft object is a sponge. Specifically, the human operator applied force on y axis at the end-effector of master manipulator during contact motion as shown in Figure 2.5.

The force and position response from both master and slave system are recorded, for both free motion and contact motion experiments. The position responses from master and slave system are obtained from rotary encoders while the external force applied to the master and slave systems are estimated by RFOB. The force and position response from both master and slave system are compared with each other to validate the operationality and reproducibility of the bilateral teleoperation control system. Nevertheless, the operationality can be validated from the free motion experiment while the reproducibility can be validated from the contact motion experiment. Then, the evaluation of this part of experiment is explained in the results section**.**

Here, singularity is not cancelled. For this case, the singularity points according to end-effector are when the second joint (elbow) is at 0° or 180°.
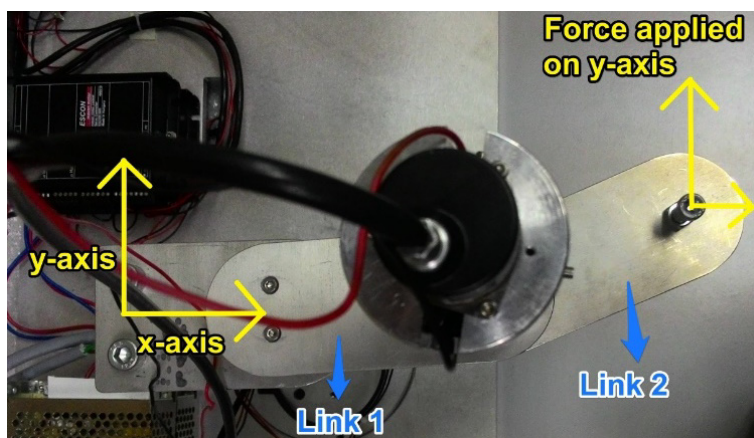
Figure 2.5. Direction of applied force at the end-effector of master manipulator (top view)

3. Results

Table 1. Parameters in Experiment

Parameter	Description	Value
l_1	Link 1	$0.13m$
l_2	Link 2	$0.13m$
M_{n1}	Nominal mass 1	$1.085kg$
M_{n2}	Nominal mass 2	$0.19kg$
K_{tn}	Nominal torque constant	$0.7164Nm/A$
K_p	Position gain	10000
K_d	Velocity gain	200
K_f	Force gain	2
$N_1 : N_2$	Master gear ratio	$36 : 1$
g_{dob}	Cut-off frequency of disturbance observer	$50rad/s$
g_{rtob}	Cut-off frequency of reaction force observer	$50rad/s$

In this part of the experiment, the master and slave manipulator are identical two link planar manipulator. The length of the two link l_1 and l_2, geared DC-motor at each joint are identical for both master and slave manipulator. Nevertheless, the nominal mass M_{n1} and M_{n2} for master and slave manipulator are identical. The experiments are conducted with the parameters shown in Table 1.

3.1 During Free Motion

In this section, the free motion experiment is conducted. Free motion means that the human operator manipulates the master manipulator freely without any obstacle and the slave manipulator also does not contact anything. This experiment is to investigate the operational torque of this bilateral teleoperation control system during free motion. Operationality is degree of operational force which human operator feels besides reaction force from the environment which is desired for comfortable operation for human operator (Iida & Ohnishi, 2004). Figure 3.1 shows free motion experiment result while Figure 3.2 shows the XY trajectory response during free motion (noted that the graph shows the origin of master and slave manipulator are at the same local frame).
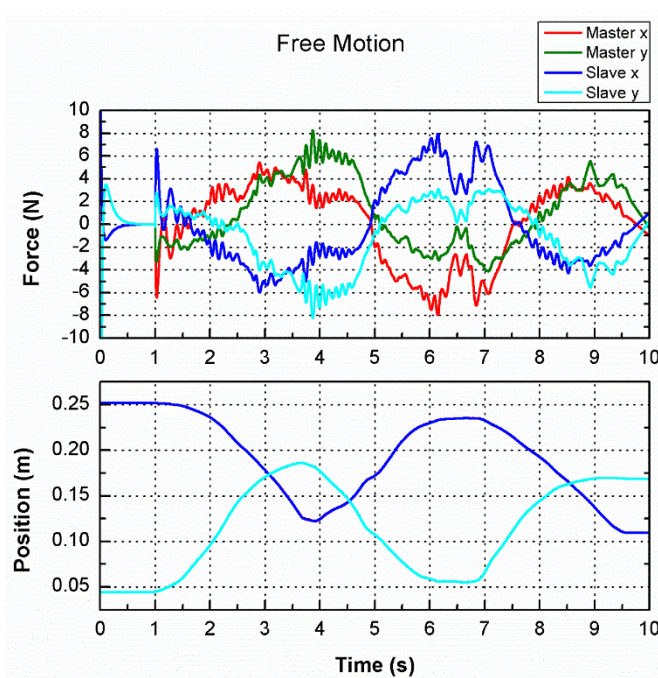
Figure 3.1. Force and position response during free motion
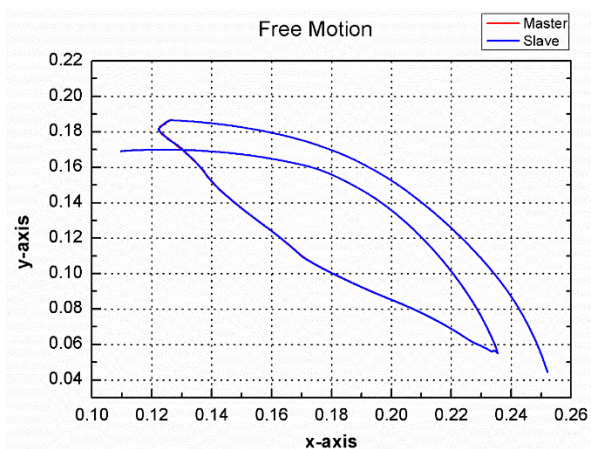
Figure 3.2. XY trajectory response during free motion

During the free motion, human operator need to apply some amount of force in order to overcome friction to

move the master manipulator as shown in Figure 3.1. Human operator also needs to apply higher force when changing the direction of motion. The force to overcome friction (friction force) largely contributes as an operational force. However, the force for both x and y position tracked very well at both master and slave system. Thus, the law of action and reaction are achieved between master and slave system.

It is also shown the position response from both master and slave system are tracked perfectly as shown in Figure 3.1 where the red and blue line overlap each other for x axis while green and cyan overlap each other for y axis. Figure 3.2 shows the position response of XY trajectory for both master and slave manipulator during random free motion. Again, the position response from both master and slave system are tracked perfectly where the red and blue line overlap each other.

3.2 During Contact Motion

In this section, the contact motion experiment is conducted. The human operator makes three contact motions with the object within 10s. This experiment is to investigate the reproducibility of this bilateral teleoperation control system when it comes in contact with object. According to Figure 3.3 and Figure 3.5, contact motion on aluminium (hard object) and sponge (soft object) are operated manually by the human operator, respectively. Figure 3.4 and Figure 3.6 shows the XY trajectory response during contact motion on aluminium (hard object) and sponge (soft object) are also operated manually by human operator respectively (noted that the graph shows the origin of master and slave manipulator are at the same local frame).
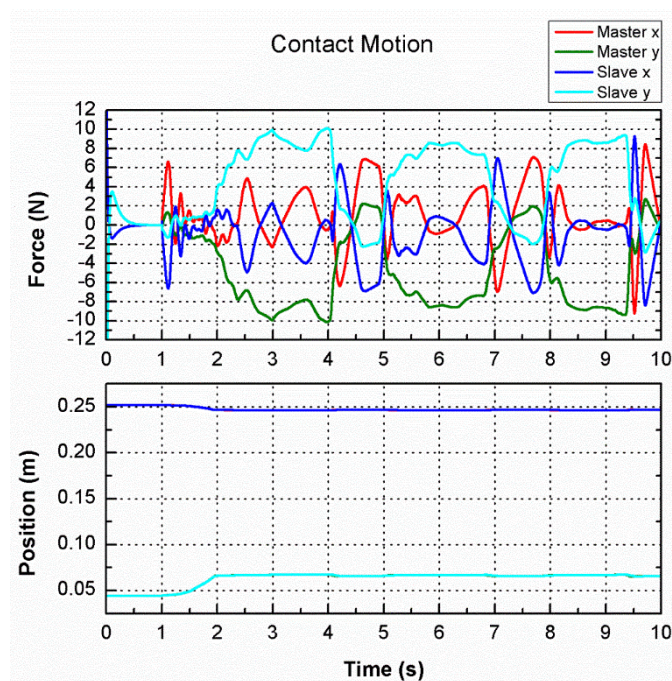
Figure 3.3. Force and position response during contact motion (hard object)
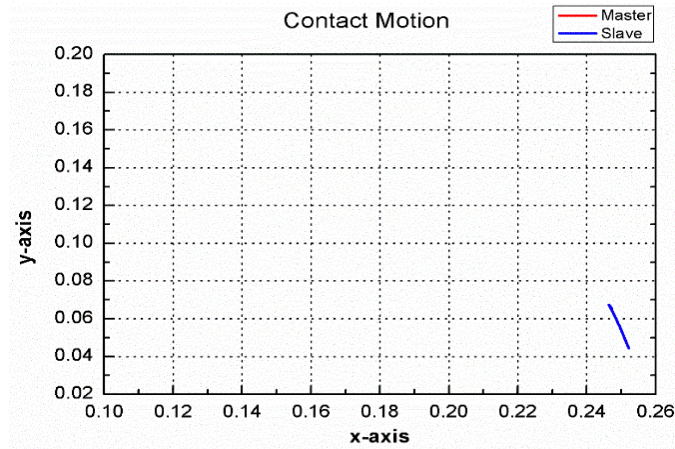
Figure 3.4. XY trajectory response during contact motion (hard object)
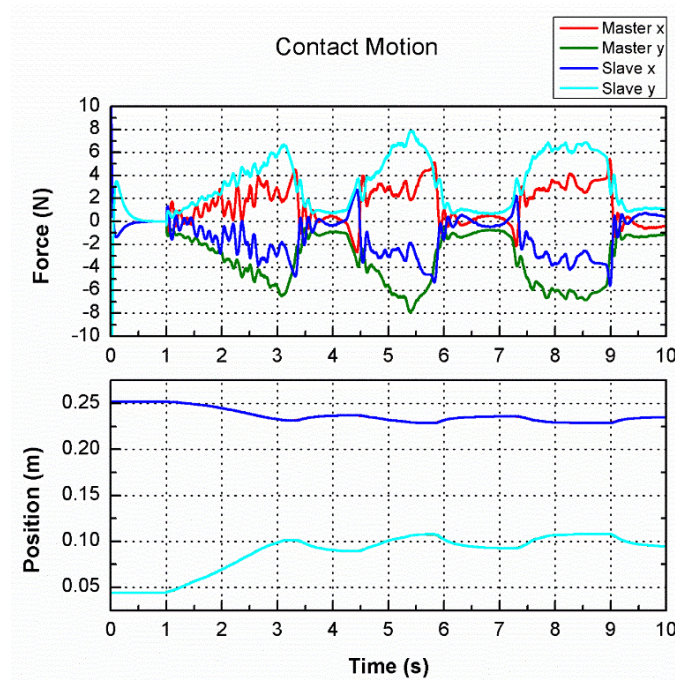
Figure 3.5. Force and position response during contact motion (soft object)
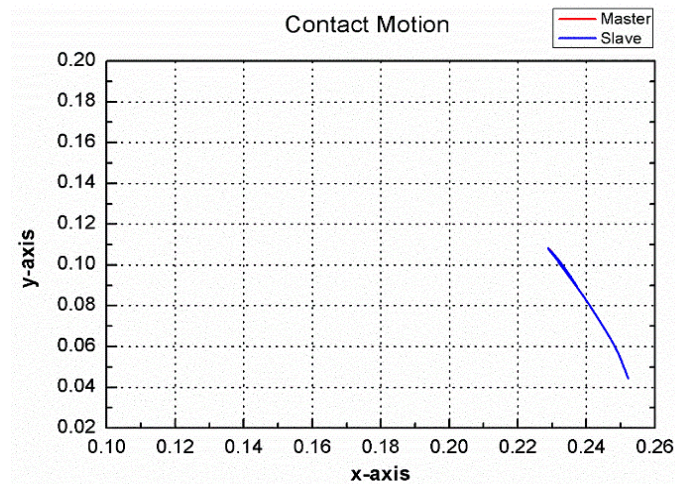
Figure 3.6. XY trajectory response during contact motion (soft object)

During contact with aluminium, the force response between master and slave manipulator are tracked perfectly. The law of action and reaction force between master and slave system is realized in force response as shown in Figure 3.3.

It is shown that the position response from both master and slave system are tracked perfectly as shown in Figure 3.3 where the red and blue line overlap each other for x axis while green and cyan overlap each other for y axis. Figure 3.4 shows the position response of XY trajectory for both master and slave manipulator during random contact with the aluminium block. Again, the position response from both master and slave system are tracked perfectly where the red and blue line overlap each other.

Next, during contact with the sponge, the force and position response between master and slave manipulator are tracked perfectly. The law of action and reaction force between master and slave system is realized in force response as shown in Figure 3.5.

It can be seen that the position response from both master and slave system are tracked perfectly as shown in Figure 3.5 where the red and blue line overlap each other for x axis while green and cyan overlap each other for y axis. Figure 3.6 shows the position response of XY trajectory for both master and slave manipulator during random contact with the sponge. Again, the position response from both master and slave system are tracked perfectly where the red and blue lines overlap each other.

Meanwhile, when the human operator released force at the master manipulator, the sponge eventually expanded to regain its shape. During the expansion of the sponge, an expansion force from the sponge pushed the slave manipulator which is in contact with sponge. Pushing the master manipulator too causes changes in position response in both master and slave manipulator, especially in y axis direction, as can be observed in Figure 3.5 and Figure 3.6. Then, the human operator was able to feel the expansion force applied by the sponge.

By observing the force response shown in Figure 3.3 and Figure 3.5, the force for y axis at master and slave are higher compared to x axis. This is because the human operator applied more force at y axis during the contact motion as mentioned in the procedures. This also can be shown in position response where y position deviated during the contact motion. Figure 3.4 and Figure 3.6 showed the trajectory motion where master and slave manipulator start from initial position and contact with the aluminium and sponge, respectively. In brief, human operator manipulated the master manipulator more in the y axis direction.

4. Discussion

During the experiments on this bilateral teleoperation control system with free motion, the position tracking of both master and slave manipulators are tracked perfectly. However, there is a large operational force that human operator needed to perform in order to move the master and slave manipulator comfortably and easily. It is shown that the operational force is multiplied by gear ratio of the gearhead.

During contact motion, it is shown that both position and force tracking at both master and slave manipulators are well tracked. The reproducibility during contact motion is satisfied by this experiment. The stable contact of the slave manipulator is achieved on aluminium and sponge. The human operator can feel sharpness of reaction force from hard object. The friction force is almost neglected as there is no free motion during the contact motion of hard object.

However, during contact with the sponge, there is extra operational force to compress the sponge which is frictional force from gear. Then, during the expansion from the sponge, the expansion force needs to overcome the frictional force at the slave system to expand. Thus, human operator from master manipulator felt less expansion force from the sponge. Overall, the position tracking of the end-effector and the "law of action and reaction" are achieved between master and slave system in the workspace. This shows that the geared DC-motor performs well in contact motion and reproduce the reaction force from the environment and the bilateral teleoperation control system is achieved.

5. Conclusion

A two link planar bilateral teleoperation systems are developed where each joint is actuated by DC-Micromotor with planetary gearhead to increase the output torque at master and slave manipulator. WOB and RFOB are implemented in the system to compensate the disturbance and to estimate the external torque, respectively. The experiments are conducted to validate the bilateral teleoperation control system. The haptic information which is the position and torque information from both master and slave manipulators are plotted and compared. The operationality and reproducibility are analysed by conducting free and contact motion, respectively. Experimental results supported the theoretical background of the proposed setup and displayed accurate position and force tracking. As a result, the proposed two link planar bilateral teleoperation control system using geared

DC-motor is promising for future bilateral teleoperation applications.

Furthermore, since the geared motor is used in every setup, the human operator felt the stiffness of the gear. The higher the gear reduction ratio, the stiffer the human operator feels. This leads to high operational force for a haptic device and is a disadvantage in this haptic system. Thus, compensation of frictional force within gear is important. Additionally, the singularity is a common issue in MDOF manipulator. It gives a limitation and precaution for a MDOF manipulator during operation, or even injury or damage to the human operator or the manipulator itself. Thus, methods to eliminate singularity are a priority in MDOF manipulator to fully utilise the structure without compromising the position and force performance of MDOF bilateral control teleoperation system.

As for the future work, this bilateral teleoperation control system could be extended to further study on the application on MDOF two link planar micro-macro bilateral teleoperation control system using geared DC-motor for scaling purposes.

Acknowledgments

References

Hace, A., & Jezernik, K. (2010). Bilateral teleoperation by sliding mode control and reaction force observer. *Proc. IEEE Int. Symp. Ind. Electron*, 1809–1816. http://dx.doi.org/10.1109/ISIE.2010.5637717

Horie, R., & Murakami, T. (2011). An analysis of a novel master-slave control and its application to MDOF motion systems. *IECON Proceedings (Industrial Electronics Conference)*, 474–479. http://dx.doi.org/10.1109/IECON.2011.6119357

Iida, W., & Ohnishi, K. (2004). Reproducibility and operationality in bilateral teleoperation. *Proceedings of 8th IEEE International Workshop AMC*, 217–222. http://dx.doi.org/10.1109/AMC.2004.1297669

Ishii, E., Nishi, H., & Ohnishi, K. (2007). Improvement of performances in bilateral teleoperation by using FPGA. *IEEE Transactions on Industrial Electronics*, *54*(4), 1876–1884. http://dx.doi.org/10.1109/TIE.2007.898295

Jamaluddin, M. H., Shimono, T., & Motoi, N. (2014). An integration method between vision-based disturbance observer and bilateral haptic system for robust tracking of target object. *IEEE 13th International Workshop on Advanced Motion Control (AMC), 2014*(1), 723–728. http://dx.doi.org/10.1109/AMC.2014.6823370

Lasnier, A., & Murakami, T. (2010). Workspace based force sensorless bilateral control with multi-degree-of-freedom motion systems. *The 11th International Workshop on Advanced Motion Control, AMC*, 583–588. http://dx.doi.org/10.1109/AMC.2010.5464065

Leksono, E., Murakami, T., & Ohnishi, K. (1996). On hybrid position / force cooperative control of multimanipulator based on workspace disturbance observer. *Proceedings of the IEEE 22nd Int. Conf. on Industrial Electronics, Control, and Instrumentation*, 1873–1878. http://dx.doi.org/10.1109/IECON.1996.570758

Murakami, T. et al. (1995). A motion control strategy based on equivalent mass matrix in multidegree-of-freedom manipulator. *IEEE Transactions on Industrial Electronics, 42*(2), 123–130. http://dx.doi.org/10.1109/41.370377

Murakami, T., & Ohnishi, K. (1993). Torque sensorless control in multidegree-of-freedom manipulator. *IEEE Transactions on Industrial Electronics, 40*(2), 259–265. http://dx.doi.org/10.1109/41.222648

Ohnishi, K., Katsura, S., & Shimono, T. (2010). Motion control for real world haptics. *IEEE Industrial Electronics Magazine*, *4*, 16–19. http://dx.doi.org/10.1109/MIE.2010.936761

Prasanga, K., et al. (2012). Achievement of real haptic sensation with tendon driven segregated jaws for laparoscopic forceps. *ICIAFS 2012 - Proceedings: 2012 IEEE 6th International Conference on Information and Automation for Sustainability*, 65–70. http://dx.doi.org/10.1109/ICIAFS.2012.6419883

Sarlyildiz, E., & Ohnishi, K. (2014). A comparison study for force sensor and reaction force observer based robust force control systems. *2014 IEEE 23rd International Symposium on Industrial Electronics (ISIE)*, 1156–1611. http://dx.doi.org/10.1109/ISIE.2014.6864777

Shimono, T., & Yamashita, T. (2012). A suppression of cut-off frequency fluctuation based on workspace observer with estimated equivalent mass for mdof bilateral system. *The 2012 IEEE/ASME International Conference on Advanced Intelligent Mechatronics*, 320–325. http://dx.doi.org/10.1109/AIM.2012.6265972

Tai, H., & Murakami, T. (2010). Equivalent mass matrix based bilateral control for multi-degrees-of-freedom Systems. *International Workshop on Advanced Motion Control, AMC*, 343–348. http://dx.doi.org/10.1109/AMC.2010.5464107

Tanida, K., et al. (2012). Function separation for 2-DOF haptic surgical forceps robots driven by multi brive linear motors. *The 12th IEEE International Workshop on Advanced Motion Control, AMC*, 1–6. http://dx.doi.org/10.1109/AMC.2012.6197134

Togashi, N., et al. (2014). Experimental comparison of design methods for equivalent mass matrix in motion control system based on workspace observer. *AMC2014*, 669–674. http://dx.doi.org/10.1109/AMC.2014.6823361

Wei, L. J., Shukor, A. Z. H., & Jamaluddin, M. H. (2016). Investigation on the effects of outer-loop gains , inner-loop gains and variation of parameters on bilateral teleoperation control system using geared DC-motor. *International Journal of Mechanical & Mechatronics Engineering IJMME-IJENS, 16*(01), 54–69. Retrieved from http://ijens.org/Vol_16_I_01/161601-2929-IJMME-IJENS.pdf

Wei, L. J., Shukor, A. Z. H., & Jamaluddin, M. H. (2015). Workspace control of two link planar robot using Micro-Box 2000. *Jurnal Teknologi, 77*(20), 9–18. http://dx.doi.org/10.11113/jt.v77.6545

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Effective Cultural and Economic Indicators on Business Communications Growth (With an Emphasis on Iran)

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Abstract

Today, society became an international trade lifeline. The study of this science has become a necessity to understand the cultural differences in intercultural communication. Although it increasingly crossed the borders and business barriers had been denied, but cultural boundaries do not sidestep easily and unlike legal, political, or economic, business environment tangible aspects, culture is largely invisible. Hence, an aspect of international trade is often overlooked. For economic growth and development inside and outside the borders, attentions should be paid to the cultural aspects of our society and other societies.

The purpose of this study was to evaluate the effect of cultural dimensions on growth of economic indicators. This study is a practical in terms nature and purpose, and is descriptive, and library study in terms of data collection. In order to data collection, questionnaire and financial information of financial institutions were used (information of economic indicators of Asian Development Bank and the Central Bank of the Islamic Republic of Iran). Validity and reliability of the questionnaire were evaluated through Cronbach's alpha and exploratory and confirmatory factor analyses were done. The population in this study was the country's capital market participants. Sampling was done through probabilistic sampling strategy and simple random sampling method was used and 92 persons were estimated through the Morgan table. Structural equation modeling was used, to test the hypotheses. The results of this study showed that, there is a positive relationship between cultural dimensions and growth of economic indicators.

Keywords: cultural dimensions, communication, globalization, economic indicators

1. Introduction

Globalization is a fact that the world is facing, whether it is a historical and spontaneous inevitability or planned and imposed project. Given that the markets are going towards globalization; so deregulation and competitiveness of the market would makes organizations to adapt to new goals and make plans to change the strategy (Jaros, 2010).

Despite the importance of this issue, we are witness of organizations failure reports in this area. One of the reasons for the high failure rate is failure to understand cultural differences and the presence of culture of changes avoidance in organizations. Culture is rooted in the values (Hwang, 2005) and its signifycance for the 21st century is such an extent that some people consider it as "century of culture and cultural paradigm" and some people remember the emergence of the sixth continent as "culture continent" (Ebrahimian, 2012; Mostafavi, 2013). According to the expression of the importance of culture and globalization of trade; the most desirable method is their interactive effects on each other. Therefore, in the study of theoretical concepts, globalization, culture and communication are studied.

Today, the world is witnessing massive and amazing transformation of economy, communications, culture, politics, international treaties and affairs in the globalization. The globalization process due to its broad scope is affected all facets of human life; for this reason, some scholars have considered it as the greatest event in human history. Therefore, globalization and its discussion can't be ignored. Indeed, globalization has created a communication revolution, and the world has become a village.

In the past, human relations and communications were limited to geographic areas, but today with the movement towards the global village and eruption of the communication revolution, human trade exchanges are not confined to a geographic area anymore. Businesses have grown and spread throughout the world. Hence, appropriate and effective communication for the survival and success of businesses would be necessary. Despite the globalization of businesses environment, merchants of each area are committed to their regional customs and culture. To achieve a successful business at the international level, merchants should manage their communications by acquiring information about the culture of their business; respect the opponent's principles and the impacts of cultural dimensions of economic indicators in the country, because this communication awareness will lead to loss of cultural misunderstanding. In this paper, we decided to review the factors affecting the growth of economic indicators which is the groundwork for establishing a successful business by evaluating cultural aspects of selected GLOBE studied Asian countries.

2. Theoretical Foundations

Given the importance of the interactions of globalization, communication and culture, in this section, the literature of each section are reviewed.

2.1 Globalization

Term of globalization has been used in scientific and literary texts since the 1960s. According to Giddens, globalization means deepening of social relations in large level, so that the distances become insensible and the cause of an accident at a location can be searched in a quite different and far area (Safiri & Nematollahi, 2012; Khanifar, Zarvandi & Zarvandi, 2010). Robertson stated that globalization is not merely a process of visual communication, but also it refers to mental knowledge and hope (Rangkesh, 2010). Lucas (2004) expressed that globalization is a continuous flow of internationalization's historical path which increases dependence of countries to each other in economic, political, cultural, and especially environmental aspects. Globalization has caused that your problem, be our problem (Zahedi, 2011; Beigi, 2011).

Globalization means liberalization, elimination of trade barriers, means deterritorialization (Mikami, 2011), or development of integration the areas into a single realm (Ghaheri, 2010; Tavakol & Zadmehr, 2011), or creation a glass border (Millar Wood, 2008).

Some scholars have used metaphors to define globalization and they believe that, globalization is a historical process (Dlanty, 2000); project or scheme (Latvsh, 2000; Darvishi, 1378; Ham, 1999; Friedman, 1995); a phenomenon (Nash, 2001; Nasri, 2001; Dadz, 2000); development of human's common values (Ham, 1999); a new meta-discourse (Tajik, 2001); a domain oriented expansion (Held, 1999) (Quoting et al., 2004). Definitions of globalization focuses on three common elements; creating an integrated economy in global level (same market); creating transnational governments and third prism is increasing information and communication resulting from technology development (Millar, 2008).

In the phenomenon of globalization three factors; proximity, location and attitude are related to each other. Proximity; at the current time than any other time in the past, countries are close to each other and they must observe more regulations. Location; location of companies and their integration activities are beyond the international borders and creating permanent competition. Attitude; in the globalization phenomenon, the countries with a new perspective pay attention to performances at the global level. In this attitude, the world outside the country's border should be considered from one side and they need to grow their abilities on the other hand, so that they can take an active role in the international system (Stoner, Freeman & Gilbert, 2005). Globalization has created a revolution in communication, and the world has become a village (Wong, 2007) and for success in global environmental communication skills, including knowledge of the cultural dimension should be reinforced.

2.1.1 Dimensions of Globalization

Globalization is studied in two dimensions, internal (according to performance indicators in the field of human, financial, structural and efficiency resources) and external (due to the globalization of the economy, technology, politics, culture). With the globalization literature review, most researchers have pointed to the exterior dimensions of globalization (Turner, 2004; Ameli, 2004; Miller Wood, 2008; Movius, 2010; Liu, 2010). Economic dimension: Globalization, for the first time was extensively highlighted by researchers in the field of economy, but nowadays everyone admits that, this concept has spread to other areas of human life (Tajik & Darvish, 2004). Political dimension: The political impact of globalization is considered on the sovereignty issue. Of course, complete separation of the political dimensions of economic and cultural aspects of society is not possible. Cultural dimension: In this dimension, there are deep concerns about the threat of invasion and the

decline of norms, values, and indigenous and local beliefs (Pour Ezzat, Gholipour, Bagheri & Naddaf, 2011).

2.2 Culture

Increasing the attention to issues of intercultural communication arose after publication the book of the cultural achievements of Hofstede (1980), which was the most influential works in this area. Hofstede's work presented a five cultural dimensions value system and plotted a cultural map of the world with 53 countries. In the GLOBE study (2004), the cultural map of the world was plotted with investigating 9 cultural dimensions among 62 countries and in the last GLOBE study (2007), was plotted with investigating 25 countries.

2.2.1 Dimensions of Culture

In this section, three famous studies of Hofstede's four cultural dimensions and KluckHohn's six dimensions and GLOBE's nine dimensions study were investigated. The research results of Hofstede, lead to the expression 4 dimensions (differences) of culture. These dimensions are:

- Power distance; the extent to which, people with less power in a society accept unequal power and consider it as a common event (Mansouri, Motiei, Shekarriz & Nejati, 2013). In a country like Denmark, low power distance means that the acceptance of inequality for people is difficult.

- Uncertainty; ways in which human societies have learned to cope with uncertainty. The technology often is used to defend against the natural uncertainty. Religion is a cultural tool, which helps us to accept the uncertainties that we can't defend against them. The cultures characterized by low avoidance of uncertainty, accept the individuals with innovative ideas, abnormal and deviant behavior. While, there is resistance to the phenomenon in cultures characterized by high avoidance of uncertainty (Oughi, 2011). Acceptance degree of ambiguity should not be mistaken with risk avoidance, this doesn't include the willingness of people to take risks, but also it is associated with preferences for clear rules and principles (Mansouri Sepehr et al., 2013; Oughi, 2011).

- Individualism versus collectivism; in individualistic cultures, individuals do activities independently from the other members of the society. In many countries, this case is considered as a very undesirable case. In individualistic societies, the connections between individuals are weak and everyone is expected to take care of themselves and their immediate families. In these communities, personal interests precede the interests of the group (Oughi, 2011). In collectivist cultures, cohesive groups, give people a sense of identity and belonging and due to its sense of security, it demands considerable loyalty.

- Masculinity versus female-oriented: in cultures with high masculinity, the men are expected to play a positive and assertive and with specific business goals along with career progression path and increase revenue. Women are responsible for supervisory roles and interpersonal relationships and appropriate environment (ibid).

These cultural traits can be thought as a part of the semantic context that shapes the culture (Johich, 2002). A Canadian man named Michael Bond added the fifth dimension entitled long-term orientation to four dimensions of Hofstede (Aarabi & Omid, 2009). This dimension represents the degree to which a society has pragmatic and based on future approach instead of having a cross-sectional and short-term view (Mansouri et al., 2013).

KluckHohn and Strodtbeck framework is the most common framework to distinguish cultures from each other. The criteria with six dimensions:

- Man and nature; is human subdues of natural and environmental factors and compromise with them? Or governs it? In basic terms, goal setting can't be taken seriously, but in the second situation people are looking for their own purposes.

- Culture and time; is the culture pay more attention to the present and future or the past? If it pays much attention to the present and future, so time is gold for this culture. But if it pays attention to the past, time doesn't have value and programs are often short-term. This dimension enables individuals to engage in any society to realize its long borders.

- Culture and space or location ownership; some cultures are very open and very clear, but some cultures prefer the privacy and confidentiality issues (Robbins, 1998).

Definitions of Cultural Dimensions of the Globe Study

The most comprehensive research in the field of culture is the studies of House et al. (2004) and Kokar et al. (2007) known as the GLOBE study. Iran has been investigated in both studies. This research was done in collaboration with more than 150 social scientists (as cultural representatives of different parts of the world) by

distributing 17,000 questionnaires 825 organizations, food industry, telecoms and banks. In This study, national cultures are classified based on 9 dimensions.

1) Performance oriented: The extent to which an organization or society rewards its members for performance improvement and excellence. This dimension of Mc Kland's study is about success. In cultures where there is a high need to succeed, there are people who launch new businesses and organize productive and economic units and increase productive capacities (House et al., 2004; Kokar et al., 2007).

2) Future oriented: Represents the extent to which people in society or organization involve in the future behaviors such as planning and future investment and don't associate with the present's success. The important point is that, the performance doesn't improve in the long term, unless the culture contains values and norms that can help organizations to adapt to changing environment. However, the long term thinking should be dominant in programs (ibid).

3) Assertiveness: Represents the degree to in which people in society or organization are decisive, aggressive and aggressive in social relations. In such cultures, organizational strategy has an entrepreneurial orientation. In organizations with high certainty, people are encouraged to competition and ambition. The level of participation and involvement in employees is high. The dominant approach is based on the organization's ability to do works and to make the emphasized results, the desire to victory is distributed among all members of the organization and it is believed that success depends on effort (ibid).

4) Power distance: An agreement between the members of an organization or society about dividing power unequally. In cultures with high power distance, organizational structures tend to be high and decisions tend to be concentrated, but in low power distance, decision-making are participative (ibid).

5) Human oriented: Represents the extent to which an organization or society rewards people for being fair, gallantry, friendly, generous, caring and kindness toward others. This dimension retrieved from Maslow's humanistic psychology that emphasizes is on the identification and development of human potential and it combines with measures such as creating confidence, promising, optimism, peace of mind and emotional intelligence. This situation provides groundwork for the creation of an appropriate and friendly institutional environment (ibid).

6) Institutional collectivism: Represents the extent in which an organization or society encourages collective actions and teamwork. This dimension measures societal emphasize on collectivism so that it leads individuals and groups to integration. The opposite of social collectivism is individualistic. Individualism represents the tendency to violate norms and intensifying motivation for seeking success. Both of these tendencies can lead to entrepreneurship (ibid).

7) In- group collectivism: This dimension is different from the institutional collectivism. It refers to people's loyalty toward family members or local organizations in which they serve and the extent to which people are proud to join in these collections concerned about its integration. In fact, individual's commitment to the organization causes the acceptance of the overall organization's goals and values, tendency to strive for organize, intention to continue their membership in the organization. Finally, optimum use of individual differences and enhances motivation led to the formation underlying innovative behaviors (ibid).

8) Uncertainty avoidance: The extent to which a culture encourages or rejects risk-taking culture. In cultures with low uncertainty, people tend to experience less stress from ambiguous situations and are more prepared to take risks. High uncertainty accurately and clearly identifies duties and on the other hand, it is a threat; because, people are resistant to change and innovation (ibid).

9) Gender egalitarianism: Reflects the extent in which the organization or society minimizes the differences in gender roles and sexism. In other words, the opportunity to achieve higher positions in organizations and society for men and women are equal. This equal possibility for upgrade increases the level of trust in the organization. This causes the tendency of women to participate more and take advantage of their competence (ibid, Faani, Babashahi, Afkhami Ardakani & Ebrahimi, 2012).

In this paper, the four cultural dimensions; boldness, individualism and collectivism, power distance, uncertainty avoidance and its impact on economic indicators, intercultural communication and trade success were discussed.

2.2.2 Typology of Culture

The metaphor is sometimes used to introduce the culture, some of which include: Network, society members as nodes, nodes that have bonded through their shared concerns (Mcveli, Duberley & Johnson, 2007). Shredder; they are social, inconsistent, ambiguous, multi- species cultures and they are placed in continuous and fluid

mode. Social glue; culture is viewed as glue that holds the sections of the society together (ibid). Culture is a control tool; researchers believe that, most of the basic regularities in social life arising from cultural systems (Scott, 2003; Mcveli et al, 2007). Power; culture is power and impacts on political, ideological, economic and military fields (Tomilson, 1999; Ameli, 2004). Culture is a living civilization (Ameli, 2007). Culture is a rooted and critical variable that is used by two means. Independent external variables that have impacts on the society (culture of the society) and internal independent variables that are the values and styles of one or more sub-culture (Scott, 2003).

In each society, there is often a dominant culture and a set of different subcultures. Dominant culture; emphasizes on the basic values shared by the members of the society and subcultures; reflects the issues, situations and experiences that members have encountered. If the dominant culture is strong, people respect fundamental social values. Because most of them are adopted and stick to it. Subcultures may don't have agreement, but they will support the values within the culture with a high intensity (Johich, 2002).

It can be said organizations' culture in every society is influenced by the prevailing culture. Organizational culture affects all organizational aspects and based on common values and beliefs of the organization empower the individual behavior, attitude, motivation, job satisfaction and affection. Just with review, modify, and create a good organizational and flexible culture, the interaction pattern between people can be changed in the organization and knowledge management can be utilized as a competitive advantage (Sadeghi et al., 2010).

2.3 Communications

In organizational communication theory, metaphors assist the theory: Pizza, the organization is a pizza in which people (flour), communications (the water that keeps the flour warm) and goals (yeast) is (Miller, 2011). Machine; emphasizing that each part of the machine performs a specific job, so each connection should be established. Each machine has a predictable result. Conduit, tool or channel; communications are technology transmission and communication tools to achieve organizational goals. Lens; organizations are such as a perceptual phenomenon or eyes that control the environment and filter and sort the data. Link; communications can be led to contact patterns and interdependence between individuals. Symbol; comes from the culture and knows communications as a literal interpretation such as stories, rituals and traditions (intergenerational communications) (Dadmehr, 2010).

2.3.1 Challenges of Organizational Communication

Challenges facing the organizational communication are because of the complexity of today's world. In this section, some aspects are discusses.

1) Globalization: What should be done for this challenge? The answer is in the application of communication accommodation theory and understanding the cultural differences (Tourish & Hargie, 2004). Today, due to the increasing global communication and creating multinational corporations and cultural diversity, increasing knowledge and human skills to confront the conflicts and issues in a global society are the definitive requirements. In different cultures, and even subcultures within a national culture, there's a range of emotions. In the absence of understanding, development of good working relationships would be difficult. Understanding cultural differences or cultural intelligence is the factor that is taken into consideration in this context and it is the deflator.

Understanding of effective communication in terms of time and place in world markets is the cultural understanding in the workplace, international and multinational organizations (Miller, 2011) in exchange for the purposes of conflict management and colloquial language across cultures (Tourish et al., 2004), understanding how to protect the rights of native workers in the country, understanding how to organize political and economic policy (Miller, 2011), understanding and knowledge of organizational rules and norms of communication inside and outside the face to face communication to the mail and negotiate, necessary communication skills to achieve personal, team and organizational goals in organizations' framework, and self-openness to cultural awareness and differences (Tourish et al., 2004), so that it reduce intercultural communication barriers and gives people the cultural diversity management power (Abzari & Khani, 2010).

The concept of cultural intelligence for the first time was raised by Earley and Ang (2004). The ability to learn new patterns is defined in cultural interactions and provides appropriate behavioral responses to these patterns. Ang et al. identified four factors in the cultural intelligence hypothesis to measure. They are:

- Motivational cultural intelligence: The personal tendency to experience other cultures and communicate with people in other cultures.

- Meta cognitive cultural intelligence: This means that, how a person understand the intercultural experiences and describes the processes that people apply for business and understanding cultural knowledge.

- Cognitive cultural intelligence: It is a knowledge that represents an understanding of cultural similarities and differences and shows the general knowledge and intellectual and cognitive maps of other cultures.

- Behavioral Cultural Intelligence: This shows the person's ability in consistent with the verbal and nonverbal behaviors that are appropriate for dealing with different cultures (Hamidi, Andam & Feizi, 2013).

All of the above can be summarized in four axial skills in that the connection is effective communications: International business knowledge, cultural compatibility, the ability to understand the perspective of others, the ability to play a role in innovation.

2) Climate Changes: Climate change increases the communications development for production of energy systems, build factories and transportation. Communications development is an opportunity for business and increasing environmental responsibility (Miller, 2011).

3) Population changes: Age, breed, income, educational attainment and etc. Outsourcing occurs especially in the environments in which corporations are multinational. How can establish communications with workers from different cultures? (ibid) and establish a multi-cultural management. Management in these organizations creates the major conflicts for customers, suppliers, employees and managers (Eisenberg, 2009).

4) Communication and culture: Intercultural communication is a communication between people in those cultural perceptions and symbolic systems are distinct enough from each other that present the communication phenomenon differently. In intercultural communication commonalities and differences should be found. And events should be analyzed and interpreted. One of the major features intercultural communications is the inevitability of conflicts and misunderstanding. In intercultural encounters, there's a good chance that the behavior of others does not meet our expectations. When it happens, that behavior will naturally be interpreted as violation of our value system. Intercultural Communications can be considered as a third culture. The results of interaction between two cultures' representatives are different.

2.4 Tips on Cultural Differences

- Value systems may be different, but no culture is better or correcter than another.
- The difference is not generally negative; the aim is understanding that how people see the world and it is important how we communicate with these differences.
- People should not be judged solely on the basis of a cultural dimension.
- When we increase our awareness, we can expect that others will have their own views.
- In order to understand someone from another culture, we need to understand the 3p of culture (Perspective, Practice, Product) (Abzari and Khani, 2010).

2.5 Intercultural Communication and Negotiation

Communications is the basis of all connections and commercial and social interactions. In intercultural communications many things can prevent the common understanding, because people with different cultures don't have common ground or similar codes and conventions. Negotiation is a particular communicative situation in which the parties' goals are in conflict potentially. Although all negotiations are in the same process, the emphasis on each stage of the process considerably varies between the cultures. Since the negotiations are controversial, knowing these notes that when, how and to what extent we should have adapted behaviors, require very high cultural intelligence.

2.6 Problems of Intercultural Communication

Today the communications have become an international trade lifeline and to understand the cultural differences in intercultural communications, the study of this science has become a necessity. Cultural differences in micro and macro levels, lead to disruption of communication and mutual understanding (Pazoki Zadeh & Tishedar, 2010). Communications within each society have high complex interactions and when a relationship is created between the two societies with different cultures, these interactions become more complex. When messages are transferred across cultural boundaries, it will be encrypted in one context and it will be decoded in another context. In this type of communications there are misunderstandings and unexpected reactions.

Culture usually refers to those specific behavioral characteristics that are reflected through verbal and nonverbal communication (Robbins, 1996). Differences in cultural values and deduction, often leading to a lack of understanding among people who have different cultural and historical backgrounds and incorrect understanding

of the concepts and practices in areas such as language, interaction, nonverbal communications, and values, in turn, lead to irreparable damage to the relationship between culture (Aarabi & Hedayati, 2009). On the other hand, understanding cultural differences provides the way to make an effective communication in the workplace. Learning the skills to effectively communicate with different cultures in today's world is very important.

According to Edward Hall, the famous anthropologist, "Culture is communications and communication is culture". Many of the challenges are rooted in cultural differences and misunderstandings in communication (Pazoki Zadeh et al., 2010).

According to theoretical principles and what is mentioned in the related researches, hypothesis can be stated as follows:

Hypothesis 1: Societies that have high boldness significantly are more successful in their intercultural business communication.

Hypothesis 2: Societies that have high individualism significantly are more successful in their intercultural business communication.

Hypothesis 3: Societies that have low power distance significantly are more successful in their intercultural business communication.

Hypothesis 4: Societies that have low uncertainty avoidance significantly are more successful in their intercultural business communication.

Hypothesis 5: Societies that have high understanding of cultural differences significantly are more successful in their intercultural business communication.

Aarabi and Hedayati (2009) presented a strategic model for their research on Hofstede's four cultural dimensions in the Iranian governmental organizations. The results of the studied population showed high uncertainty avoidance, high power distance, high female orientation and high collectivism.

Table 1. Iranian cultural features (Faghihi, Vaezi & Aaghaz, 2010)

Cultural Features	Source
Individualism and attention to links and strong family communications	Gable,1959; Keddie, 2002; Javidan & Hadizadeh Dastmalchian, 2003; Bar, 2004; moghadam & Assar, 2008; Sadeghkhani, 2007; Hofstede, 2005 Sari al-Ghalam, 2007; Iran Nezad, 2006
Authoritarianism and granting special privileges to the holder of the power	Gable, 1959; Javidan & Dastmalchian, 2003; Bar, 2004; Hofstede, 2005; Yeganeh & Sue, 2007 Homayoun & Katouzian, 2005
Rejection of dissenting views	Javidan & Dastmalchian,2003 Sari al-Ghalam, 2007
Uncertainty avoidance	Javidan & Dastmalchian, 2003; Hofstede, 2005; Gable, 1959; Bar, 2004; Iran Nezad, 2006
Strong orientation toward getting success and superior performance	Javidan & Dastmalchian, 2003; Bar, 2004
Low level of foresight and a short-term trends	Javidan & Dastmalchian, 2003; Bar, 2004; Yeganeh & Sue, 2007; Homayoun & Katouzian, 2005
Care about for human dignity	Gable, 1959; Javidan & Dastmalchian, 2003 Iran Nezad, 2006
Low trust towards each other	Gable, 1959; Keddie, 2002; Javidan & Dastmalchian, 2003; Bar,2004; Yeganeh & Sue, 2007 Sari al-Ghalam, 2007
Valuing rationality and yet operating emotionally	Iran Nezad, 2006; Bar, 2004
Valuing hard work and enthusiasm and yet escape from liability	Mohseni, 2000; Bar, 2004; the findings of the surveying in 28 provinces of Iran: Iranian values and attitudes, 2001

Hofstede's study placed Iranian culture in the bureaucratic culture with tendency to participatory and tribal culture. In a survey by the Mehraban Far and Noubari (2013), unlike Hofstede, who selected an organization as his target population, managers of Industries and Mines, Islamic Guidance, municipal council members, centers

of 30 provinces were selected as the target population with 745 persons. The purpose of this work was to compare the conditions in the two periods in 1980 and 2006, the following results were obtained:

- In power distance dimension: 64% orientation towards high power distance
- In uncertainty avoidance: 87% orientation towards very high uncertainty avoidance
- In collectivism: 82% orientation towards collectivism
- In masculinity: 67% orientation towards masculinity

The comparison between the results of research in a 27-year interval:

- Score of power distance from 52 to 64
- Score of uncertainty avoidance from 53 to 87
- Score of individualism from 18 to 45
- Score of masculinity from 45 to 67 is reached.

Increasing the Iranian culture's orientation in the past 27 years to the high power distance, high uncertainty avoidance, high masculinity and high collectivism represents the consolidation of culture in passing the previous years.

The GLOBE study by House et al. 2004 and Kokar et al. 2007 is one of the most prestigious studies of cultural dimensions on the global level. In these two studies, Iran's rank in 9 dimensions is as following: Activism with a high-ranking number 4.58 (expressing the tendency to very high welfare), foresight with a very low number 3.70 (stating the lack of attention to planning for the future), gender equality with a lower rank number 2.99 (stating the dominance of men in different areas), boldness with a median number 4.04 (represents low boldness in activity), individualism and collectivism with a relatively moderate number 3.88 (represents high collectivism), power distance with a high-ranking number 5.43 (represents a very high power distance), humanism with a high-ranking number 4.23 (stating the obviousness of people's emotions to each other), uncertainty avoidance with a relatively high ranking number 3.67 (stating the lack of attention to innovation and willingness to past methods) are estimated.

Eimay (2007) evaluated the effects of cultural intelligence (Note 1) (understanding cultural differences) on the effectiveness of intercultural business negotiations among western Asian and American negotiators, in that cultural intelligence is introduced as a key factor in the effectiveness of intercultural negotiation. Exploratory analyzes of this study suggest that individuals with cultural intelligence, have a stronger predictive power than others. Because, cultural intelligence is the capacity that allows individuals to have a good understanding of a wide range of cultures and appropriately act (Thomas, 2006).

According to above contents and thinking about stated objectives in order to communicate successfully with other countries, cultural dimensions must be considered. Based on this conceptual model can be presented as follows.
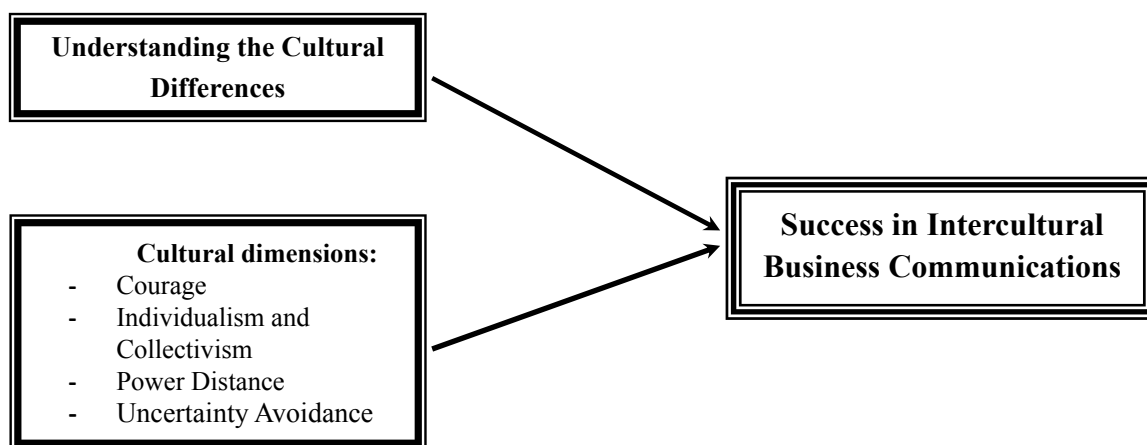
Figure 1. Conceptual model

3. Research Methodology

This study is a practical in terms nature and purpose, and is descriptive, and library study in terms of data collection. 92 questionnaires were distributed between economic activists (including commercial managers of

350 companies listed in Tehran Stock Exchange and members of the Chamber of Industry and Mines) and analyzes were performed on these questionnaires. In this study, researchers operated five variables for the hypothesis test. GLOBE study standardized questionnaire (2004) was used to assess the cultural dimensions and Cultural Intelligence Questionnaire of Ang et al. (2004) was used to assess the understanding of cultural differences. This questionnaire has been used in several studies in Iran. Reliability and validity of this questionnaire have been approved by Kazemi (2008), Vedadi et al. (2009) and Taslimi et al. (2009) (Eghdampour, Mehrdad & Jafari, 2011).

Fifteen economic indicators for the fifteen countries in this study include; Gross domestic product, added value in agriculture, added value in mining and industry, added value in services, percentage of non-governmental consumption costs, percentage of governmental consumption costs, percentage of gross capital formation, percentage of the exports value, percentage of the imports value, percent growth of the liquidity increase, percent growth of the liquidity increase to GDB, percentage of interest rate on investment in one year (short-term), the growth of consumer total index (inflation), the growth of foodstuffs index, the growth of manufacture index. This data for Iran was used from the database of the Central Bank of Iran and for other Asian countries was used from published information by the Asian Development Bank. In Table (2), number of designed items to measure cultural dimensions for Iran, Cronbach's alpha and reliability of aspects were presented. It is noteworthy that cultural aspects information of other countries exist in GLOBE book (2004), which has been used.

Table 2. Cronbach's alpha coefficient and reliability of the cultural dimensions

Dimensions	Number of items	Cronbach's alpha
Boldness	8	0.803
Uncertainty avoidance	8	0.822
Power distance	12	0.722
Individualism and collectivism	12	0.746
Understanding the cultural differences	19	0.840

Note. As can be seen, Cronbach's alpha coefficients of all dimensions in this study is more the minimum value of 0.6 (Nunnally, 1978), 0.65 (Lee & Kim, 1999).

3.1 Assessment of Structural Validity

To assess the structural validity, confirmatory factor analysis is used (Houman, 2008, p 17). The validity of the cultural dimensions was assessed using LISREL software. This software is measured using correlation and covariance and it can estimate or infer factor loading values, the variances and latent variables errors and it can be used for confirmatory factor analysis and etc. In the confirmatory factor analysis, experimental data are described, explained and justified based on a relatively small number of parameters. This model is based on experimental information about the structure of the data. The study has five cultural dimensions. All these aspects are latent variables and their measurement is determined using a structural model. Figures one to four show the confirmatory factor analysis using LISREL software.
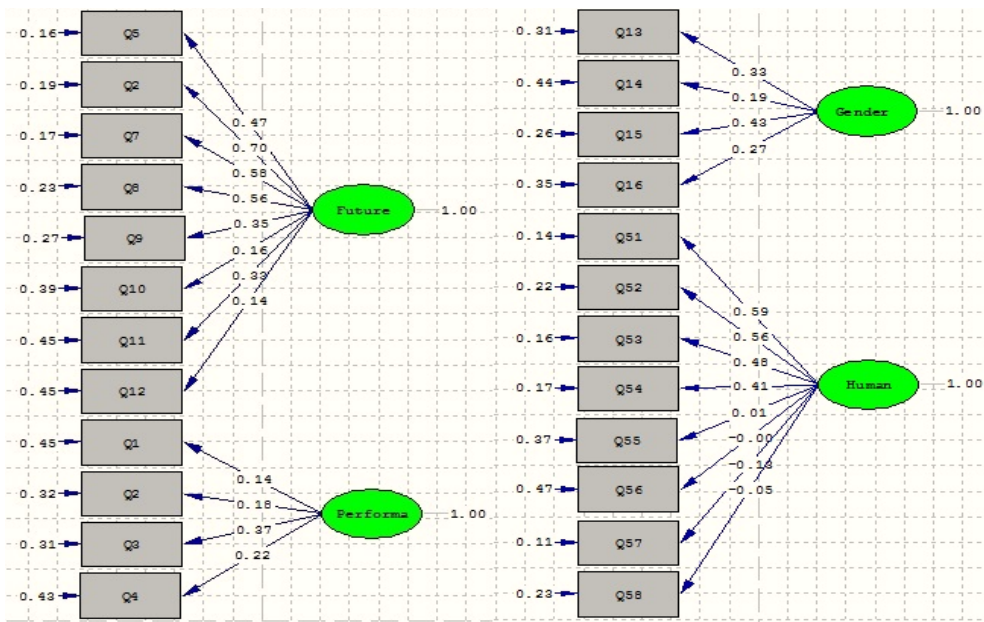
Figure 2. Factor loadings of the questions of cultural dimensions in the confirmatory factor analysis

Figure 2 shows the values of the factor loadings. Factor values more than 4.0 are acceptable.
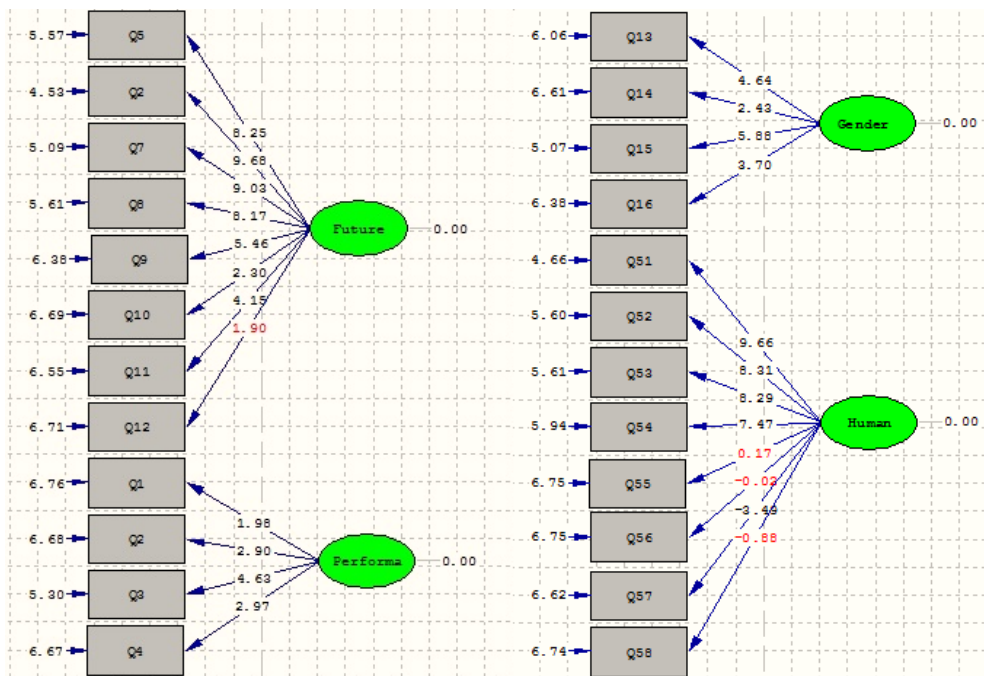
Figure 3. T value of the questions of cultural dimensions in the confirmatory factor analysis

Figure 3 shows the T values. Based on these results it is evident that the first indicator of power distance dimension is not important to measure the structure of power distance, because the value of T is less than 1.96 and it should be removed from the model. Also, the third structure for avoidance dimension and fifth, sixth and tenth structures for collectivism and individualism dimension is not important. After removal of these structures, require analysis is performed.
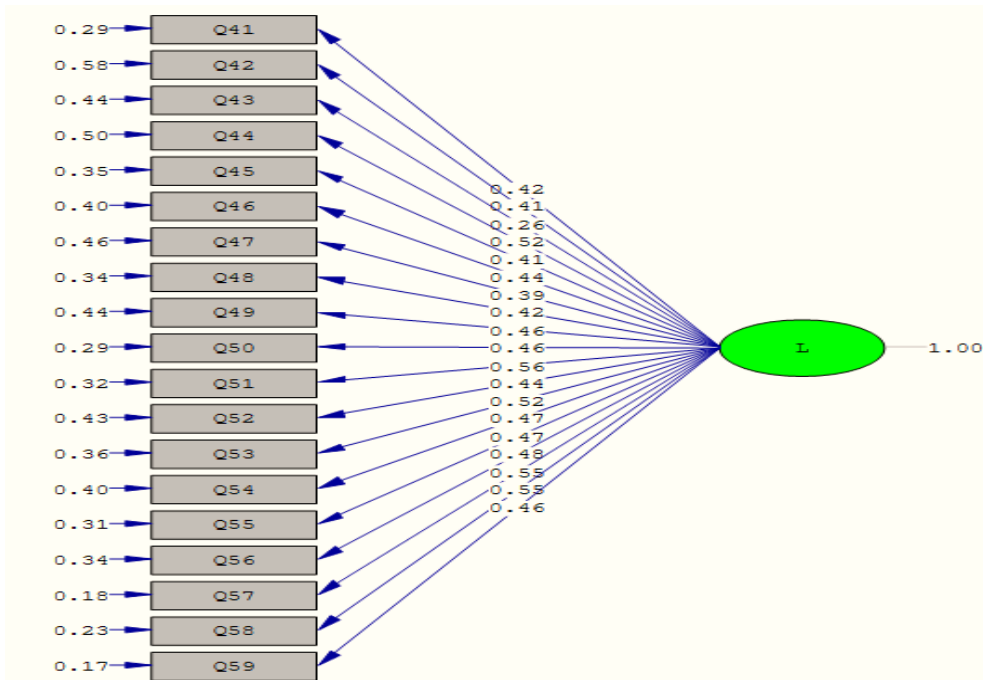
Figure 4. Factor loadings of the questions of understanding cultural differences in the confirmatory factor analysis
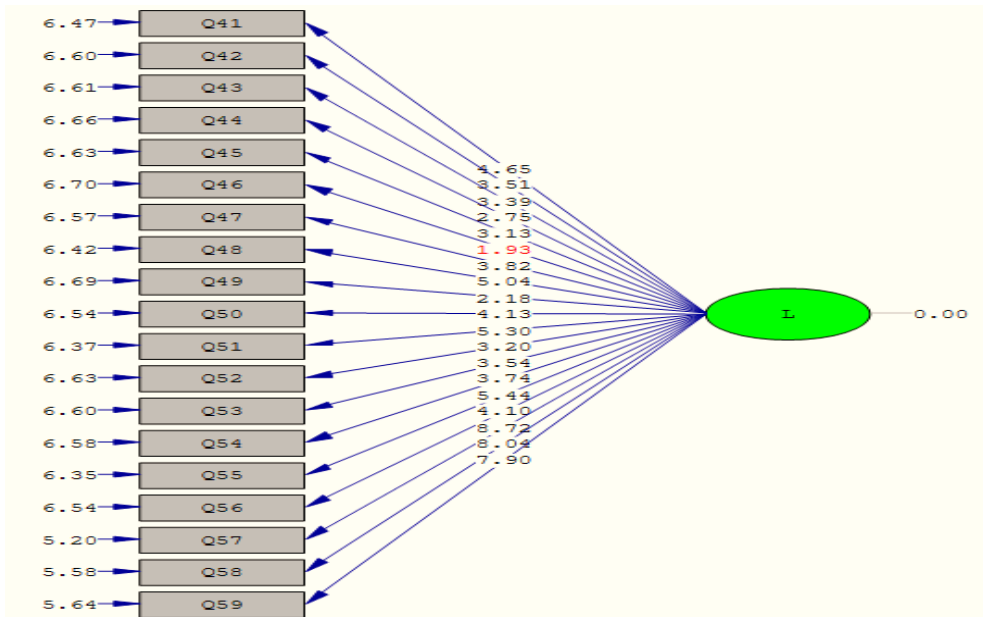
Figure 5. T value of the questions of understanding cultural dimensions in the confirmatory factor analysis

Figure 5 shows the T values. Based on these results it is evident that the seventh indicator of understanding cultural differences dimension is not important to measure the structure of understanding cultural differences, because the value of it is less than 1.96 and it should be removed from the model. After removal of these structures, require analysis is performed.

3.2 Expression of Subjects

Specifications of respondents were examined by four variables of age, gender, education and work experience. 90% of respondents were male and 10% were female. 30% of respondents aged between 24 and 27 years, 27%

of those between 28 to 32 years, 13% of those aged between 33 to 37 years and 30% were older than 37 years. 50% of respondents were Bachelor of Science, 40% were Master of Science and 10% were PhD. In terms of work experience of about 10% have served between 3 and 5 years, 40% have served between 6 and 9 years, 30% have served between 10 and 13 years, 15% have served between 14 and 17 years and 5% have served more than 17 years.

3.3 Data Analysis and Hypothesis Tests

Linear regression is used to modeling the value of a dependent variable based on its linear relationship to one or more predictor. The linear regression model assumes that there is a linear relationship (or straight line) between each dependent variable and predictor variable. This relationship is illustrated in the following formula (Houman, 2008).

$$y_i = b_0 + b_j x_{ij} + \ldots + b_p x_{ip} + e_i$$

In which;

y_i: Is the value of ith dependent variable.

P: Is the number of predictors.

b_j: Is jth coefficient, j = 0, ..., p

X_{ij}: Is jth value of the ith predictor.

ei: Is the error in the ith observed value.

In this study, the economic indicators are the dependent variables and the cultural dimensions are the independent variables. Using multiple linear regressions cultural dimensions of economic indicators were evaluated.

3.4 Research Findings

The multiple linear regression is used in order to evaluate the impact of cultural dimensions on intercultural business communication. The results of the calculation are reported in Table 3:

Table 3. Table of regression coefficients of cultural dimensions impacts on intercultural business communication

Dependent variable	Independent variable	Regression coefficient	T value	Significant level
	Boldness	0.003	2.68	0.008
	Uncertainty avoidance	0.011	8.23	0.000
Intercultural business communication	Power distance	-0.009	-2.42	0.016
	Individualism and collectivism	0.005	3.11	0.002
	Understanding cultural differences	0.003	1.81	0.071

Table 4. The results of the main hypotheses tests of the research

No.	Hypothesis	Results
1	Societies that have high boldness significantly are more successful in intercultural business communication.	Approval
2	Societies that have high individualism significantly are more successful in intercultural business communication.	Approval
3	Societies that have low power distance significantly are more successful in intercultural business communication.	Approval
4	Societies that have low uncertainty avoidance significantly are more successful in intercultural business communication.	Rejection
5	Societies that have high understanding of the cultural differences significantly are more successful in intercultural business communication.	Rejection

According to the results in Table 4, whatever the boldness increases, power distance decreases and individualism increases in the societies, their success in intercultural business communication becomes higher.

4. Conclusion

The results show that, boldness has the most impact on gross domestic product, percentage of gross capital

formation, percent of the value of exports and imports and has the least impact on the percentage of non-governmental consumption. So the countries who want to increase their gross domestic product, they should increase the boldness in the organizations' members. Because, boldness leads to the adoption of entrepreneurial orientation. Thus, societies with more courage in the organizations have better reactions in dealing with the ups and downs of business and trade. This issue is regarded as one of the cultural and moral driving forces like an engine for growth. Another point is that, economically the more rewards belong to organizations that increase the profits or reduce costs of production. This property theoretically has a strong and positive relationship with the decisiveness and boldness and has an inversed relationship with uncertainty avoidance. Therefore, it is recommended that, organizations which emphasize on being a leader in the markets (both internal and external), should hire managers with higher boldness and decisiveness and they should also strengthen these features in their cultural programs.

The results of the research show that, individualism has the most positive impact on the added value in mining and industry and then power distance has the most negative impact. Collectivism has the most positive impact on the added value in services, percent growth of the liquidity increase to GDB and the growth of consumer total index (inflation). Therefore, the results of research on the effects of collectivism and power distance were in line with the theoretical expectation of researchers. Basically the issue of individualism and collectivism is the most important factors that can be realized by means of the differences between the societies. One of the major consequences of collectivism for economic growth is preference of the interests of the organization or group to the individual interests. This causes that, innovation and risk taking be in a more suitable position than individualism. Individualism leads to solitary, preferring individual interests over group interests, risk aversion, an increase in the total error and the loss of industrial competitiveness. This in turn, leads to a decrease in exports and a decline in national production.

The negative impact of power distance can also be interpreted in the same direction. Basically, in groups and organizations that authoritarianism and centralization of power is higher, more individualism is seen and loyalty to the group is reduced and this is the negative effect that is accrued from individualism. It should be noted, though, individualism has a positive effect on entrepreneurship; but because of high power distance and a lack of profits raised from economies scale, these positive effects can be transient and unstable and doesn't ensure the sustainable growth of society.

Scholars such as Fukuyama (1999), Inglehart (1999), Biogls Dick et al. (2002) and Bengtson et al. (2005) believe that, one of the indicators of economic development is decreasing the cost of uncertainty and consequently increasing the trust. Because, in a society where trust is decreased, uncertainty avoidance will increase. People are extremely conservative, and innovation will decline (Rahmani & Amiri, 2007).

Also, several studies in the field of management in the 21st century represent evidence of strong positive relationship between competence of cultural understanding and commercial success in economic growth (Hofstede, 2001; Thomas & Inkson, 2003; Tan, 2004; Peterson, 2004). Because, cultural differences have emerged as potential sources of conflict, in a way that, in the absence of clear understanding makes it difficult to develop a good business relationship (Trendys, 2006). Therefore, cultural diversity management in various business activities such as business communication (Gudykunst, 2003) and trade negotiations are used (Thomas & Inkson, 2003; Peterson, 2004; Ferraro, 2006).

In the results of the study, two hypotheses concerning the relationship between uncertainty avoidance and understanding cultural differences in business communication success are not accepted. This contrasts with the results of the study that some of them were noted. Therefore, it can be concluded from the implicit findings of the research that Iran, according to data released by the World Bank (Note 2), is economically in transition (or developing). In the developing countries, high uncertainty avoidance leads to lower levels of trust in the society. On the other hand, the scientific and practical abilities of the immigrated elite were unused in the business communications or the power of their influence is very limited. As a result, understanding of cultural differences will lose its effectiveness to develop the business communications (Rahmani & Amir, 2007).

According to the above contents and importance of cultural dimensions; culture is a set of values, beliefs and opinions in a society that has the ability to influence and affect. The culture of a society doesn't form instantaneous and immediately. When it is formed, it doesn't disappear immediately. Thus, whatever the foundations of the cultural identity of a society be stronger, its effects on society will be less. On the other hand with the spread of globalization, increasing interdependence and interconnectedness of countries for economic development, people at all levels of the organization should be empowered through the cultural preparations.

At the organizational level, structural empowerment should be created. In this method the structures should be

shattered, in the way in which the cultural dimension of power distance decreases and a structure is created, in which all people equally have the chance to be empowered.

At the management level, empowerment for participation in decision-making is delegation (strengthening the dimension of collectivism), which is called functionalist empowerment.

In humanist empowerment, with emphasis on human values and attention to the human and his dignity, it is tried to eliminate the root of the disability and intends to provide all empowerment aspects for them (strengthening the dimension of boldness) and increases the capacity of members to embrace innovation and change (management of the cultural dimension of uncertainty avoidance). Finally, strengthening the cultural dimensions leads to the understanding the cultural differences (Aarabi & Fayazi, 2008).

For future research it can be suggested that:

- Evaluation the nine dimension GLOBE studies in non-governmental organizations and institutions and its impact on their success
- Evaluation and comparative study about the relationship of cultural dimensions and economic development in the GLOBE studied countries.
- Evaluation the effects of cultural dimensions of the GLOBE study on scientific development in the country
- Evaluation and comparative study of the impacts of cultural dimensions of the GLOBE study in governmental and non-governmental organizations

References

Aarabi, S. M., & Hedayati, S. H. (2009). Strategy model based on the culture. *Journal of Human Resource Management University of Imam Hussain (AS), 1*(3), 145-127.

Aarabi, S. M., & Omid, M. (2008). The edition methodology and deployment the strategy of human resources empowerment in Iran's context of culture. *Journal of Human Resource Management University of Imam Hussain (AS), 1*(1), 18-1.

Aarabi, S. M., & Omid, M. (2009). Human resources strategy, national culture and organization challenges. *Human Resources, 2*, 20-29.

Abzari, M., & Khani, A. (2010). Cultural intelligence, dealing with differences. *Journal of Management Era, 16-17,* 57-52.

Ameli, S. R. (2004). Global Space: Powerfulness & Powerlessness of Cultures, University of Tehran. *Journal of Social Science*, *22*(11), 99-81.

Ameli, S. R. (2007). The major challenge of cultural engineering. *Cultural Engineering Magazine, 10-11,* 18-25.

Beigi, A. H. (2011). Assessment of the factors affecting the cultural preservation of the Islamic Republic of Iran. *Strategy Journal, 58*, 366-335.

Chhokar, J. S., Brodbeck, F. C., & House, J. R. (2007). *Culture and Leadership across the World: The GLOBE Book of In-Depth Studies of 25 Societies.* New Jersey: Lawrence Erlbaum Associates, Publisher.

Dadmehr, L. S. (2010). The impact of technology on organizational communication. *Bank, 51-50*, 112-106.

Ebrahimian, S. H. (2012). Rereading cultural engineering and cultural pathology in the higher education system. *Soft Power Studies, 5*, 150-121.

Eghdampour, A., Mehrdad, H., & Jafari, H. (2011). Reviewing the relationship between personality traits and cultural intelligence of Lorestan province's Heritage, Handicrafts and Tourism personnel. *Journal of Educational Psychology, 2*(1), 181-101.

Eisenberg, E. M., Goodall, H. L. & Trethewey, A. J. R. (2010). *Organizational Communication* (6th ed.). New York: Boston.

Faghihi, A., Vaezi, R., & Aghaz, A. (2010). Focusing on the interaction between the bureaucracy and the culture in Iran. *Journal of Management Sciences, 19*, 31-1.

Fani, A., Babashahi, J., Afkhami Ardakani, M., & Ebrahimi, M. (2012). Promoting entrepreneurship, analyze the role of the cultural model parameters Globe. *Entrepreneurial Development, 5*(2), 144-125.

Ghaheri, R. (2010). Globalization and Education. *Culture and Globalization Research, 1,* 71-98.

Gudykunst, W. B. (2003). *Cross-Cultural and Intercultural Communication, Thousand Oaks.* CA: SAGE,

Yarmouth, ME: Intercultural Press.

Hamidi, M., Andam, R., & Feizi, S. (2013). Cultural intelligence aspects of volunteers in sport. *Sport Management, 5*(3), 20-5.

Hofstede, G. (2001). *Culture Consequences: Comparing value, Behaviors, Institutions and Organization Cross Nation, Thousands Oaks.*

Houman, H. A. (2008). Structural equation modeling using Lisrel, Tehran: The Side.

House, J. R., Hanges, P. J., Javidan, M., Dotfman, P. W., & Gupta, V. (2004). *Culture, leadership and organizations (The GLOBE study of 62 Societies)*. London: SAGE Publications.

Hwang, B. Y. (2005). Globalization, Strategic Culture, and Ideas: Explaining Continuity in Kore and Foreign Economic Policy, Unpublished Ph. D, Georgetown University. United State, Washington.

Imai, R. (2007). The Culturally Intelligent Negotiator: The Impact of CQ on Intercultural Negotiation Effectiveness, Thesis, University of Maryland.

Jaros, S. (2010). Commitment to organizational change: A critical review. *Journal of Change Management, 10*(1), 79–108.

Johich, M. (2002). *Organization theory: Modern, symbolic, interpretive, postmodern* (H. Danaei Fard, Trans.). Tehran: Publishing Opinion.

Khanifar, H., Zarvandi, J., & Zarvandi, N. (2010). Globalization and messianic Culture views of the Qur'an and Islamic tradition. *Promised east, 4*(16), 91-115.

Lee, J. N., & Kim, Y. G. (1999). Effect of Partnership Quality on IS Outsourcing Success: Conceptual Framework and Empirical Validation. *Journal of Management information systems, 15*(4), 29-61.

Liu, Y. (2012). Exploring the Impacts of Cultural Globalization on Cultural Awareness/Values and English, Writing in Chinese Context, *Intercultural Communication Studies, 2*(2), 110-94.

Mansouri Sepehr, R., Motiei, H., Shekarriz, J., & Nejati, V. (2013). Assessment factor structure and reliability of the questionnaire of cultural values. *Journal of Occupational and Organizational Consultation, 5*(15), 71-57.

Mcveli, J., Duberley, Zh., & Johnson, F. (2007). Organization theory: perspective and challenges (H. Danaei Fard, & S. H. Kazemi, Trans.). Tehran: University of Imam Sadiq (AS), Volume I and II.

Mehrban Far, A., & Noubari, S. (2013). The role of culture on entrepreneurial alertness in Iran using data from GEM, *Journal of Technology Management, 9*(34).

Mikami, K. (2011). *Cultural Globalization in People's Life Experiences: Japanese Popular Cultural Styles in Sweden,* Unpublished Ph. D, Stockholm University. Sweden, Stockholm.

Millar Wood, J. C. (2008). *The Impact of Globalization on Educcation Reform: A Case Study of Uganda*, Unpublished Ph. D, Maryland University. United State, Maryland.

Miller, K. (2011). *Organizational Communication: Approaches and Processes* (6th ed.). New York: Lyn Uhl.

Mostafavi, S. M. (1392). The effect of globalization on market opportunities for goods and solvent services (Brand). *Journal of Islamic Banking and Economics, 2,* 137-167.

Movius, L. (2010). Cultural Globalisation and Challenges to Traditional Communication Theories, University of Southern California, USA. *Journal of Media and Communication*, *2*(1), 18-6.

Nunnally, J. C. (1978). *Psychometric Theory* (2nd ed.). New York: McGraw-Hill.

Oughi, V. (2011). Collectivism and individualism of our culture messianic vision. *Islam and Management Research, 1*(2), 98 75.

Pazokizadeh, Z., & Tishehyar, M. (2010). Communication challenges in cultural relations. *Fantastic, 219*, 21-13.

Peterson, B. (2004). *Cultural Intelligence: A Guide to Working with People from Other Cultures.* London: Nicholas Brealey.

Pour Ezzat, A. A., Gholipour, A., Bagheri, M., & Naddaf, M. (2011). The effects of globalization on the trade policy of the Islamic Republic of Iran. *Journal of Business Management, 3*(10), 54-35.

Prado, & William, H. (2006). The Relationship between Cultural Intelligence and Perceived Environmental Uncertainty, Ph. D, University of Phoenix.

Rahmani, T., & Amiri, M. (2007). The effect of trust on economic growth in provinces with spatial econometric approach. *Journal of Economic Studies, 78,* 57-23.

Ranjkesh, J. (2010). Globalization. Paper presented at the Second Conference on Islamic Economics and development, Ferdowsi University of Mashhad, Mashhad.

Robinz, A. P. (1996). *Organizational Behavior* (AS. Parsaeian, SA. M. Arabs, Trans.). Tehran: Office of Cultural Research, 3.

Robinz, A. P. (1998). *Organizational Behavior* (AS. Parsaeian, SA. M. Arabs, Trans.). Tehran: Office of Cultural Research, 1.

Sadeghi, A., Jafari, H., Khodayari, R., Pakdaman, M., Mohammadi, R., & Ahadi Nezhad, B. (2011). The relationship between organizational culture and knowledge management. *Hospital Quarterly, 10*(2), 8-1.

Safiri, Kh., & Nematollahi, Z. (2012). The relationship between instruments of globalization and religious identity. *Social Studies and Research, 1*(1), 39-70.

Scott, R. (2003). Organizations: Rational, natural and open systems (H. Mirzai Ahranjany, Trans). Tehran: The Side.

Stoner, G. A. F., Freeman, R. A., & Gilbert, D. R. (2005). Planning, Management in the 21st Century (AS. Parsaeian, & S. A. M. Arabs, Trans.). Tehran: Office of Cultural Research.

Tajik, M. R., & Darvishi, F. (2004). Ideals of the Islamic Revolution in the Age of Globalization: Challenges and Responses. *Of Sociology, 5*(3), 140-171.

Tan, J. (2004). Cultural Intelligence and the Global Economy. *Leadership in Action, 24*(5), 19-21.

Tavakol Nia, M. R., & Zahedmehr, A. (2011). Analysis of the impact of globalization on the index of quality of life, QOL, based on data panel estimates for oil exporting countries. *International Journal of Strategic Studies, 3,* 19-26.

Thomas, D. C., & Inkson, K. (2003). Cultural Intelligence: People Skills for Global Business, San Francisco: Berrett-Koehler Publishers.

Tomlinson, J. (1999). Globalization and Culture. *University of Chicago Press.*

Tourish, D., & Hargie, O. (2004). *Key Issues in Organizational Communication* (6th ed.). New York: Routledge.

Triandis, & Harry, C. (2006). *Cultural Intelligence in Organizations, Group & Organization Management, 32*(1), 20-26.

Turner, B. (2004). The sociology of cultural resistance to globalization: strong aesthetic/ weak structure. *Journal of Social Science, 11*(2), 17-32.

Wang, Y. (2007). Globalization Enhances Cultural Identity. *Intercultural Communication Studies, 6*(1), 83-86.

Zahedi, Sh. A. (2011). Globalization and sustainable development. *International Journal of Strategic Studies, 3,* 1-18.

Notes

Note 1. It is worth mentioning that in America, as well as scholars and experts in this field, commonly use the term CQ stands for Cultural Quotient for this phrase.

Note 2. www.worldbank.org

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Improvement of Orchid Vanda Hybrid (*Vanda limbata* Blume X *Vanda tricolor* Lindl. var. *suavis*) by Colchicines Treatment *in Vitro*

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Abstract

The purpose of this research was to evaluate the growth phase of orchid Vanda hybrid (*Vanda limbata* Blume X *Vanda tricolor* Lindl. var. *suavis*) response with colchicines treatment, to determine precise effective concentration of colchicines and duration of treatment to induce polyploidy. This research used variation of colchicines concentration which were 0.01%; 0.05%; 0.1%; 0.5%; 1% and 0% and incubation for 6 hours; 12 hours; 18 hours; 24 hours; and 4 days. Treatment was done in aseptic condition using protocorm aged 7 week after sowing. After treatments, plants were planted on Vacint and Went (VW) medium supplemented with of 150 ml/l coconut water. After four months, plants were subcultured in medium VW + 150 ml/l + 150g/l banana extract. The results showed that the orchid Vanda hybrid was intolerant to colchicine concentration of 0.1; 0.5 and 1% by death protocorm was more than 50%. Concentration of 0,5% with 6 hours soaking time is the most effective to induced tetraploid in orchid Vanda hybrid. Morphological characters of tetraploid plantlets had lower average number and length of roots, number, length, and width of leaves than those of control. Anatomical characters of tetraploid plantlets revealed the highest stomatal size and had smaller of stomatal index than controls. This evident indicated a negative correlation between stomatal index and ploidy level. Cytological analysis with *flow cytometry* revealed that tetraploid plantlets (2n=4x=76) stained with DAPI showed the chromosome number more than those of control (2n=2x=38).

Keywords: polyploidization, colchicine, Vanda orchid, chromosome number

1. Introduction

Indonesia is a country that is very rich in diversity of species and varieties of various horticultural crops, one of them is orchid. Of the 20,000 species of orchids in the world, Indonesia has about 5000 species of wild orchids (Irawati, 2002; Schuiteman, 2010). The types of orchids that have been received in the international market, among others Dendrobium, Arachis, Cymbidium, Phalaeonopsis, Vanda, and Oncidium (Nurmalinda et al., 1999). *Vanda* limbata Blume and Vanda tricolor Lindl. var. suavis is a local orchid of Indonesia which has a superior characters as the parent crosses, so expect through crossbreeding both local Indonesian orchid species will be produced orchid hybrids that have diverse properties because it comes from a different species. Quality improvement of orchid can be achieved by genetic improvement through crossing, while quantity improvement can be done by propagation through in vitro culture, number of seedlings obtained more in a relatively short time.

Development of orchids can be done through mutation and transgenic. Genetic mutations are increasingly being used to produce new varieties with physical characteristics and particular phenotypes, such as changes in growth, flower color, increase in size and adaptability. One of mutation techniques can be applied to plants is a chemical mutation using colchicine compound. Treatment with colchicine mutation would cause a duplication of chromosomes (polyploidization) followed by an increase in the size of the cells and tissues of plants. Polyploid orchids generally showed more characteristics compared to its diploid type. Some of the characters are related with polyploidy is an increase in vigor and plant resistance to pests and diseases, the size of the larger flowers and flower colors are more vivid, and the vitality of flowers longer than the type diploid (Zainuddin, 2006; Silalahi, 2011). The method used in this research is explant immersion technique is protocorm in a solution of colchicine that has been dissolved in a liquid medium. Various of concentration and length of immersion was

conducted to determine the optimum concentration and soaking time that can produce the highest percentage of cells undergoing changes become polyploid.

2. Materials and Methods

Materials used in this research were protocorm aged 7 Weeks After Sowing derived from F1 seed germination from crossing of *Vanda* limbata Blume X Vanda tricolor Lindl. var. suavis on medium Vacint and Went (VW) containing 150 ml / L of coconut water.

2.1 Colchicine Treatment

Protocorm were treated at a concentration of 0.01; 0.05; 0.1; 0.5; 1% with long time 6, 12, 18, 24 hours and 4 days. Control plants soaked in a VW liquid medium without colchicines. Soaking stopped when compliance with the time variation of each treatment and washed with distilled water three times and placed in a petri dish which was covered with filter paper, waiting for it to dry before planting again to VW solid medium. The cultures were maintained under continuous white light at of 25^0C.

2.2 Plant Regeneration

After the colchicine treatment, explants were grown on VW solid medium enriched 150 ml / L of coconut water. After two months, protocorms were subcultured on medium protokorm VW + coconut water 150 ml / l + banana extract 150 g / l for 4 months.

2.3 Evaluation of Stomata Size, Stomata Index and Morphology

Anatomical analysis done by making preparations in the lower epidermis of leaves using glue ALTECO. Orchid plant leaves are cut with a scalpel as much as a leaf blade and then made pieces rectangles with a size of $\pm$ 1 x 1 cm. Samples were placed on a glass object that has been given glue ALTECO, wait for 30 minutes. Samples removed with tweezers (Andini, 2011). Mixture was observed with a microscope with a magnification of 40X, images taken using opti lab.

2.4 Determination of Ploidy Level

2.4.1 Staining with DAPI (*4,6-diamidino-2-phenylindole* dihydrochloride*)*

Chromosome preparation is done by cutting root tip $\pm$ 3-4 mm then inserted into the tube containing carnoys solution and incubated at 4^0C for 15 minutes. Samples were washed with 50% ethanol solution to remove carnoys. Solution of DAPI included 100 mL and incubated for 15 minutes. The sample is placed on a glass object and then drops of glycerin and covered with a deck glass. Squashing process conducted with the tip of the brush to form a single layer cells. Mixture was observed with inverted microscope and documented through optilab. Slide preparation are stored in boxes and placed at 4^0C.

2.4.2 Analysis of Flow Cytometry

Samples were analyzed is the leaf of orchid Vanda hybrid plantlets $\pm$ 6 months old. Leaves chopped in a petri dish which has been given 1 ml of buffer solution OTTO I (0, 1 M citric acid monohydrate 4,2 gr, 0,5% (v/v) Tween 20 1 ml). Sample is filtered using 30 μm nylon mesh filter into the eppendorf tube. The filtered solution was incubated $\pm$ 1 minute and centrifuged 5000 rpm for 5 min, the supernatant was discarded and then added solution of OTTO II buffer (0.4 M Na2HPO4.12H2O 28.65 g) to 500 mL. The solution was homogenized and poured into the cuvet. The solution added propidium iodide 100 mL and 100 mL RNase. Samples were analyzed by Flow Cy space.

2.5 Statistical Analysis

Data were analyzed using analysis of variance (ANOVA). Significant differences among treatments were detected using Duncan's Multiple Range Test (DMRT) at the 0, 01 or 0, 05 level of probability (Gomez & Gomez, 1995).

3. Results

3.1 Survival Level

Protocorm tolerance 0.01 to 0.05% colchicine in the treatment of 6, 12, 24 hours, and 4 days with a survival rate above 50%, but treatment 18 hours increased to 0.1% (Figure 1).
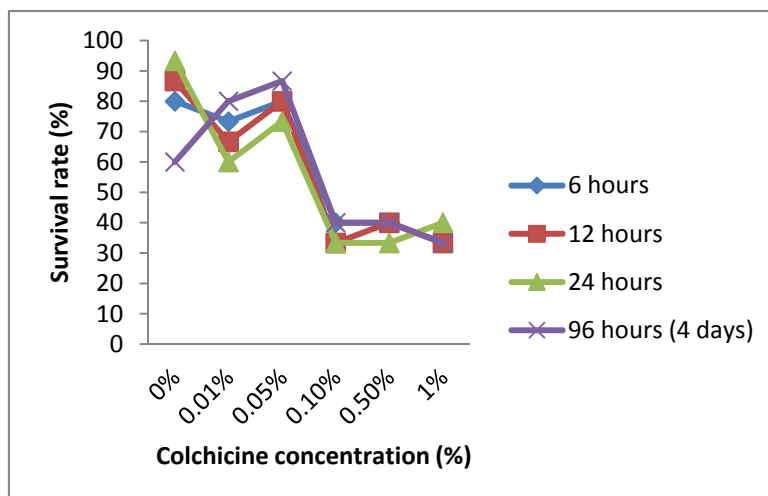
Figure 1. Survival rate of protocorms at various colchicine concentration

3.2 Morphological Analysis

Interaction between concentration of colchicines with soaking time significantly affected on morphological characters. Colchicine treatment decreases the amount of root, root length, number of leaves, leaf length and width of leaves. This is shown at the treatment of colchicine concentration of 1% for 24 hours and 4 days resulted average number of roots as much as 1 less than the controls had a average number of roots 3 (Figure 2A and 2B).
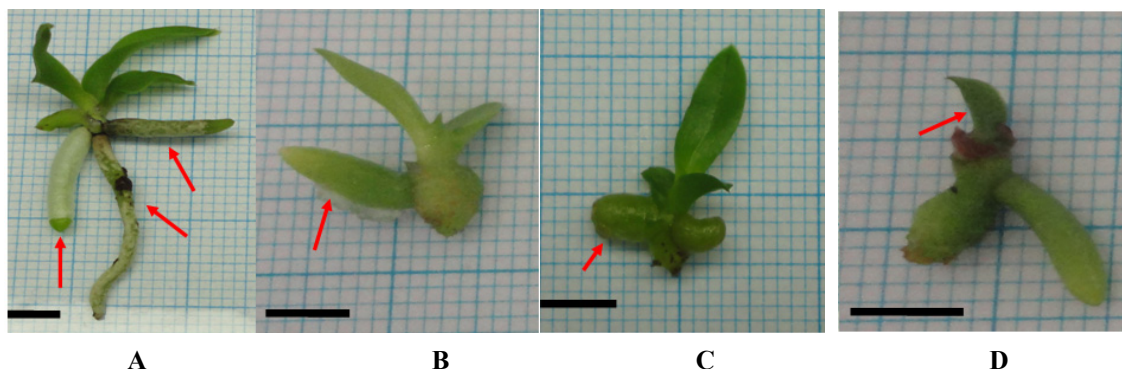
Figure 2. Orchid Vanda hybrid ± 6 months old, A) Control; B) and C) Colchicine 1% for 4 days

Note. The red arrow show character root changes. Bar: 0, 5 cm.

Root length on all variety of concentration and duration of colchicine treatment is smaller than control with a mean length of the roots were 1 cm. The smallest root length was obtained at the concentration of 0.1% for 4 days, 0.5% for 12 hours and 4 days and 1% for 24 hours and 4 days. Root observation in the control and different colchicines treatment, the colchicine treatment have roots that swell and appear thicker and shorter than the size of the control (Figure 2C). Number of leaves decreased at concentrations of 0.5 and 1% with 4 day long treatment compared to control as much as one piece with the average number of leaves 4 strands (Figure 2D).

3.3 Anatomical Analysis

The length and width of the highest stomata obtained at a concentration 1% with long colchicine treatment 24 hours compared with controls. Average length of stomata at 1% colchicine treatment for 24 hours was 170.32 μm and width stomata 118.31 μm. Stomata length obtained in the control plants was 92.6 μm and increased after treated with colchicine 1% for 24 hours to 170.6 μm (Figure 3A). The width of stomata also increased from 95.8 μm becomes 118.0 μm (Figure 3B).

A   B
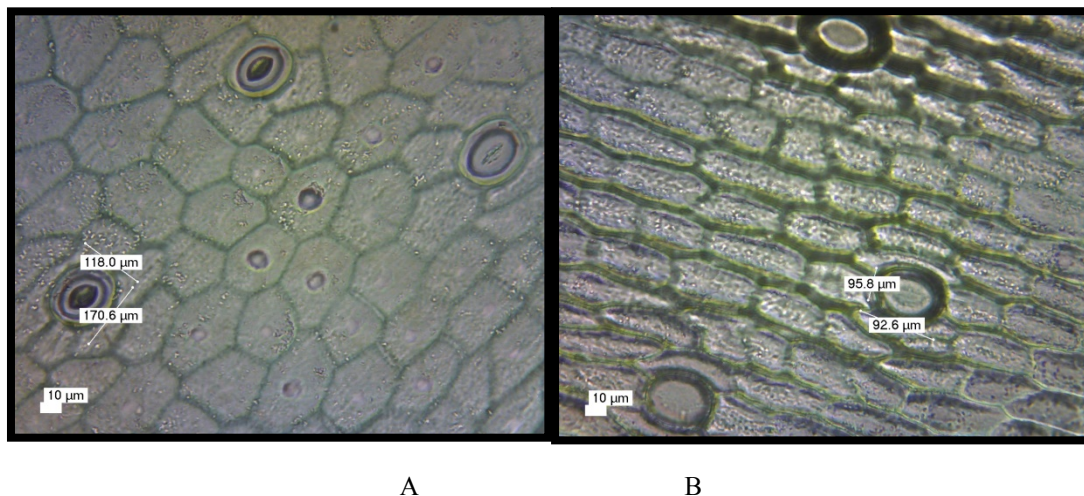
Figure 3. Effect of colchicines on length and width stomata orchid Vanda hybrid

Note. A. Control; B. Colchicine 1% for 24 hours.

3.4 Cytological Analysis

The calculation result of chromosomes by staining with DAPI (4, 6-diamidino-2-phenylindole dihydrochloride) after treatment colchicine concentration of 0.5% for 18 was 58. This evident that colchicine successfully induce polyploidisation by folding number of chromosomes (Figure 4). The number of chromosomes that undergo folding followed by increasing the diameter of the cell nucleus. It looks after colchicine treatment, diameter of the cell nucleus in control plants was 130.1 μm increased 162.3 μm after treatment colchicine concentration of 0.5% for 6 hours (Figure 5).

A   **B**
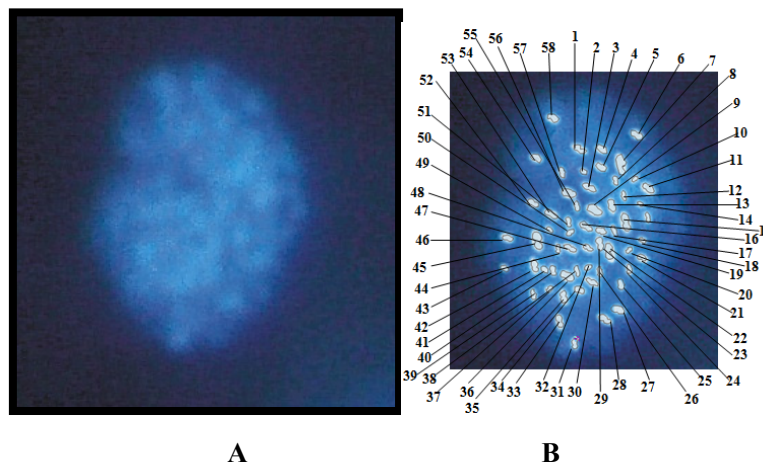
Figure 4. Number chromosomes of orchid Vanda hybrid at colchicines 0.5% for 18 hours

Note. A. Before reconstruction; B. After reconstruction.

A   **B**
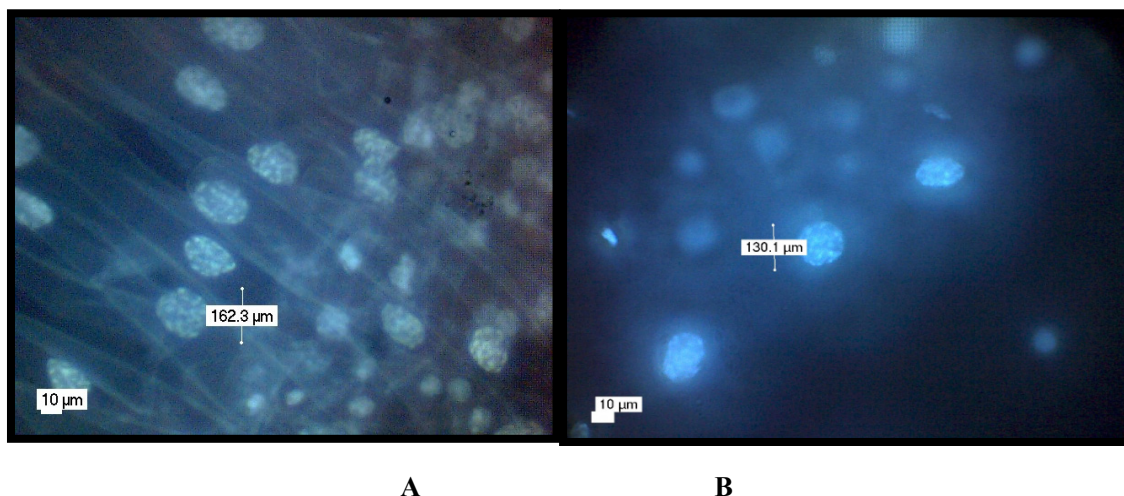
Figure 5. Diameter of nucleus orchid Vanda hybrid

Note. A. Control; B. Colchicine 0.5% for 6 hours

Cytological analysis followed by flow cytometry also showed that colchicine evidently induce polyploidization on orchid Vanda hybrid. Control plants for ploidy analysis by flow cytometry derived from plantlets ± 4 months old. Results analysis of control plants presented in the form of DNA G1 peak at channel 200, which is set as standard 2C for diploid cells with a small peak at channel 400 as a characteristic of the peak G2 (Figure 6A). Treatment colchicine concentration of 0.5% to 6 hours soaking time produce tetraploid cells with G1 DNA peak at channel 400 and peak G2 at channel 800 (Figure 6B).
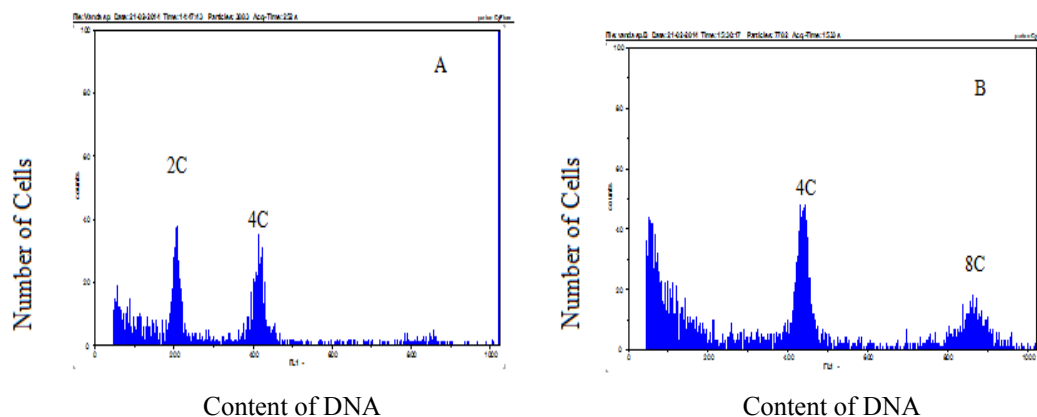
Figure 6. Flow cytometry analysis of orchid Vanda hybrid

Note. A. Diploid; B. Colchicine 0.5% for 6 hours.

4. Discussion

Protocorm resistance level after colchicine treatment depends on the concentration and duration of treatment given. According Atichart & Bunnag (2007) high concentrations and longer treatment time will decrease the survival rates of explants. Growth phase were treated with colchicine average does not show tolerance at a concentration of 0.1 to 1%. The same is stated by Sarathum et al. (2010), that colchicine concentration of 0.1% is very toxic for protokorm with the death rate more than 60%. According Atichart (2013), the use of high concentrations colchicine 0.1; 0.15 and 0.2% with longer treatment more than 24 hours will cause to reduced chlorophyll content and plantlets death after treated with colchicine.

Colchicine treatment at various concentrations showed browning occurs more rapidly than the control that occurs on average in the third week. The possibility as a result of colchicines treatment perceived threats that cause changes in plant physiological and biochemical. Plant reaction to this threat will induce defense

mechanisms, one of which is to produce phenolic compounds. According to Ebrahim et al. (2011), higher plants have mechanisms to protect themselves from various threats of physical, chemical and biological. This threat will cause to physiological changes in the plants are like strengthening the cell walls through lignifikasi, suberisation, and production of phenolic compounds. As Abdelwahd et al. (2008) states that the phenolic are secondary metabolites regulate plant growth and protect plants from abiotic and biotic stresses. An increase of phenolic compounds in response to the threat of colchicine would cause the accumulation of phenolic causing delays protocorm growth orchid Vanda hybrids.

Colchicine treatment significantly affected number of roots, root length and leaf length, that is high concentration and long treatment decreases the number of roots, root length and leaf length smaller than control. As Chen et al. (2009) stated that plantlets at a lower ploidy levels grew faster and bigger than plantlets which have higher ploidy levels in the same culture period. Oktoploid plant growth is very slow and very small in size compared to plants with low ploidy level.

According Omezzine et al. (2012) identification of polyploid plants can be known through the parameters of morphological, cytological, chemical and physiological. The same is stated by Wongpiyasatid et al. (2005), that length of stomata is an accurate indicator to determine the ploidy levels in some plant species. Size and number of stomata change significantly with the increasing number of chromosomes. Colchicine has been proven as a chemical compound used to induce polyploid on orchids. According to Alberts et al. (2008) colchicine cause depolymerization of microtubules thus inhibiting formation of threads of the spindle and chromosomes do not separate into cell poles at stage of anaphase resulting doubling of chromosome.

5. Conclusion

The results showed that the orchid Vanda hybrid was intolerant to colchicine concentration of 0.1, 0.5 and 1% by death protocorm was more than 50%. Colchicines concentration 0,5% for 6 hours is the most effective to induced tetraploidization in orchid Vanda hybrid (Vanda *limbata* Blume x Vanda tricolor Lindl. var. suavis). Tetraploid plantlets had lower average number and length of roots, number, length, and width of the leaves than those of control. Anatomical characters of tetraploid plantlets revealed the highest stomatal size and had smaller of stomatal index than controls. Cytological analysis with *flow cytometry* revealed that tetraploid plantlets (2n=4x=76) stained with DAPI showed the chromosome number more than those of control (2n=2x=38).

Acknowledgement

References

Abdelwahd, R., Hakam, N., Labhilili, M., & Udupa, S. M. (2008). Use of an Adsobent and Antioxidants to Reduce the Effects of Leached Phenolics In Vitro Plantlet Regeneration of Faba Bean L. *African Journal of Biotechnology, 7*(8), 997-1002.

Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2008). *Molecular Biology of the Cell* (5th Eds.). New York: Garland Science.

Andini, A. N. (2011). *Anatomi Jaringan Daun dan Pertumbuhan Tanaman Celosia cristata, Catharanthus roseus, dan Gomphrena globosa pada Lingkungan Udara Tercemar*. Bogor. Departemen Biologi FMIPA IPB, Indonesia.

Atichart, P., & Bunnag, S. (2007). Polyploid Induction in Dendrobium secundum (BI.) Lindl. By in vitro Techniques. *Thai Journal of Agricultural Science, 40*(1-2), 91-95.

Atichart, P. (2013). Polyploid Induction by Colchicine Treatments and Plant Regeneration of Dendrobium chrysotoxum. *Thai Journal of Agricultural Science, 46*(1), 59-63.

Chen, W. H., Tang, C. Y., & Kao, Y. L. (2009). Ploidy Doubling by In Vitro Culture of Excised Protocorms or Protocorm-Like-Bodies in Phalaenopsis Species. *Plant Cell Tissue Organ Culture, 98*, 229-238.

Ebrahim, S., Usha, K., & Singh, B. (2011). Pathogenitas Related (PR) Protein in Plant Defense Mechanism. *Science Againts Microbial Pathogens*, 1043-1054.

Gomez, K. A., & Gomez, A. A. (1984). Statistical Procedures for Agricultural Research.

Irawati (2002). *The Conservation of Orchid Species in Indonesia*. Indonesian Orchid Seminar, Yogyakarta, Indonesia, October, 20, 2002.

Nurmalinda, D., Widyastoeti, L., Marpaung, & Dan, D. M. (1999). Preferensi Konsumen terhadap Bunga Anggrek Potong di Jakarta. *Jurnal Hortikultura, 9*(2), 146-152 (*In Indonesia*).

Omezzine, F., Ladhari, A., Nefzi, F., Harrath, R., Aouni, M., & Haoula, R. (2012). Induction and Flow Cytometry Identification of Mixoploidy through Colchicine Treatment of Trigonella foenum-graecum L. *African Journal of Biotechnology, 11*, 16434-16442.

Sarathum, S., Hegele, M., Tantiviwat, S., & Nanakorm, M. (2010). Effect of concentration and duration of Colchicine treatment on polyploidy induction in Dendrobium scabrilingue L. *Europ. J. Hort. Sci., 75*(3), 123-127.

Schuiteman, A. (2010). *Orchid in Indonesia and Their Conservation*. Prosiding the 2010 International Seminar on Orchid Coservation and Agribusiness, Yogyakarta, Indonesia, October, 27, 2010.

Silalahi, R. L. W. (2011). *Induksi Poliploid pada Anggrek Dendrobium strebloceras dengan Kolkisin*. Fakultas Pertanian. Universitas Brawijaya, Malang, Indonesia.

Wongpiyasatid, A., Hormchan, P., Chusreeaeom, K., & Ratanadilok, N. (2005). Stomatal Size, Stomatal Frequency and Pollen Grain Diameter as Indirect Method for Identification of Ploidy Levels in Cotton. *Natural Science, 39*, 552-559.

Zainuddin, A. (2006). *Optimasi Proses PCR-RAPD Anggrek Phalaeonopsis sp. yang telah diperlakukan dengan Colchicine*. Jurusan Agronomi. Fakultas Pertanian. Universitas Muhammadiyah Malang, Indonesia.

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Studying Quality Factors of Townscape in Coasts (Case Study: Joffre Neighborhood Center in Persian Gulf Coast of Boushehr)

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Abstract

Men's tendency and requirement have been increased for being represented in natural areas in the city through industrialization and cities development. On the one hand, the necessity of surviving of urban damaged and dense areas and protecting and improvement of natural resources in cities and on the other hand, the townscape has been considered because of increasing the quality of urban spaces of environment in nature. Based on these views, surviving sea coasts, wharfs, green spaces, making connection among them and urban residential areas require coordination between environmental approaches and urban issues and solutions should be chosen to provide a balance among urban, aesthetic and ecology approaches. The present essay attempts to study the concept of townscape quality through descriptive-analysis method by considering Joffre coastal neighborhood center in western south of Boushehr as a part of coastal townscape and effective indicators on its quality and present solutions for promoting and improving the quality of coastal townscape in the studied part.

Keywords: townscape, coast, boushehr, Joffre neighborhood center

1. Introduction

The landscape of a city is a collection of natural and artificial factors that is formed through affection of natural, cultural, social, economic special features of that especial city and it is a place that special features change to reality. The townscape is an objective and real item as an introduced category in cities' quality and desirability and it is achieved through observing and understanding different and tangible manifestations of the city such as buildings, spaces, activities, voices, smells at the time of citizens' encountering with the city phenomena (in different scales including seeing the city from far distance or when they are located in city or even in buildings). The economic and social relations in cities have been led to emersion of new manifestations of townscape that sometimes are different from background culture and social origin of the region. Also, the coastal neighborhood center of Joffre in Boushehr is not exception. This neighborhood center which is located at the vicinity of Persian Gulf coast has been encountered with intensive physical and functional changes such as disruption of space structure, physical destruction of buildings and sometimes, complete destroying of spaces with native and un-static materials, disturbance in movement system between the neighborhood center and sea, the existence of incompatible usages in coastal line, the lack of collective-social service spaces in recent decades because of constructions without considering the neighborhood center location and structure and its citizens' profession.

2. Theoretical Basis

2.1 Quality

"Quality" is a word which has been understood in all art, scientific and industrial subjects intuitively and used in the framework of disputation in related areas continuously. This word is a two-faced concept; it is a clear and explicit and also multilateral concept. When it is used for tangible qualities such as hardness, softness, speed and etc., it has a clear and understandable concept, but when it is used for intangible qualities such as beauty, magnificence, effectiveness and etc. it will be changed to an evasive and multilateral concept. The extent of dimensions and sides of two mentioned states changes the concept of "quality" to a relative concept which has an extra and different meaning from its usual and obvious one (Golkar, 2000, p. 38).

Billings has explained the "quality" of a thing in this way: a collection of distinct features or characteristics that causes the differentiation of a thing from others and it makes us capable to judge about priority, similarity or inferiority of something in comparison with another thing. And aesthetically, we can judge about its beauty and obscenity, badness or goodness and practically about being better or worse and effective or non-effective (Billings, 1993, p. 2)

2.2 Townscape

The landscape is the result of human's interaction and environment in outside spaces. Studying the landscape or different dimensions of its perceptions is possible from methods of studying the city and urban regions. The expression of townscape has been used by Gordon Cullen in his book "Townscape" for the first time. Through his emphasis on emotional affects that the townscape can have on urban citizens and visitors, he has demanded visual pleasure in the scale city. Cullen's main discussion has been about this fact that buildings will make a visual desirability that none of them cannot create it alone (Cullen, 2003, p. 10).

Based on Rapoport's interpretation, townscape is a generality from interaction between human (observer) and his environment that will remain in his mind even after leaving the place. The townscape is a collection of gestalts. It becomes a subjective generality when it is given a stable meaning which is derived from its cultural or regional capacity. Actually, the townscape is a connected generality from symbols and signs that gives the reality to values, meanings and similar things (Golkar, 2006, p. 40).

Edmond Bacon in a part of his book "Designs of Cities" has studied the problem of knowledge about space as an experience by mentioning the communion of internal-space elements and considered the items which are recognizable in townscape obviously such as seeing the sky and earth, points and surfaces, depth, ups and downs their relation with human which are models that are effective in explaining space (Bacon, 1976, pp. 15-27).

Also, Lynch has studied the mentioned issue based on subjective point of view and considered five main factors of city view: path, edge, node, landmarks and distinct in formation of city view in people's mind (Lynch, 2006, p. 90). Gordon Cullen has expressed results about his studies in relation to townscape in four scopes: successive view, place, content and functional tradition. Therefore, different concepts such as territory, turning point, inside landscape, marking, changing surface, complexity, precision, and many other concepts have been studied too (Cullen, 2003, p. 6).

Generally, systematized and desirable townscape has created pleasure feeling of living in urban environment and has been one of main factors in relation to the city and citizens. When the townscape is encountered with disarrangement, confusion and non-identity, these feelings have also transferred to citizens and appeared as urban abnormal behaviors and on the other hand, they destroy the logical relation between them and the city.

2.3 The Existential Condition of Townscape Quality

The problem of existential condition in relation to quality is derived from two arenas "individual's subjective arena" and "thing's objective arena". The qualities belonged to subjective arena is located in individual's ego. Mutually, the qualities belonged to objective arena are located as an outside existence subject to mind and deals with the realities of outside world. Golkar (2000, p. 43) expresses the existed ideas in relation to existential condition of townscape based on two arenas as followed:

1.   Treating the townscape as a quality or feature that originally belongs to physical environment of the city and is existed from human as an observer and evidence independently.

2.   Treating the townscape as a complete subjective and personalization category which has been made by observer and it does not have any relation with physical structure and characteristics of environment.

3.   Treating the townscape as a phenomena and an event which is formed during the exchange between physical and tangible features of the environment from one hand and models and cultural codes and observer's mental abilities on the other hand.

2.4 The Quality of Coastal Townscape

Wherever water has manifested in the city, always, it has played an obvious role in attracting people of that city or passengers. Usually, this manifestation has been like a river that crosses among the city or a sea, a lake or a gulf which has been widespread near the city. Each of these cases has a significant role in the feature of many important cities in the world, so that the waterfront has played a key role in citizens or passengers ' mental picture of that city as an indicator element. Also, the waterfront can be a bed for many events on urban scale and local scale. The elements such as bridges and wharf which have been created in relation to these waterfronts and their near water also have the same potential (Pakzad, 2010, p. 353).

In coastal cities or cities where a river flows in them, the coast is a memorable and historical area of the city that usually, the core and historical center of the city are located beside them (Mansouri, 2010, p. 4). Actually, the coast and coastal stripe of the city has a key role in explaining the townscape and it is considered as a valuable source for promoting environmental qualities. The quality of townscape has been studied based on different point of views that in continue four of them are discussed as followed:

2.4.1 The Physical Quality of Coastal Townscape

The physical structure of coastal townscape should be in the event of satisfying human's requirements and for improving and evolution of public areas of the city. The physical qualities of townscape are in relation with access method, location and physiological welfare in different climate and safety (Kaplan & Kaplan, 1998, p. 14). The made usages around the coast and the method of their development, being responsive of usages to citizens' requirements, organizing open spaces and their distributing and dispensation in the coast have affected the physical quality of coast townscape significantly. One of the main principals of townscape is considering banks including: banks with existed value, banks required improvement and suggested banks. Based on environmental quality according to landscape and the method of its exploitation, the important points for physical structure in coastal townscape are incorporation of homogenous and familiar forms in the coast and creating the spaces which have the potential for creating memorability.

2.4.2 The Cultural and Social Quality of Coastal Townscape

Landscapes are inevitable results of cultural interpretations and representations of the culture during the time. Expressing the landscape in relation to culture is the result of human's existence in the environment. The urban natural environments and the form of the city have created together the history of interaction between natural process and human's actions during the time (Spirn, 1984, p. 162). The townscape has a significant role in sharing people in social activities, considering cultural requirements and protecting native identity of the region. Therefore, the correct understanding of consumers' requirements from space, kinds of interests and their points of views give a new opportunity for achieving proper ideas. Through this point of view, a desirable coastal landscape has spaces which give the possibilities of partnership, exchange of views and creating memorability to human's group and lead to record common memories and belonging to these spaces. The cultural structure of coastal landscape includes perceptual and behavioral dimensions that can be considered as a gift from social-cultural structure of the city.

2.4.3 The Aesthetical Quality of Coastal Townscape

Needing beauty is a part of human's most unknown requirement. Malraux believes that this requirement is existed in some people. These people become sick by seeing obscenity and they will be cured by being in beautiful environments. The effect of this tendency is obvious in different aspects such as environment organizing, townscape, and resolving some of people's material and spiritual requirements. According to architectural beauty, the environment and landscape are inevitable; because the content of a work is usually transformed to a frame of a physical form (Feyzi, 2007, p. 124).

Each beauty has a value and it should be considered that the purpose of value in visual beauty is protecting and keeping people's cultural and social values of that city which they reveal themselves in a logical and principled composition in the view of city (Bell, 2003, p. 36). Generally, the purpose of planning landscape leads to creating beautiful spaces and decreasing undesirable visual environments in urban environments. Therefore, for planning the landscape in the coastal environments, it needs a deep consideration to protecting the natural beauty of the coast and creating lateral spaces and satisfying people's requirements. Concentrating on visual information in the environment as a communication language can express a discussion between the designer and audiences (Feyzi, 2007, p. 125).

2.4.4 The Ecological Quality of Coastal Townscape

The landscape architecture has been introduced from the beginning of the history in interchange with other activities in relation to decorating earth. Experimentally, human has attempted to control his biological environment based on physical, physiological, psychological, security and social requirements and etc. through reacting against natural dominant forces in different ages to safe himself from probable adversities and live in welfare (Esfandiyari, 1997, p. 64). Human's requirements have not been coincidence with natural ecosystem and neglecting the existed nature can insert irreparable damages to existed resources in the earth. In this relation, there is a close connection between landscape ecology and human's ecology. Therefore, the view of different societies has not actually been changed for exploiting from these resources, as development models consist of least damages and extreme protection of the environment. Based on these conditions, natural and environmental

resources can be protected and offered to future generation. The necessity of considering the environment and also its protecting in the process of landscape designing and planning is an important fact. In ecology of the landscape, instead of studying environments separately, existed structures and models in landscape are analyzed and designed (Feyzi, 2007, p. 128).

3. The Coastal Townscape of Boushehr, Persian Gulf Coast; Joffre Neighborhood Center

3.1 The Location of Joffre Neighborhood Center

Joffre is located in western south of Boushehr and it is closed from east to Chamran Street and west to Persian Gulf Street. Its entire western boundary is toward the coast and Joffre fishing pond is connected to it. Also, some important buildings of the city such as municipality building are built in this region. Being at the vicinity of western coast and also location of fishing ponds has made this region different. The landscapes toward sea and the frequency of berthed boats and dhows in the coast in addition to fishing activities are the principal identity of this region.
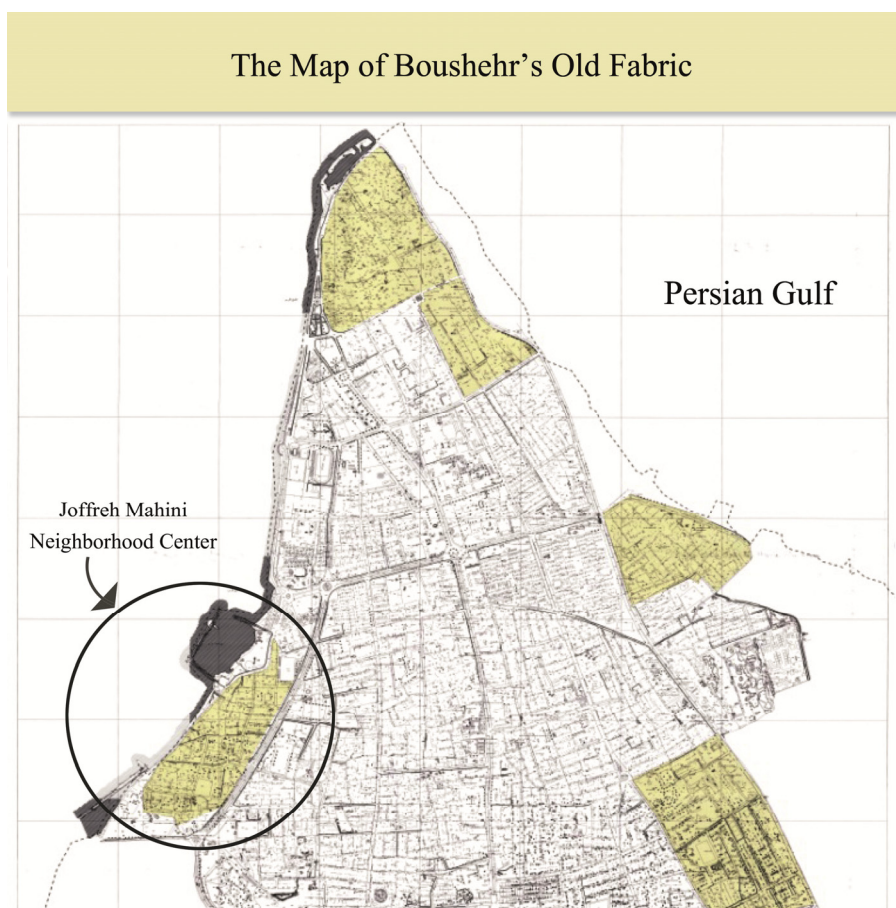
Figure 1. The location of Joffre neighborhood center in the city (Detailed Plan of Boushehr, 2006)

3.2 Studying Effective Factors in the Landscape of Joffre

As researchers and architects have presented different explanations about landscape, also they have different point of views in relation to effective factors in townscapes. The features such as usage, movement and access, the physical form of the city and environment are common among almost architects. In continue, these factors are studied generally and strengths, weaknesses, opportunities and every threat that they are encountered in Joffre neighborhood center are analyzed in a table.

- Usage: the most important feature of usage in this region is being in the vicinity of Joffre wharf, municipality building, stadium and military areas. On the other hand, sport fields give an especial importance to this region extremely. The most important usages in Joffre neighborhood center in urban scale are municipality building and Stadium.

- Movement and Access: this region is connected to access network from two ways. From west to coast street of Persian Gulf and from east to Chamran wide street. Permeability of this region based on very wide vehicle roads is very high for passengers and drivers.

- The Physical Form of the City: the structure model is different in various blocks and it includes from residential sky scraper building to 40% and 60% buildings. Rebuilding is applied in this region and many building are in the process of constructing. Also, extremely old buildings are seen in this region.

Joffre is explained and bounded by important elements of urban space organization. From west it is reached to the western coast and the street is closed along it and from west to Chamran Street. In another side, three main nodes of the city, Daliran Tangestan Square, Raeesali Delvari Square and Military Force Martyrs Square have made its corners. Joffre fishing pond is in its neighborhood and Boushehr municipality building is located in the big possession part in the north of this region.

- Environment: this region is encountered with intensive pollution of urban spaces such as municipal waste, sewage, surface water, construction waste of destructed buildings and accumulated in arid lands and other new materials like other Bushehr neighborhood centers that each of them has harmful environmental effects. Also, the consuming of electricity energy is high because of the frequency of the gas air conditions which have been increased by changing in the model of building construction like the rest of the city. The vegetation is seen as low-number rows of the trees and arboriculture is seldom seen in house yards. Public health and cleaning are low. The problems of Joffre fishing wharf impose its environmental effects on this region.
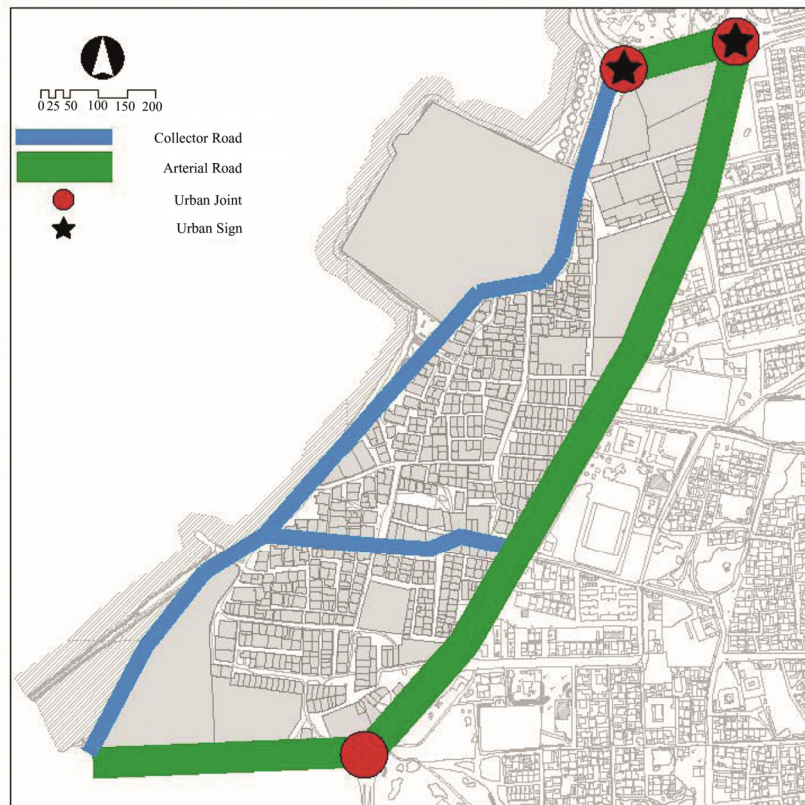
Figure 2. The plan of Joffre accesses (Detailed Plan of Boshrhr, 2006)
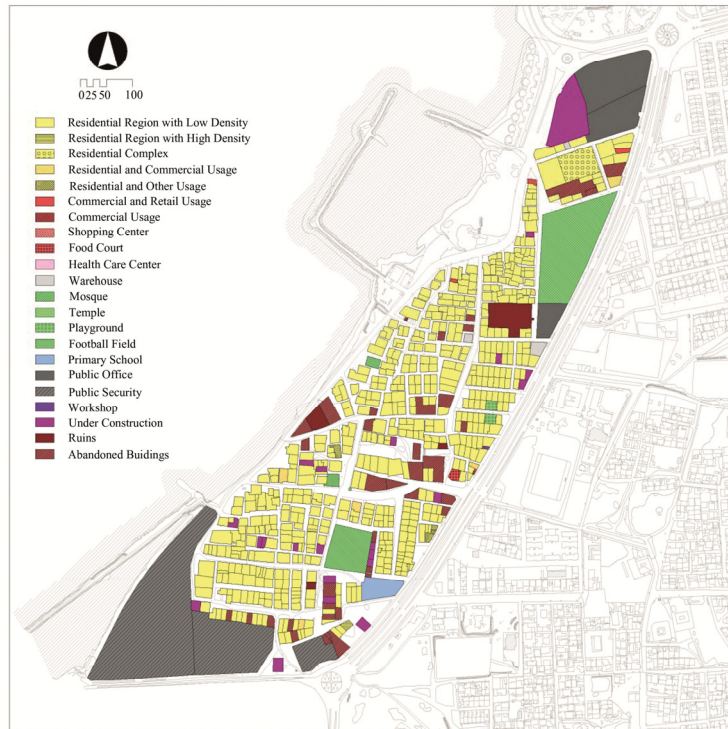
Figure 3. Usage Plan of Joffre (ibid)
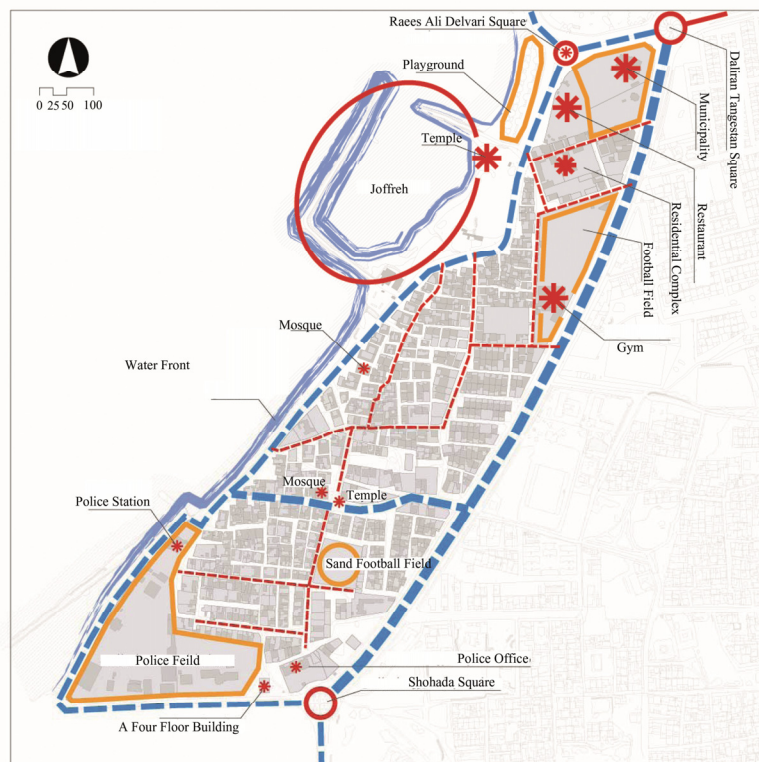
Figure 4. A physical plan of Joffre sector (ibid)

Table 1. The effective factors in the coastal townscape in Joffre

Effective Factors Joffre townscape	Strengths	Weaknesses	Opportunities	Threats
Environment	- Controlling Fishing Activities Pollution -Direct Access to Sea	- Passages Flooded -Accumulation of Construction Waste -Shortage of Vegetation in all Region	- in the Vicinity of the Sea -Tourism Development	-Process of Rebuilding with nonrenewable Materials -Process of Rebuilding based on Building Model incompatible with Climate
Physical Form of the City	-Wide View to the Sea -Location of the Fishing Wharf - Desirable Physical Permeability	-Very Low Quality of the Building -Discontinuity of Urban Bodies -Very Low Quality of the Environment	- Frequency of Arid Lands for Rebuilding	- Increasing Process of Rebuilding without Criterion
Movement and Access	-Suitability of Width Passages based on Height and volume of the Buildings	- Lake of Suitable Flooring for Passengers - Problem of Expulsion of Surface Water during Rainfall		Destroying high Levels of Land based on Applying Widening Passages
Usage	-the Existence of Sport Usage in this Region -Tendency and Continuing the Process of Rebuilding in this Region	- Shortage of Education Usage - Shortage of Cultural-Recreation Usage -Shortage of Health-Treatment Usage in this Region	- Possibility of Applying Joffre Pond in Providing Recreation-Leisure Usage	- Existence of Around Incompatible Usage

4. Presenting Solution and Suggestion

- Coordination in details, scale, proportionality of the texture, materials, color and form of buildings in the historical and old textures (protecting face bricks, pitched roof, old buildings) through urban plans especially for every passage or axis.
- Giving permit for views against the environment and street appearance should be prevented (controlling banks and views in the street view).
- Studying the appointed or suggested points as registered national monuments in the considered region and comments and recommendation for planning neighborhoods and city view of these points to provide the background for creating continuity in all historical textures (it means changing points to axis and spots in detailed plan scale).
- Making a powerful executive structure in municipality with determined duties for observing and controlling in performance of public and individual plans.
- Providing qualitative identifications for applicants for damaging and rebuilding buildings.
- Planting trees in the middle axis of the street for making shadow.
- Recognition the physical distance of privacy in historical buildings based on used materials, height, collective dimensions and natural condition of the environment and studying the geology.
- Constructing high buildings should be prevented that causes the disorder in the environment coordination and affects the existed view and landscape.
- Using uncoordinated and discordant material should be prevented near the building.
- Organizing and creating green space in the privacy of the buildings or considering technical and archeological criterion.
- Removing of historical supplements of the building and composed domains around it should be prevented
- Attempt to protect combination of composed piece of urban texture which is located near the historical texture (Mehdizadeh & Masoomian, 2010, p. 96).

References

Bacon, E. (1976). *Design of the Cities*. New York: Penguin Books.

Bell, S. (2003). *Townscape: Pattern, Perception and Process*. (Behnaz Aminzadeh). Tehran: Tehran University Publication.

Billings, K. (1993). *Quality in Design*. University of Sydney: Department of Architecture.

Cullen, G. (2003). *Townscape Concise*. (Manouchehr Tabibiyan). Tehran: Tehran University Publication.

Detailed Plan of Boushehr. (2006). Urban Planning Organization of Boushehr.

Esfandiyari, M. (1997). A Prospect on Nature in Urban Habitat. *Tehran Municipality Journal, 60*, 61-68. Tehrran.

Feyzi, M., et al. (2007). Human-environmental Approach in Architectural Plan of Townscape. *Education and Technology Journal, 3*, 122-131. Tehran.

Golkar, K. (2000). Constructive Components of Urban Planning Quality. *Soffe Journal, 32*, 38-65. Tehran.

Golkar, K. (2006). Townscape Concept. *Abadi Journal*, *53*, 38-47. Tehran.

Kaplan, S., & Kaplan, R. (1998). *Human Escape: Environments for People*. Washington DC: Island Press.

Lynch, K. A. (2006). *Town View*. (Manouchehr Mozayani). Tehran: Tehran University Publications.

Mehdizadeh, F., & Masoomian, F. (2010). Necessity of Attitude toward Designing New Fabric Elevations Adjacent to Old Fabric in Historic Cities. *Danesh Nama Journal, 180*, 95-103. Tehran.

Pakzad, J. (2010). *Theoretical Basis and Urban Planning Process* (4th ed.). Tehran: Shahidi Publication.

Spirn, A. (1984). *The Granite Garden: Urban Nature and Human Design*. Basic Book.

Mansouri, S. A. (2010). Coast, Unknown Opportunities for Promoting Space Quality. *Art and Architecture Journal, 9,* 4-5.

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Investigation on Standardization of Modal Space by Ratio for MDOF Micro-Macro Bilateral Teleoperation Control System

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Abstract

This paper presents the research on micro-macro bilateral teleoperation control system of two ink planar manipulator. The micro-macro bilateral control system consists of different size between master and slave system using geared DC-motor. Both master and slave manipulators are actuated by DC-Micromotor attached to planetary gearhead to increase the output torque. In the previous researches the most common actuators used were linear motor and direct-drive DC motors. However, the application of DC motor with gearhead are vast in industry, which need high output force or torque. Thus in this paper, research on micro-macro bilateral teleoperation control system is proposed with the use of gear with the DC-motor. The micro-macro bilateral teleoperation control system provides the human operator with a sense of feel to a micro or macro environment as if it is in the same scale environment. Thus a standardization method is proposed to achieve micro-macro bilateral teleoperation control system. During the experiment, experiment on free motion and contact motion are conducted to validate the proposed setup in bilateral teleoperation control system. The position and torque responses of both master and slave manipulators are observed. The operationality and reproducibility of this proposed system are evaluated through proposed experimental results.

Keywords: micro-macro, standardization, modal space, haptics, MDOF bilateral teleoperation control system, geared DC-motor, operationality, reproducibility

1. Introduction

Further application of bilateral control system is micro-macro bilateral teleoperation control system. The micro-macro bilateral teleoperation control system consists of macro master system and micro slave system or vice versa. To manipulate macro object, the slave system is generally large compared to master system. This is where the scaling technique is used for force and position between master and slave manipulator which is different in size. For example, to manipulate micro object, the slave system is smaller while master system is the size of human operator. This method enables human operator to manipulate the master and slave system with a different size structure. The micro-macro bilateral teleoperation control system provides the human operator with a sense of feel to a micro or macro environment as if it is in the same scale environment. In other words, the human operator feels the reaction force as if they are touching the real micro or macro environment. It is effective for manipulation which cannot be operated directly. Micro-macro bilateral teleoperation system provides benefit in many fields such as industrial environment and medical applications. A micro-macro bilateral teleoperation is essential in medical field such as minimally invasive surgery (MIS) for brain surgery (Salcudean & Yan, 1994).

Since the micro-macro bilateral teleoperation control system consists of different size between master and slave system, the inertia and scaling of the master and slave system manipulators are different. This also leads to force and position scaling required for micro-macro bilateral teleoperation control system. Few researches about micro-macro bilateral teleoperation control system on control method have been presented. K. Kaneko presented micro-macro bilateral teleoperation control system based on operational force feedforward (Kaneko et al., 1998). K. Takeo proposed an alternative control algorithm for micro-macro teleoperation system (Takeo & Kosuge, 1997). A. Sano proposed stabilization method on bilateral teleoperation control system with scaling factors based on H_∞ theory (Sano et al., 2000). Then the standardization between master response and slave response by

nominal mass of master and slave system in micro-macro bilateral teleoperation control was proposed (Shimono & Ohnishi, 2007; Susa et al., 2007). S. Susa presented scaling factors of the control gains at master and slave system in the micro-macro bilateral teleoperation control system (Susa et al., 2008). S. Susa further presented with three channel micro-macro bilateral teleoperation control with arbitrary scaling factors able to achieve high accuracy control although using lesser information channels (Susa et al., 2008). N. Motoi proposed a modal space disturbance observer (MSDOB) in the micro-macro bilateral teleoperation control system to realize high transparency (Motoi et al., 2010).

In particular, linear motor is often utilised in this field of research. It is powerful, but cost is high. Linear motor provides very high linear force along its length. However, linear motor cannot provide rotary motion for applications such as in articulated robotic arm. Moreover, the DC-motor has limitation of torque output generated by the specific size of the motor. To obtain higher torque, the size of motor will need to be increased, which is not practical for haptic applications. To do so, the most desirable way is by attaching gears. Moreover, the applications of geared DC-motor are vast in industry due to the need for high output torque.

Until now, micro-macro bilateral teleoperation control system for MDOF systems using geared DC-motor has not been derived yet. This is significantly useful in robotic surgery because it requires MDOF. Thus, our research focuses on two link rotary planar manipulator for micro-macro bilateral teleoperation control system. Nevertheless, transmission of haptic information is used with micro-macro bilateral teleoperation control system with the use of geared DC-motor drives. The micro-macro bilateral teleoperation system uses the planetary geared DC-motor to achieve a realization of high torque and small size motor for haptic applications. Since most of the researchers researched in the bilateral teleoperation control system by using linear motor and direct-drive DC motors, this proposed setup is to give an idea in the application of robotics such as in industries which mostly uses geared motor. The performance of the proposed setup is analysed by using reproducibility and operationality.

Even though teleoperation systems used for human to operate larger scale slave manipulator such as excavator, Autonomous Underwater Vehicle (AUV) for exploration or maintenance purposes, these applications have no haptic feedback information from the environment. To execute meaningful task remotely, the operator is able to simultaneously control the slave manipulator and efficiently obtain the information from the environment side. This is to say that the operator's task execution performance is improved due to haptic feedback.

This paper is organized as follows. The first part introduces about the bilateral teleoperation control system following by the workspace observer (WOB) and reaction force observer (RFOB) for two DOF planar bilateral teleoperation manipulator. Then, the proposed method of standardization of modal space by ratio for mdof micro-macro bilateral teleoperation control system is introduced. Next the experimental setup and experimental manipulations is demonstrated. At the result and discussion, the experiments of free and contact motions are conducted and discussed. Ultimately, this paper focused on the performance of the proposed setup is analysed by using reproducibility and operationality.

2. Bilateral Teleoperation Control System

In bilateral teleoperation control system, the information from the remote environment is acquired to help human operator to feel as if they are physically present at the remote place. While the human operator moves the master manipulator, its position responses transmit to the slave manipulator which causes it to follow every master manipulator's movement. When the slave manipulator contacts an object at a remote environment, the object reaction force responses transmit back to the human operator to sense the reaction force of the object. The idea of this bilateral teleoperation system is that the position and force tracking between master and slave system are followed at every time instant. Moreover, the position and force tracking at master and slave system are matched in steady state, which can lead to stable and transparent teleoperation system (Lawrence, 1993). This ideal behavior of teleoperation bilateral system enables the human operator to feel they are directly interacting with the object at a remote environment.

In the application of bilateral control system, only position information from master and slave manipulators are required. The position information from master system is transmitted to the slave system then the slave system will try to follow every command of position information from master system and vice versa. This control scheme is completely symmetric. The master and slave manipulators are followed closely to each other if the position controller have good position tracking capabilities.

In order to fulfill the bilateral control system requirement and to comply the concept in a haptic system, this bilateral control system is equipped with disturbance observer (DOB) (Ohnishi et al., 1994) and the reaction force observer (RFOB) (Murakami & Ohnishi, 1993). The differential mode of the system is position controlled

using DOB while the common mode of the system is force controlled using RFOB. This system can automatically calculate force disturbance and external force that present in both master and slave system. The sensorless type of motion control system provide robustness of the system. Thus, the operator at the master system can feel the real sensation of the environment at the slave system even though the operator is not at the environment area. Figure 1 shows the block diagram of single link bilateral control based on acceleration control.
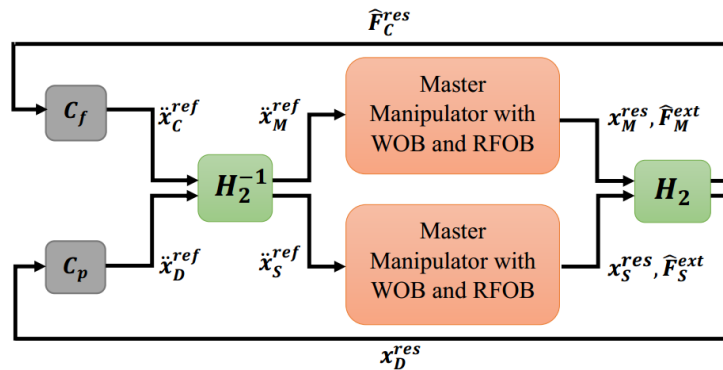
Figure 1. General acceleration based four channel bilateral controller

2.1 Disturbance Observer (DOB) and Reaction Force Observer (RFOB)

In the previous paper, the implementation of workspace observer into Direct Cartesian scheme was presented and results showed improvement in the workspace control (Wei et al., 2015). Although bilateral control system is used in this paper, the meaning and implementation of WOB are the same. However, reaction force observer (RFOB) is used too.

The DOB is a robust control tool that able to estimate the external disturbance and system uncertainties. DOB is also designed to cancel the disturbance torque as quickly as possible which act as disturbance compensation in a motion control system. Robust motion control is attained by using the disturbance observer, the robust motion controller makes a motion system to be an acceleration control system (Katsura et al., 2007). That is the reason DOB is implemented in order to establish robust acceleration controller (Ohnishi et al., 1996). The output of DOB is the friction effect under the constant angular velocity motion in the mechanism. A robust system means that the system is insensitive to the external disturbance and parameter variations and will maintain control. It can obtain wider bandwidth than force sensor due to settling sampling time and observer gain by using DOB (Murakami & Ohnishi, 1993).
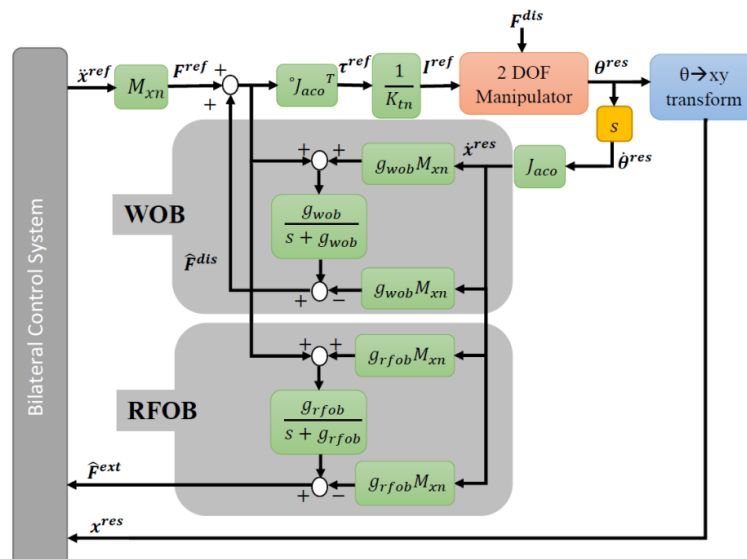
Figure 2. Block diagram of workspace based disturbance observer and reaction force observer

Figure 2 shows the block diagram of the implementation of WOB and RFOB into the MDOF bilateral control system. The estimated disturbance, $\hat{F}^{dis}$ and estimated external force, $\hat{F}^{ext}$ for master and slave system are estimated using WOB and RFOB for both x axis and y axis, respectively.

However, identification of frictional force is needed in advance to estimate the external torque. The friction disturbance can be compensated by DOB only if an accurate friction model is provided. Here, the frictional force is not compensated and cannot be ignored. Thus later in the experiments, the system has friction effects largely from planetary gear. The friction force contributed as an operational force. However, the compensation of friction force is not in the scope.

2.2 Standardization of Modal Space by Ratio for MDOF Micro-Macro Bilateral Teleoperation Control System

In MDOF bilateral system with different structure, the operational range and mass between master and slave system are different. For instances, both system can have completely same motion but different operational range. Similarly, the force is reproduced much more than the other one if one system is much bigger than the other. Thus, the position and force between both systems need to be standardized by scaling second order quarry matrix;

$$H_2 = \begin{bmatrix} 1 & \alpha \\ 1 & -\beta \end{bmatrix} \tag{2.1}$$

where α is the scaling ratio of force information and β is scaling ratio of position information. Thus, the slave system reproduces force and track position based on α and β gain with respect to master system. These scaling enables bilateral teleoperation with arbitrary ratio.

$$\begin{bmatrix} F_C^{res} & * \\ * & x_D^{res} \end{bmatrix} = \begin{bmatrix} 1 & \alpha \\ 1 & -\beta \end{bmatrix} \begin{bmatrix} \hat{F}_M^{ext} & x_M^{res} \\ \hat{F}_S^{ext} & x_S^{res} \end{bmatrix} = H_2 \begin{bmatrix} \hat{F}_M^{ext} & x_M^{res} \\ \hat{F}_S^{ext} & x_S^{res} \end{bmatrix} \tag{2.2}$$

Force information is scaled by the equivalent nominal mass matrix M_{xxn} and M_{yyn} in each system. The force scaling ratio, α_x and α_y are designed to scale force at each axis of $\hat{F}_S^{ext}$ of x and y axis as shown in Equation (2.3) and Equation (2.4), respectively.

$$\alpha_x = \frac{M_{xxMn}}{M_{xxSn}} \tag{2.3}$$

$$\alpha_y = \frac{M_{yyMn}}{M_{yySn}} \tag{2.4}$$

Position information is scaled by the operable region of each system by l_1 and l_2. The position scaling ratio, β is designed by utilizing nominal mass l_1 and l_2 as:

$$\beta = \frac{l_{M1}}{l_{S1}} = \frac{l_{M2}}{l_{S2}} \tag{2.5}$$

Figure 3 shows the proposed four channel micro-macro bilateral control system with respect to the standardized modal space.
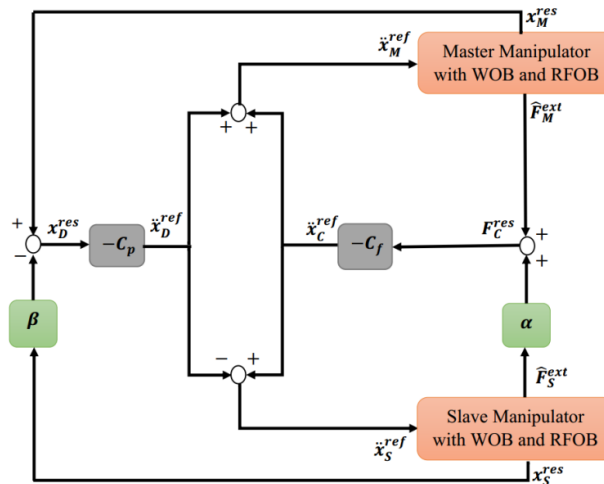
Figure 3. Proposed micro-macro bilateral control system

2.3 Hardware Setup

There are two sets of two link planar manipulators. Each joint is actuated by a planetary geared DC-Micromotor with incremental encoder. It has 5000ppr (pulse per revolution) before gearhead. The links are designed with a 0.13m each with a base attached to a platform to prevent any unwanted vibration. The link can either be used to operate the system by human operator on master side or to the environmental contact on the slave side. The links at both master and slave side are in horizontal orientation that produces zero gravitational motion. Thus, only disturbance effect and frictional force presented in the gearhead and motor. Moreover, the main purpose of this setup is to investigate the operationality torque and reproducibility of this propose geared micro-macro bilateral teleoperation control system.

Planetary gearhead able to provide higher torque for a low torque DC-Mircomotor. Moreover, the backlash is crucial to the haptic application where it can affect the performance of the bilateral system. The output of master and slave manipulator is position that measured by the encoders mounted at the back of each motor shaft. The velocity response is obtained by derivative of position response and Low Pass Filter (LPF) filters away noise from the signal in the control loop within the computer software. Within the Simulink, the processed data is set to analogue voltage reference signal from the Micro-Box to the motor driver. Motors are driven by Maxon motor driver (ESCON 50/5) in current based control mode. The reference value represents the desired current that the motor driver injected to the motor. The motor torque is directly proportional to the motor current (Hace & Jezernik, 2010). Figure 4 shows the experimental setup of this research.

Nevertheless, before conducting the experiment, the position controller gains, force controller gain, bandwidth of DOB and RFOB/RTOB are stochastically tuned in order to achieve the required performance of the particular system. These gains are tuned based on random trials until the overall system is stable and shows good performancev (Wei et al., 2016).
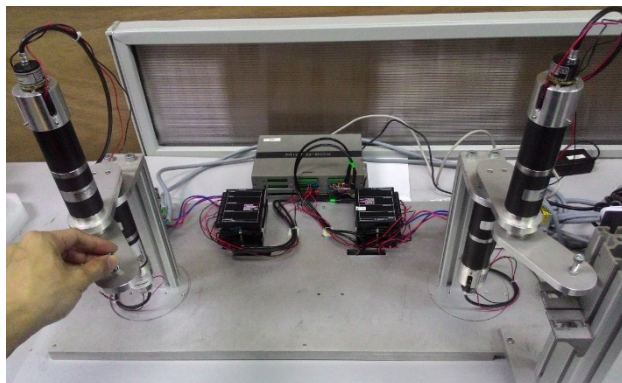
Figure 4. Experimental Setup

2.4 Experimental Manipulations

In this part, there are two experiments to be conducted. The first experiment is free motion and the second experiment is contact motion. During the free motion, the human operator control freely at master system while the slave system also follow freely without contact with any obstacle. During the contact motion, the initial position of the end-effector of the slave system is near to the surface of the objects as shown in Figure 4. The human operator operates the master manipulator manually in order for the slave manipulator to contact the object. During contact motion, human operator holds the master handle and move the handle while the slave handle is constrained by a static object. The human operator then applies torque at the master handle. The hard object is an aluminium block while the soft object is a sponge. Particularly, the human operator applied force on y axis at the end-effector of master manipulator during contact motion.

The force and position response from both master and slave system are recorded, for both free motion and contact motion experiments. The position response from master and slave system are obtained from rotary encoder while the external force applied to the master and slave system are estimated by RFOB. The force and position response from both master and slave system are compared with each other to validate the operationality and reproducibility of the bilateral control system. Nevertheless, the operationality can be validated from the free motion experiment while the reproducibility can be validated from the contact motion experiment. Then, the evaluation of this part of experiment is explained in discussion and conclusion.

Here, singularity is not cancelled. For this case, the singularity points according to end-effector are when the second joint (elbow) is at 0° or 180°.

3. Results

In this part of the experiment, proposed micro-macro bilateral teleoperation control system is applied to two link planar manipulator master and slave system. In this case, this is a scaled up bilateral teleoperation control system, where the master system is micro while the slave system is macro. It is noted that both master and slave manipulator has the same structure, but the gear reduction ratio in master manipulator, $N_{M1}:N_{M2}$ is relatively smaller than gear reduction ratio in slave manipulator, $N_{S1}:N_{S2}$. This lead to each joint at master manipulator has lower torque constant compared to slave manipulator. Similarly, the pulse per revolution was also affected by the gear reduction ratio. This lead to different pulse per revolution at joint between master and slave system. Moreover, in order to perform a micro-macro bilateral teleoperation control system, the master system has two times virtually smaller nominal mass M_{n1} and M_{n2} than the slave system. In this case, M_{xxn} and M_{yyn} are different between master and slave system. It is also noted that slave system is virtually two times the operable range compared to master system, this master-slave system has the same operable area, though. This means the length of each link, l_{S1} and l_{S2} at slave manipulator is two times compared to master system. The experiments are conducted with the parameters shown in Table 1.

Table 1. Parameters in Experiment

Parameter	Description	Value
l_{M1}	Master Link 1	$0.13m$
l_{M2}	Master Link 2	$0.13m$
l_{S1}	Slave Link 1 (Virtual)	$0.26m$
l_{S2}	Slave Link 2 (Virtual)	$0.26m$
β	Position scaling factor	0.5
M_{Mn1}	Master nominal mass 1	$1.085kg$
M_{Mn2}	Master nominal mass 2	$0.19kg$
M_{Sn1}	Slave nominal mass 1 (Virtual)	$2.17g$
M_{Sn2}	Slave nominal mass 2 (Virtual)	$0.38kg$
α	Mass scaling factor	≈ 0.5
K_{tMn}	Master nominal torque constant	$0.3184Nm/A$
K_{tSn}	Slave nominal torque constant	$0.7164Nm/A$
K_p	Position gain	3000
K_d	Velocity gain	110
K_f	Force gain	2
$N_{M1}:N_{M2}$	Master gear ratio	$16:1$
$N_{S1}:N_{S2}$	Slave gear ratio	$36:1$
g_{dob}	Cut-off frequency of disturbance observer	$50rad/s$
g_{rtob}	Cut-off frequency of reaction force observer	$50rad/s$

3.1 During Free Motion

In this section, the free motion experiment is conducted. Free motion means that human operator manipulates the master manipulator freely and the slave manipulator doesn't contact anything. This experiment is to investigate the operational torque of this bilateral teleoperation control system during free motion. Operationality is degree of operational force which human operator feels besides reaction force from the environment desired for comfortable operation for human operator (Iida & Ohnishi, 2004). Figure 5 shows free motion experiment result while Figure 6 shows the XY trajectory response during free motion (noted that the graph shows the origin of master and slave manipulator are at the same local frame).
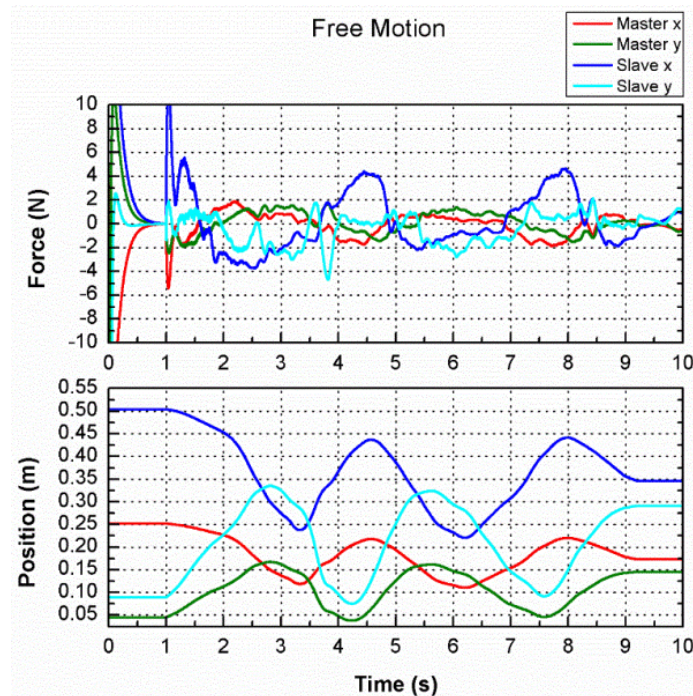
Figure 5. Force and position response during free motion
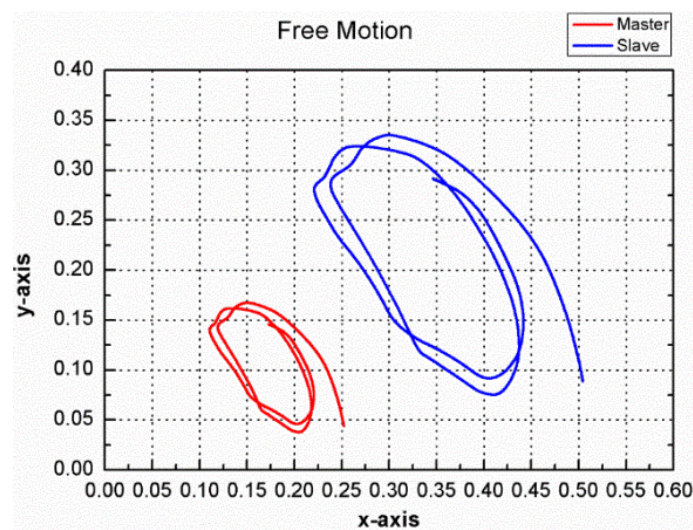
Figure 6. XY trajectory response during free motion

During the free motion, human operator was able to move the master manipulator freely as shown in Figure 5 Because the master manipulator has lower gear reduction ratio, the frictional force is low, thus the operational force is very low compared to slave manipulator which has higher gear reduction ratio. Human operator operated the master manipulator with ease. Nevertheless, the force for both x and y position tracked at slave system is twice larger force than master manipulator. This is due to the virtual mass at slave system set was twice larger than master system. Overall, the law of action and reaction are achieved between master and slave system.

Whereas, the x and y position response from slave manipulator are two times longer than the master manipulator for both x and y position as shown in Figure 5, Figure 6 shows the position response of XY trajectory for both master and slave manipulator during random free motion, where the slave manipulator has virtually twice operation range compared to master manipulator. Again, the position response from both master and slave system are tracked perfectly as the trajectory of both master and slave system are the same.
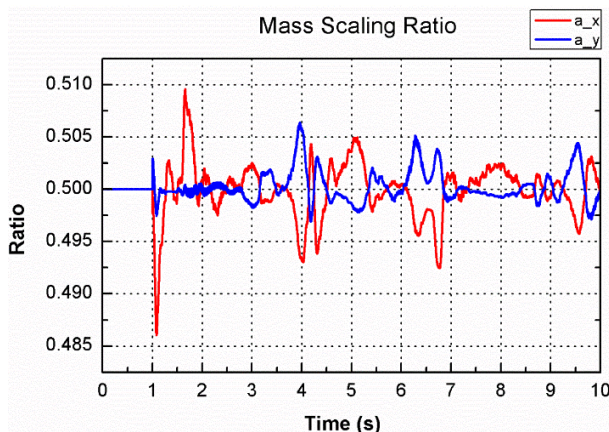
Figure 7. Scaling ratio of α_x and α_y

Figure 7 shows the scaling ration of α_x and α_y. Since the M_1 and M_2 between slave system is virtually twice larger than the master system, the nominal equivalent mass matrix, M_{xxn} and M_{yyn} between master and system were also affected. Furthermore, the α_x and α_y.changes its scaling ratio as the posture of the two link manipulator changes. After all, the ratio deviated around 0.5 scaling gain of α_x and α_y as shown in Equation 2.3 and Equation 2.4, respectively.

3.2 During Contact Motion

In this section, the contact motion experiment is conducted. The human operator makes three contact motions with the object within 10s. This experiment is to investigate the reproducibility of this micro-macro bilateral teleoperation control system when it comes to contact with an object. Reproducibility is the degree of reproduction of environmental impedance in master side which is the fundamental motive in bilateral teleoperation control system (Iida & Ohnishi, 2004). According to Figure 8 and Figure 9, contact motion experiment on aluminium (hard object) and sponge (soft object) are operated manually by human operator, respectively. Figure 10 and Figure 11 shows the XY trajectory response during contact motion on aluminium (hard object) and sponge (soft object) are operated manually by human operator, respectively (note that the graph shows the origin of master and slave manipulator at the same local frame).
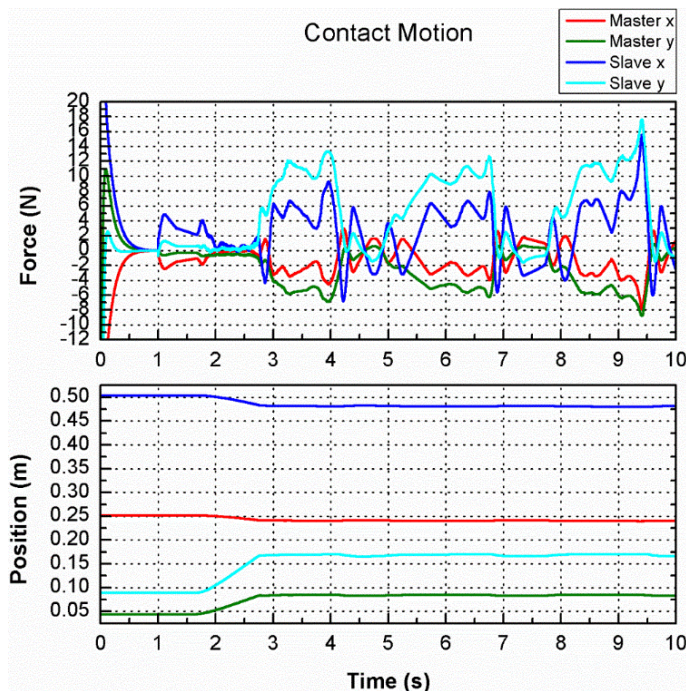
Figure 8. Force and position response during contact motion (hard object)
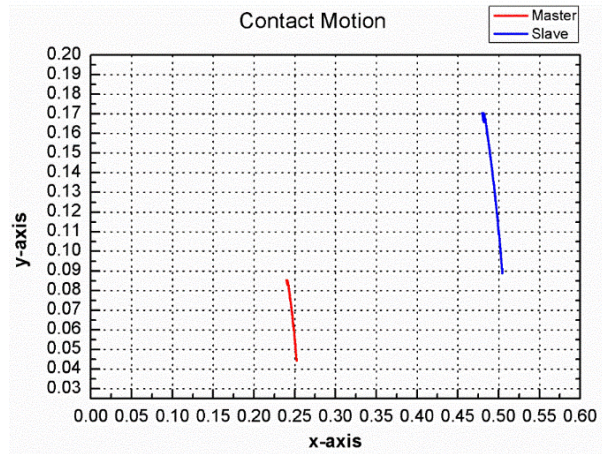
Figure 9. XY trajectory response during contact motion (hard object)
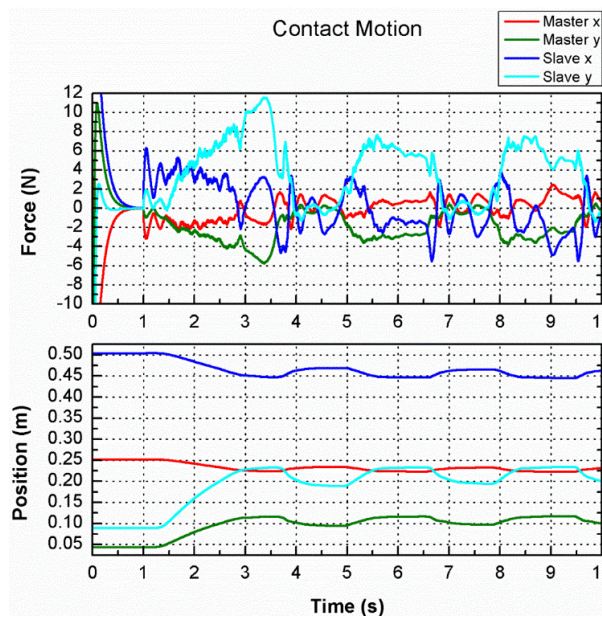
Figure 10. Force and position response during contact motion (soft object)
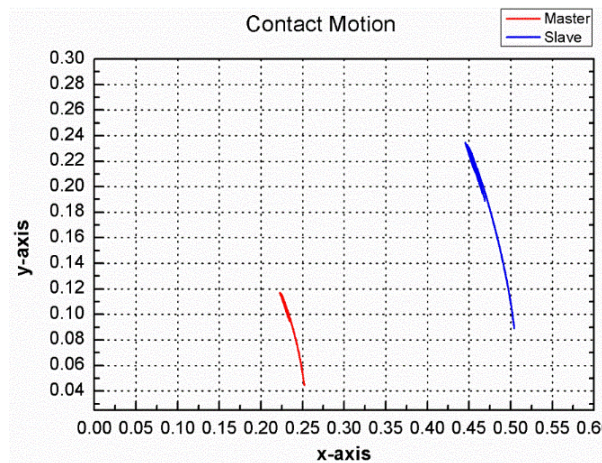
Figure 11. XY trajectory response during contact motion (soft object)

During contact with the aluminium, the force for both x and y position tracked at slave system is twice larger than master manipulator. This is due to the virtual mass at slave system which is twice larger than master system. Overall, the law of action and reaction are achieved between master and slave system as shown in Figure 8.

The x and y position response from slave manipulator are twice longer than the master manipulator for both x and y position as shown in Figure 8, Figure 9 shows the position response of XY trajectory for both master and slave manipulator during random contact motion, where the slave manipulator has virtually twice operation range compared to master manipulator. Again, the position response from both master and slave system are tracked perfectly as the trajectory of both master and slave system are the same.

Next, during contact with the sponge, the force for both x and y position tracked at slave system is twice larger than master manipulator. This is due to the virtual mass at slave system which is twice larger than master system. Overall, the law of action and reaction are achieved between master and slave system as shown in Figure 10.

Figure 10 shows that the x and y position response from slave manipulator are twice longer than the master manipulator for both x and y position. Meanwhile, Figure 11 shows the position response of XY trajectory for both master and slave manipulator during random contact motion, where the slave manipulator has virtually twice operational range compared to master manipulator. Again, the position response from both master and slave system are tracked perfectly as the trajectory of both master and slave system are the same.

Meanwhile, when the human operator released force at the master manipulator, the sponge eventually expanded to regain its shape as much as possible. During the expansion of sponge, an expansion force from the sponge pushed the slave manipulator which is in contact with sponge, pushing the master manipulator too, causing changes in position response in both master and slave manipulator, especially in y axis direction, as can be observed in Figure 10 and Figure 11 Moreover, the human operator feels half of the expansion force exerted by the sponge from the master manipulator because it is scaled down by the scaling gain.

By observing the force response shown in Figure 8 and Figure 10, the force for y axis at master and slave are higher compared to x axis. This is because the human operator applied more force at y axis during the contact motion. This also can be shown in position response where y position deviated during the contact motion. Figure 9 and Figure 11 showed the trajectory motion where master and slave manipulator start from initial position and contact with the aluminium and sponge, respectively. In brief, human operator manipulated the master manipulator more in the y axis direction.

4. Discussion

During the experiments on this micro-macro bilateral teleoperation control system with free motion, the human operator manipulated the master manipulator, the slave manipulator followed perfectly as shown in the XY trajectory response of both master and slave system. Moreover, the human operator operated the master manipulator with ease as there is very low frictional force produced by the gear. This is because the gear reduction ratio at master manipulator is lower. Thus, human operator was able to perform free motion comfortably and easily. Overall, the human operator can operate a larger scale manipulator by using a smaller scale manipulator.

During contact motion, human operator applied force to the master manipulator, slave manipulator applied the action force twice larger. Then, the reaction force exerted by the object to the slave manipulator, human operator received half of the magnitude of the reaction force from the master manipulator. This shows that the law of action and reaction achieved with scaling effect between micro-macro bilateral teleoperation control system. The stable contact of the slave manipulator is achieved on aluminium and sponge. The human operator can feel sharpness of reaction force from hard object. The friction force is almost neglected as there is no free motion during the contact motion of hard object. Overall, the reproducibility during contact motion is confirmed by these experiments.

However, during contact with the sponge, there is extra operational force to compress the sponge which is frictional force from gear. Then the expansion force need to overcome the frictional force at the slave system for the sponge to expand. Thus, human operator from master manipulator felt less expansion force from the sponge. Overall, the position tracking of the end-effector and the "law of action and reaction" are achieved between master and slave system in the workspace. This shows that the geared DC-motor was able to perform well in contact motion and reproduce the reaction force from the environment and the bilateral teleoperation control system is achieved. The validity of the standardization of modal space by ratio is achieved by the experimental results.

5. Conclusion

The proposed MDOF micro-macro bilateral teleoperation control system is demonstrated. The performance of the MDOF micro-macro bilateral teleoperation control system showed a similar result as the non-micro-macro, except that the scaling of position and force responses at the end effector of both master and slave system are achieved. The position and force response were transmitted bilaterally between master and slave system. The scaling for force and position between micro master system and macro slave system were achieved by α and β scaling gain, respectively. The experiments were conducted to validate the bilateral control system with the two link geared-manipulator. The haptic information which is the position and torque information from both master and slave manipulators were plotted and compared. Experimental results supported the theoretical framework of the proposed method and displayed accurate position and force tracking between micro master and macro slave system the standardized matrix was able to harmonize the standard of micro master system with the standard of macro slave system in the modal space. The proposed method called standardization of modal space ratio for MDOF micro-macro bilateral teleoperation control system was achieved and is promising for future micro-macro bilateral teleoperation applications in the industry.

All in all, the human operator was not just able to control a macro slave manipulator by operating a micro master manipulator, the human operator also able to aware of the environment at the macro slave manipulator. For instance, the human operator was able to feel the environment and halt the operation when the macro slave manipulator touches or hits an object. Henceforth, this would avoid any damage to the manipulator or the object. Moreover, this system is safer, accessible and human friendly in the automation industry, same as other existing teleoperation control system. Thus, standardization of modal space by ratio will be useful in fundamental personal support technology that will be developed for the future.

As for future work, there exists high operational force from the planetary gear in the form of frictional force. This brings operational force during the free motion. Moreover, high gear reduction ratio causes human operator to feel high stiffness during the operation. Thus compensation of frictional force is vital. Nevertheless, elimination/reduction of the backlash effect of the gear also must be done. This two to do list are to eliminate the characteristic of gear in order to obtain real haptic.

Additionally, the singularity is a common issue in MDOF manipulator. It gives a limitation and precaution for a MDOF manipulator during operation, or even injury or damage to the human operator or the manipulator itself. Thus, methods in eliminate singularity is a priority in MDOF manipulator to fully utilise the structure without compromising the MDOF bilateral teleoperation control system.

References

Hace, A., & Jezernik, K. (2010). Bilateral teleoperation by sliding mode control and reaction force observer. *Proc. IEEE Int. Symp. Ind. Electron*, 1809–1816. http://dx.doi.org/10.1109/ISIE.2010.5637717

Iida, W., & Ohnishi, K. (2004). *Reproducibility and operationality in bilateral teleoperation*. 8th IEEE International Workshop AMC, pp. 217–222. http://dx.doi.org/10.1109/AMC.2004.1297669

Kaneko, K. et al. (1998). *Macro-micro bilateral teleoperation based on operational force feedforward*. IEEE/RSJ International Conference on Intelligent Robots and Systems, pp. 1761–1769, October, 1998. http://dx.doi.org/10.1109/IROS.1998.724852

Katsura, S., Matsumoto, Y., & Ohnishi, K. (2007). *Modeling of force sensing and validation of disturbance observer for force control*. 29th Annual Conference of the IEEE Industrial Electronics Society, IECON '03, 54(1), 530–538. http://dx.doi.org/10.1109/TIE.2006.885459

Lawrence, D. A. (1993). Stability and transparency in bilateral teleoperation. *IEEE Transactions on Robotics and Automations, 9*(5), 624–637. http://dx.doi.org/10.1109/AMC.2010.5464046

Motoi, N. et al. (2010). *Bilateral Control with Different Inertia Based on Modal Decomposition*. 11th IEEE International Workshop on Advanced Motion Control, AMC, pp. 697–702. http://dx.doi.org/10.1109/AMC.2010.5464046

Murakami, T., & Ohnishi, K. (1993). Torque sensorless control in multidegree-of-freedom manipulator. *IEEE Transactions on Industrial Electronics, 40*(2), 259–265. http://dx.doi.org/10.1109/41.222648

Ohnishi, K., Matsui, N., & Hori, Y. (1994). Estimation, identification, and sensorless control in motion control System. *IEEE, 82*(8), 1253 – 1265. http://dx.doi.org/10.1109/5.301687

Ohnishi, K., Shibata, M., & Murakami, T. (1996). Motion control for advanced mechatronics. *IEEE/ASME Transactions of Mechatronics, 1*(1), 56–67. http://dx.doi.org/10.1109/3516.491410

Salcudean, S. E., & Yan, J. (1994). *Towards a force-reflecting motion-scaling system for microsurgery*. ICRA - Procedings of the IEEE International Conference on Robotics and Automation, 3, pp. 2296–2301. http://dx.doi.org/10.1109/ROBOT.1994.350943

Sano, A., Fujimoto, H., & Takai, T. (2000). *Personal scaling on micro-teleoperation*. 26th IEEE Anual Conference of the IEEE Industrial ELectronics Society, IECON '00, 1, pp. 7–12. http://dx.doi.org/10.1109/IECON.2000.973118

Shimono, T., & Ohnishi, K. (2007). *Reproduction of real world force sensation by micro-macro bilateral control with respect to standardized modal space*. IECON Proceedings (Industrial Electronics Conference), pp. 374–379. http://dx.doi.org/10.1109/IECON.2007.4460092

Susa, S. et al. (2007). Transmission of force sensation by micro-macro bilateral control with respect to standardized model space. *International Conference on Mechatronics, 1*(May), 1–6. http://dx.doi.org/10.1109/ICMECH.2007.4280061

Susa, S., & Shimono, T., et al. (2008). Transmission of force sensation by micro-macro bilateral control with scaling of control gains. *International Workshop on Advanced Motion Control, AMC, 1*, 532–537. http://dx.doi.org/10.1109/AMC.2008.4516123

Susa, S., Natori, K., & Ohnishi, K. (2008). Three-channel micro-macro bilateral control system with scaling of control gains. *34th Annual Conference of the IEEE Industrial Electronics Society, IECON*, 2598–2603, 2008. http://dx.doi.org/10.1109/IECON.2008.4758366

Takeo, K., & Kosuge, K. (1997). Implementation of the micro-macro teleoperation system without using slave-side force sensors. *International Conference on Robotics and Automation, 2*(April), 1600–1605. http://dx.doi.org/10.1109/ROBOT.1997.614369

Wei, L. J., Shukor, A. Z. H., & Jamaluddin, M. H. (2015). Workspace control of two link planar robot using Micro-Box 2000. *Journal Teknologi, 77*(20), 9–18. http://dx.doi.org/10.11113/jt.v77.6545

Wei, L. J., Shukor, A. Z. H., & Jamaluddin, M. H. (2016). Investigation on the effects of outer-loop gains, inner-loop gains and variation of parameters on bilateral teleoperation control system using geared DC-motor. *International Journal of Mechanical & Mechatronics Engineering IJMME-IJENS, 16*(01), 54–69. Retrieved from http://ijens.org/Vol_16_I_01/161601-2929-IJMME-IJENS.pdf

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Geometric Parameters and Behavior Factor of Knee-Braced Steel Frames Using Nonlinear Static Pushover (NSP) Analyses

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Abstract

During the recent years, the new knee-braced frame (KBF) system has been interested to achieve a proper seismic behavior. Briefly introducing KBF, the present study evaluates the geometric parameters and behavior factor of multi-story knee-braced steel frames. The studied models include three-, five- and eight-story steel CBFs, EBFs and KBFs. Using linear static analyses, the present study evaluates lateral stiffness of knee-braced frames and plots their co-stiffness curves. Using co-stiffness curves, then, the best range is determined for geometric parameters of KBFs to achieve the proper stiffness. In addition, ductility-related seismic force reduction factor ($R\mu$), over strength factor (RS), and behavior factor (R) are calculated for the frames using Nonlinear Static Pushover (NSP) analyses, and compared with the corresponding concentric and eccentric frames.

Keywords: Knee-Braced Frame (KBF), stiffness, ductility, over strength factor, behavior factor

1. Introduction

The modern designs of earthquake resistant buildings have to consider a series of factors including resistance, stiffness, and ductility. Lack of a factor makes the structure unsafe against earthquake. Conducted studies show that moment-resisting frames (MRFs) are highly ductile and excellent energy dissipation capacities; however, they are relatively flexible and uneconomic when high stiffness is required. In contrast, concentric-braced frames (CBF) show considerable resistance and stiffness in linear ranges; but, they show low and weak energy intake and ductility due to buckling braces in nonlinear ranges. Eccentric-braced frames (EBFs) combine inelastic behavior and energy intake of flexural frames with resistance and stiffness of CBFs and show a more suitable behavior. But, nonlinear behaviors of these frames are mostly related to beams (Nateghi Elahi & Akbarzadegan, 1996).

During the recent years, a new bracing system called knee-braced frame (KBF) has been developed to achieve a better seismic behavior and eliminate the defects of the other bracing systems. This system involves a diagonally-braced frame, in which at least one end of diagonal brace is connected to the knee member, which is diagonally placed between beams and columns. Diagonal bracing provides system stiffness, while ductility is influenced by severe lateral loads through yielding of knee member. A properly developed knee member acts as a ductile fuse preventing buckling of diagonal brace (Balendra, Sam, & Liaw, 1990). More discussions are provided in (Anoushehei & Daneshjoo, 2005) and (Daneshjoo & Asgari, 2003).

The present paper studies multi-story knee-braced frames to determine their best range of geometric parameters in order to achieve a proper stiffness. Thus, lateral stiffness of multi-story KBFs is considered as a function of geometric parameters and member characteristics, and the effects of these factors are separately examined on their lateral stiffness. The present study also determines ductility-related seismic force reduction factor ($R\mu$), over strength factor (RS), and behavior factor (R) for these frames. The software RAMPERFORM was used for nonlinear static analysis of studied models to extract their base shear-displacement of roof curves separately. Using the principles of behavior factor, explained as follows, the value of behavior factor are calculated for the studied frames.

2. Studied Models and Their Loads

To develop the studied models, a residential building has been considered. The earthquake resistant system for this building is developed for three-, five-, and eight-story forms using MRF system and TKBFs, EBFs, and CBFs. Thus, EBFs are initially developed according to UBC Code (UBC, 1997). To develop TKBFs and CBFs, sections of beams, columns and braces are considered similar to EBFs. Therefore, moment resisting frame and bracing member become identical in the above three systems, and the only difference is for arrangement of braces. As a result, the consumed steel is almost equal for the studied models and their main periods are adjacent. Thus, the behaviors of these models can be compared. Iranian National Building Code-Part6 (INBC-6, 2013) and Iranian Standard No 2800 (Standard-2800, 2014) were used to develop models for gravity loads and seismic loads, respectively, and the following forces were obtained:

Large gravity load including live and dead loads on beams: 2.995 t/m for stories, and 2.1 t/m for roof.

Centric gravity load including live and dead loads on columns: 5.99 ton for stories, and 4.2 ton for roof.

Base shear value resulted from seismic lateral load: 13.7 ton for three-story, 23.23 ton for five-story, and 35.58 ton for eight-story models, distributed in height according to the Code.

To develop EBFs according to UBC Code (UBC, 1997), the length of beam should not be greater than 1.6MP/VP when the link beam is connected to the column in one end. In that case, shear yield will dominate link beam. On the other hand, energy intake and dissipation of shear yield will be relatively more than flexural yield of link beam (Nateghi Elahi & Akbarzadegan, 1996). This is why the link beam is designed according to the shear yield. Table.1 shows the characteristics of EBF models, three-story TKBFs, EBFs and CBFs, as an example.
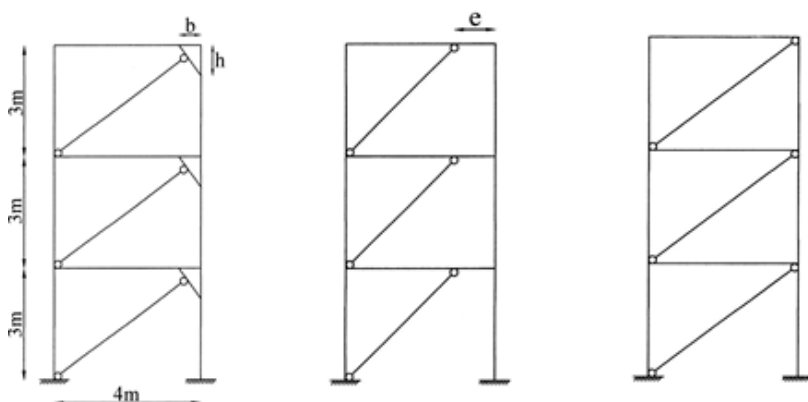
Figure 1. The studied three-story TKBFs, EBFs and CBFs

Table 1. Characteristics of EBFs with a 45 cm link beam

Models	Story	Link beam	Beam	Column	Brace
EBF-3ST	1,2,3	IPE 220	IPE 220+2PL90×15	IPB 200	2UNP 140
EBF- 5ST	1,2,3	IPE 270	IPE 270+2PL100×8	IPB 260	2UNP 160
	4,5	IPE 220	IPE 220+2PL90×15	IPB 160	2UNP 140
EBF- 8ST	1,2,3	IPE 360	IPE360	IPB 450	2UNP 220
	4,5,6	IPE 300	IPE 300+ 2PL50×10	IPB 260	2UNP 180
	7,8	IPE 220	IPE 220+ 2PL90×15	IPB 160	2UNP 140

3. Lateral Stiffness of KBF

Figure 2 shows a multi-story KBF, in which knee member is placed at the higher end of diagonal brace (T-KBF). As another design, the knee member can be located below (B-KBF) or at the both ends of the diagonal brace (D-KBF) (Balendra, Sam, Liaw, & Lee, 1991). According to the results of (Daneshjoo & Asgari, 2003), the present paper studies the behaviors of T-KBFs.
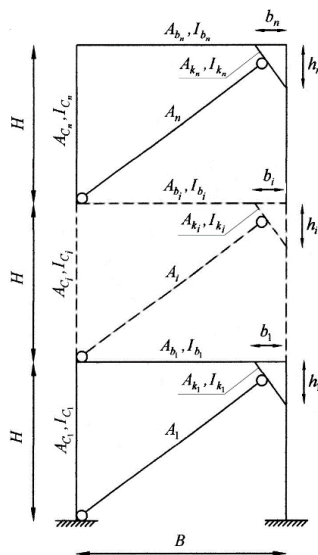
Figure 2. Effective parameters of lateral stiffness of KBFs

According to the results of (Daneshjoo & Asgari, 2003) for single-story frames, Eq. (1) shows the stiffness equation of an n-story frame in a dimensionless form:

$$\frac{K_t}{EI_C/H^3} = \varphi \quad [(\quad \frac{H}{B}, \frac{h}{H}, \frac{b}{B}, \frac{A}{A_K}, \frac{I_K}{I_C} \quad)_j \quad] \quad , \quad j = 1,2,\dots,n$$

(1)

where,

H and B : Story height and frame width

h and b : Parameters indicating knee member

A, A_K, A_c : Sections of column, knee, and brace

I_K, I_C : Moment of inertia for column and knee

E : Elasticity module

j : Number of stories

K_t : Lateral stiffness of frame

Now, the effect of the above parameters can be separately studied on the lateral stiffness of KBFs. To calculate the lateral stiffness of structure, a certain lateral force can be applied on the roof level. The structure displacement can be obtained in the roof level using linear static analysis. The lateral stiffness of structure is obtained by dividing force to displacement. It is noteworthy that the present study considers the above ratios constant in different stories to evaluate the lateral stiffness of KBFs.
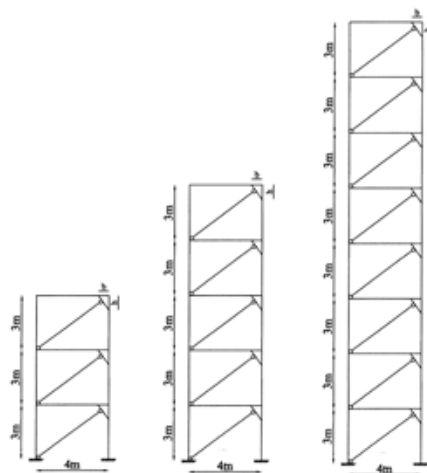
Figure 3. The studied multi-story TKBFs

3.1 Effect of $\frac{b}{B}$ and $\frac{h}{H}$ on lateral Stiffness of Multi-Story TKBFs

To evaluate the effect of knee member location on lateral stiffness of multi-story TKBFs by keeping the other different ratios constant, certain constant sections are considered for this member according to Table 2. 121 different geometric models are obtained by changing parameters $\frac{b}{B}$ and $\frac{h}{H}$ ranging from zero to one (0.0, 0.1, 0.2, …, 1) for three-, five- and eight-story TKBF models, separately. Using linear static analyses, then, lateral stiffness is separately determined for the geometric models.

Table 2. Characteristics of knee members for TKBFs

Frame	Story	Knee
TKBF- 3ST	1 , 2 , 3	BOX 100×6.3
TKBF- 5ST	1 , 2 , 3	BOX 120×6
	4 , 5	BOX 100×6.3
TKBF- 8ST	1 , 2 , 3	BOX 140×6
	4 , 5 , 6	BOX 120×6
	7 , 8	BOX 100×6.3

The dimensionless ratio $\frac{K}{EI_C/H^3}$ is determined by dividing the lateral stiffness of structure by stiffness of the first-story column. Therefore, values $(\frac{b}{B}, \frac{h}{H}, \frac{K}{EI_C/H^3})$ specify a point in the 3D space for each studied frame. These points are interpolated by the software MATLAB to find the best possible procedure. To observe more accurately, co-stiffness curves of frames are separately determined by MATLAB and plotted similar to topographic plans. By evaluating $\frac{b}{B}$ and $\frac{h}{H}$ simultaneously, the angle between knee member and beam, column and brace are automatically inserted in the analyses, and several other forms are also examined. The results are shown in Figs. 4 to 10. According to the figures, it can be concluded that:

The point $\frac{b}{B} = \frac{h}{H} = 0$ is related to CBF, in which the maximum value is obtained for lateral stiffness.

The points $\frac{h}{H}=0, \frac{b}{B}=1, \frac{h}{H}=1$ and $\frac{b}{B}=0$ are related to MRF, in which the minimum value is obtained for lateral stiffness.

The range $0<\frac{b}{B}<1$ and $\frac{h}{H}=0$ is related to EBF, in which no considerable stiffness is obtained in $0.5<\frac{b}{B}<1$ range. Increment of stiffness clearly starts from $\frac{b}{B}\leq 0.5$. As $\frac{b}{B}$ decreases, stiffness is considerably increased.

To achieve a proper stiffness, the best range for $\frac{b}{B}$ and $\frac{h}{H}$ in TKBFs matches with area S_3 in Fig. 10. This range, which can be written as $\left(\frac{b}{B}+\frac{h}{H}\right)<0.6$, $0.1<\left(\frac{b}{B},\frac{h}{H}\right)<0.4$ is common in three-, five- and eight-story frames.

3.2 Effect of $\frac{A}{A_K}$ and $\frac{I_K}{I_C}$ on Lateral Stiffness of Multi-Story TKBFs

To evaluate the effect of sectional characteristics of members on lateral stiffness of KBFs, different analytic models are separately obtained for three-, five- and eight-story TKBFs by changing parameters $\frac{A}{A_K}$ and $\frac{I_K}{I_C}$ separately, and keeping the other considered ratios constant in Eq. (1). Then, the lateral stiffness of models is separately calculated using linear static analyses by the previously explained method. The results are plotted as $\frac{K}{EI_C/H^3}$ in terms of $\frac{A}{A_K}$ and $\frac{I_K}{I_C}$, in which EI_C/H^3 is related to the first-story column.

Figures 11 to 13 show the effects of changes in cross-section of braces on stiffness of multi-story TKBFs. As the figures show, the lateral stiffness of TKBFs increases rapidly as cross-section of braces rise; however, it is limited to a certain range, above which the stiffness slowly increases.

Figures 14 to 16 show the effect of moment of inertia for knee member on stiffness of multi-story TKBFs. Accordingly, lateral stiffness of TKBFs fast increases as moment of inertia for knee member rises; however, it is limited to a certain range, above which stiffness slowly increases.
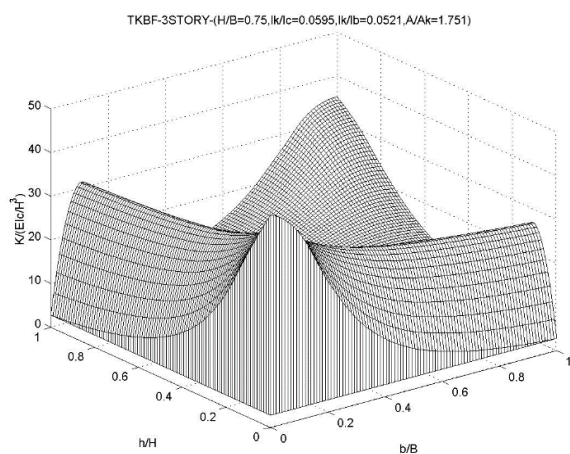
Figure 4. 3D curve of stiffness for 3-story TKBF
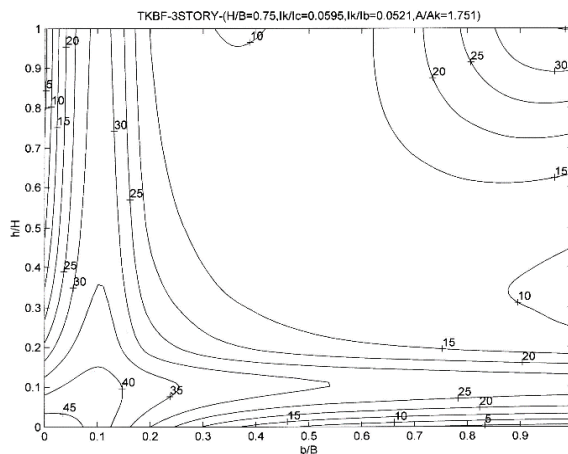
Figure 5. Co-stiffness curves for 3-story TKBFs
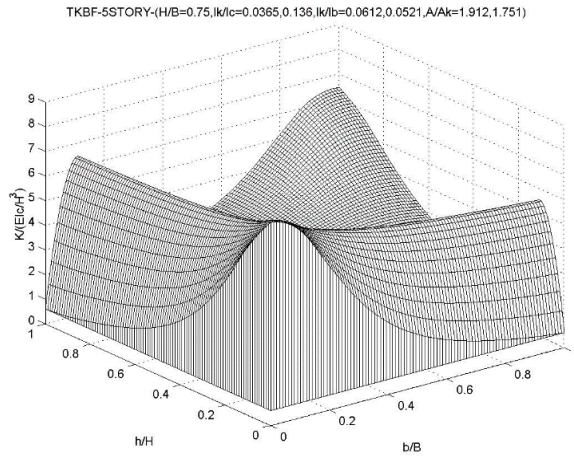
Figure 6. 3D curve of stiffness for 5-story TKBF
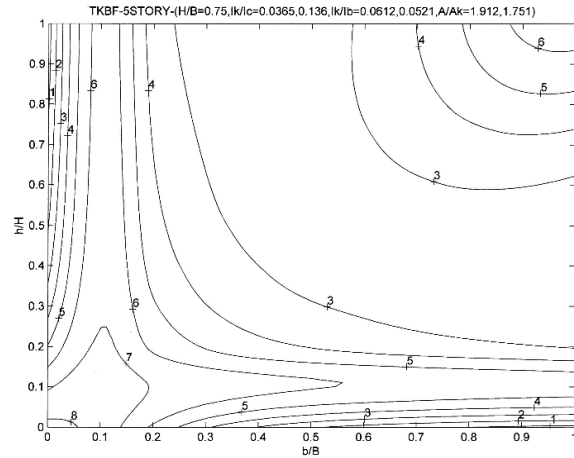
Figure 7. Co-stiffness curves for 5-story TKBFs
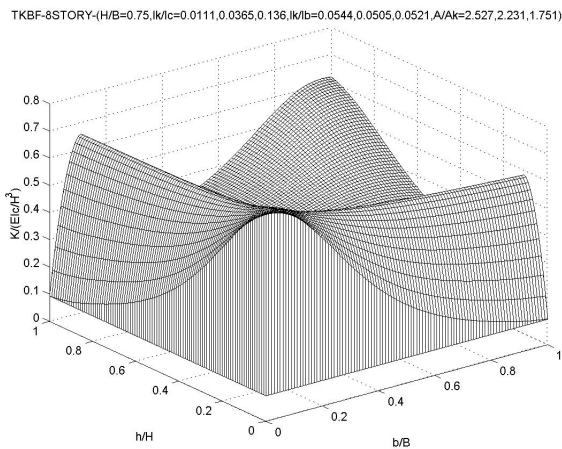
Figure 8. 3D curve of stiffness for 8-story TKBF
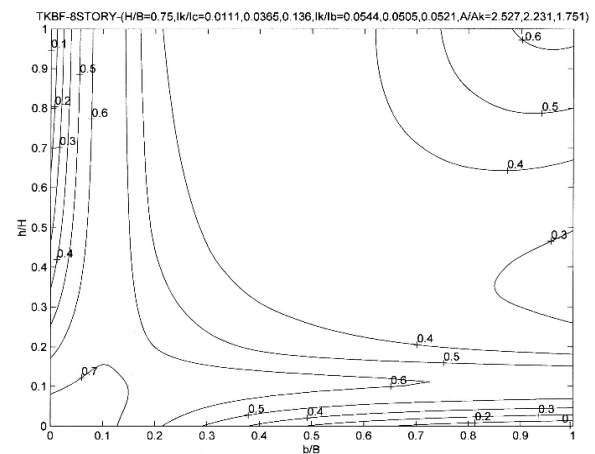
Figure 9. Co-stiffness curves for 8-story TKBFs
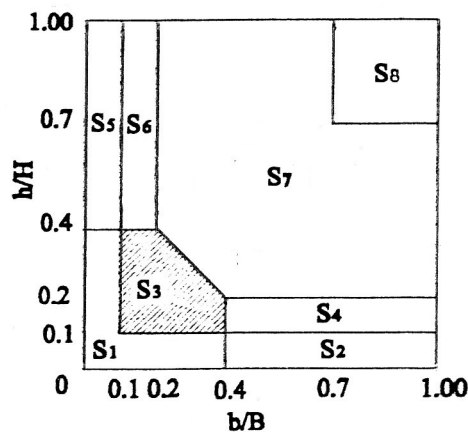
Figure 10. Suitable area of $\frac{b}{B}$ and $\frac{h}{H}$ for stiffness of multi-story TKBFs
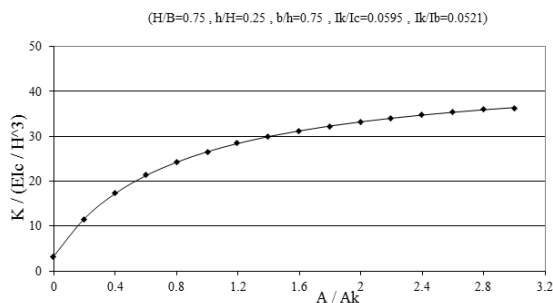
Figure 11. Effect of A/AK on lateral stiffness of 3-story TKBF
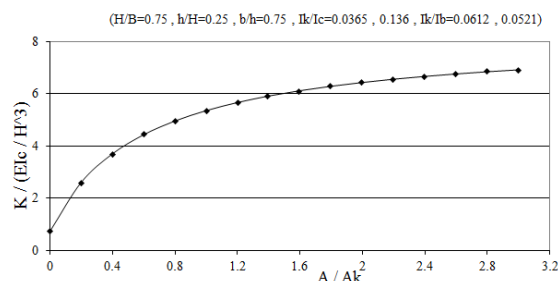
Figure 12. Effect of A/AK on lateral stiffness of 5-story TKBF
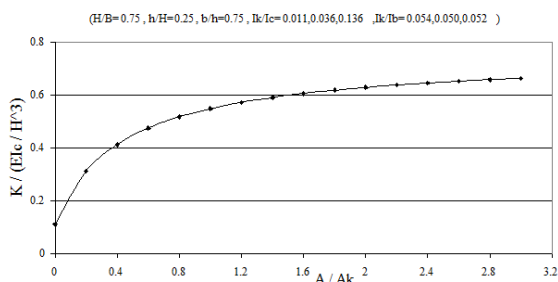
Figure 13. Effect of A/AK on lateral stiffness of 8-story TKBF
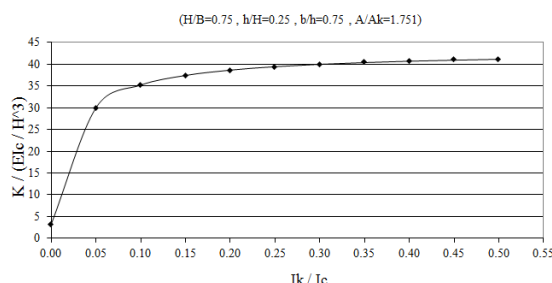
Figure 14. Effect of IK/IC on lateral stiffness of 3-story TKBF
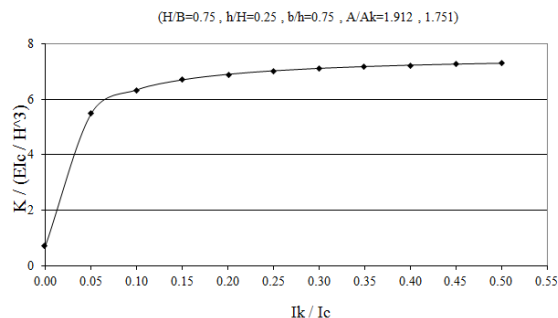
Figure 15. Effect of I_K/I_C on lateral stiffness of 5-story TKBF
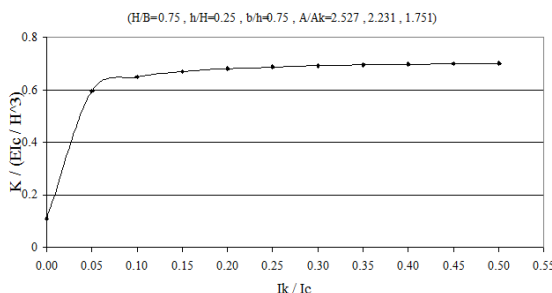
Figure 16. Effect of I_K/I_C on lateral stiffness of 8-story TKBF

4. Nonlinear Static Analyses

Nonlinear Static Pushover (NSP) analyses are used to evaluate the behaviors of studied models in inelastic range. In this method, the earthquake-related lateral load is statically applied on the structure in an increasingly gradual way. This continues until the displacement reaches to a certain value in a certain point under the lateral load, or the structure collapses. According to the suitable area of $\frac{b}{B}$ and $\frac{h}{H}$ determined in section 3.1, five different geometries are separately considered for knee members of three-, five- and eight-story TKBF models. Knee members are designed considering available forces. Tables 3 and 4 show geometric characteristics of TKBFs and characteristics of their knee members, respectively.

Table 3. Geometric characteristics of studied TKBFs

Model	B(m)	H(m)	h/H	b/h	h(m)	b(m)
TKBF-1	4.00	3.00	0.15	0.75	0.45	0.3375
TKBF-2	4.00	3.00	0.20	0.75	0.60	0.4500
TKBF-3	4.00	3.00	0.25	0.75	0.75	0.5625
TKBF-4	4.00	3.00	0.30	0.75	0.90	0.6750
TKBF-5	4.00	3.00	0.35	0.75	1.05	0.7875

Table 4. Characteristics of knee members for the studied TKBFs

Model	Story	TKBF-1	TKBF-2	TKBF-3	TKBF-4	TKBF-5
TKBF-3ST	1,2,3	Box120×5.6	Box120×6.3	Box140×5.6	Box140×6.3	Box140×7.1
TKBF- 5ST	1,2,3	Box140×5.6	Box140×7.1	Box140×8.8	Box160×8	Box160×8
	4,5	Box120×4.5	Box120×5.6	Box140×5.6	Box140×5.6	Box140×7.1
TKBF- 8ST	1,2,3	Box140×8.8	Box160×8	Box160×10	Box180×10	Box200×8
	4,5,6	Box140×7.1	Box140×8.8	Box160×8	Box160×10	Box180×8
	7,8	Box120×5.6	Box120×6.3	Box140×5.6	Box140×6.3	Box140×7.1

Therefore, considering EBFs and CBFs, there are totally 21 different analytic models for which the following assumptions are used to conduct nonlinear static analyses:

Lateral load was distributed according to Iranian Standard No 2800 (Standard-2800, 2014);

Documents of FEMA 273 was used for properties of nonlinear joints (FEMA-273, 1997);

Stiffness strain was ignored;

Lateral load was imposed in a direction to which braces compressively acted. Therefore, braces would possibly buckle;

Analysis continues until one of the following occurs:

At least one brace buckles;

The relative displacement between two stories exceed the permissible value 0.02H According to FEMA 273 (FEMA-273, 1997);

A mechanism develops in the structure.

The software RAMPERFORM was used to conduct the nonlinear static analyses and the results were separately extracted as base shear-displacement of roof curves for frames. For example, some curves can be observed in Figs. 17 to 22. Generally, the conducted analyses show that the ductility control modes for TKBFs and EBFs exceed the relative displacement between two stories in the permissible code, while ductility control modes for CBFs are brace buckling.
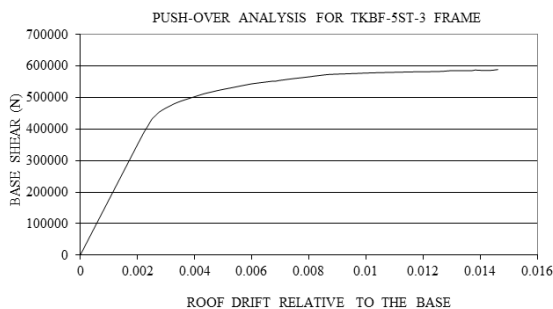
Figure 17. Push over curve for 5-story TKBF-3
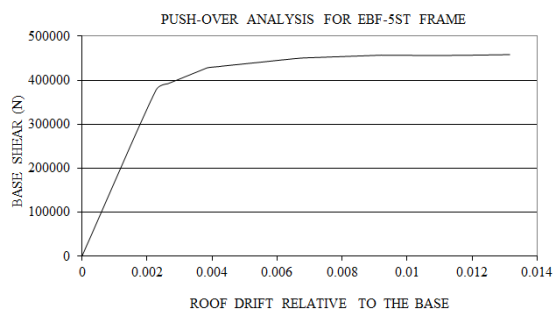
Figure 18. Push over curve for 5-story EBF
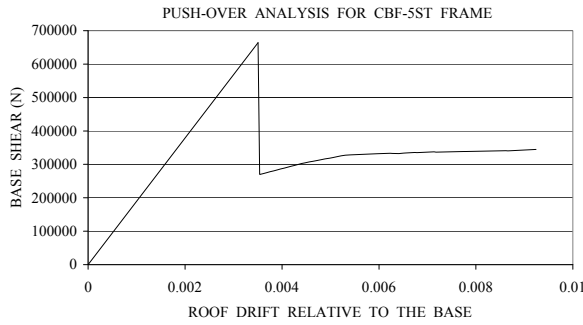
Figure 19. Push over curve for 5-story CBF
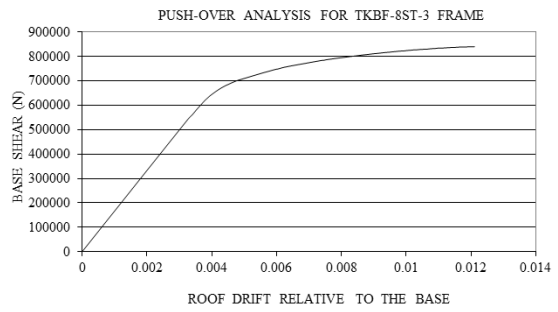
Figure 20. Push over curve for 8-story TKBF-3
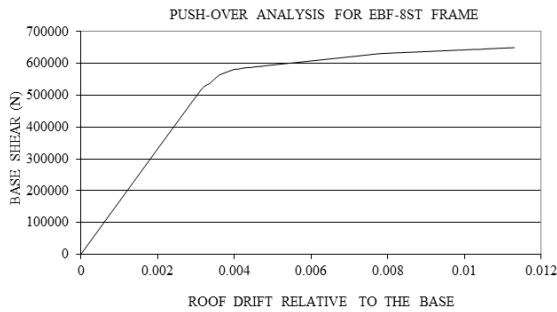
Figure 21. Push over curve for 8-story EBF
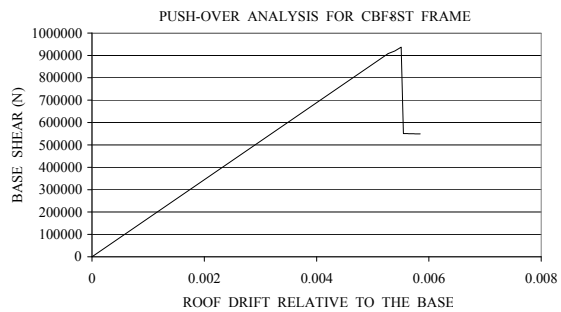
Figure 22. Push over curve for 8-story CBF

4.1 Calculating Ductility-Related Seismic Force Reduction Factor (Rµ)
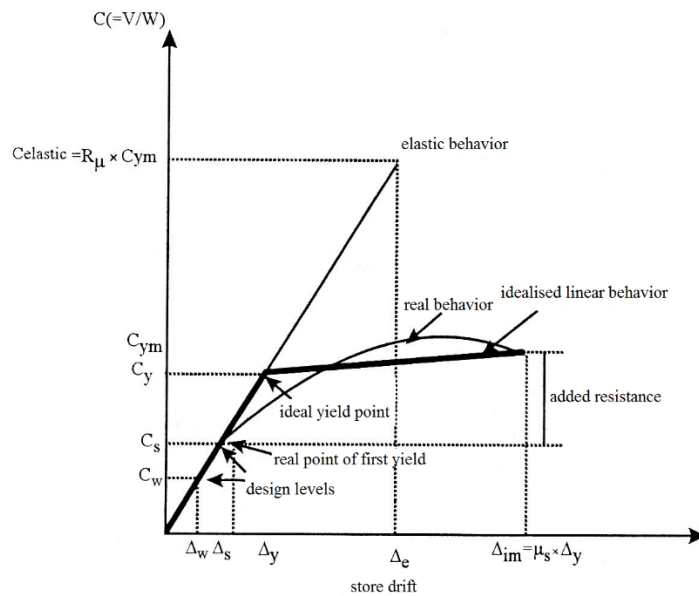
Figure 23. Parameters used to define behavior factor

According to the definition, ductility-related resistance reduction factor is defined as the ratio of elastic-required resistance to inelastic required resistance.

$$R_\mu = \frac{C_e}{C_{ym}}$$

(2)

Reduction factor, Rμ, depends on various factors including structural system, quality of connections, and number of stories. System type 1 has most influence on the above factor (Niknam, Sanaei, Hashemi, & Baji, 2002).

Factors Rμ are calculated for the studied three-, five- and eight-story models using the results of Nonlinear Static Pushover (NSP) analyses and equation 2, which are shown in Tables 5 to 7. As an example, changes in Rμ are shown in Fig. 24 for the studied three-story frames.

Rμ FACTOR FOR 3 STORY FRAMES
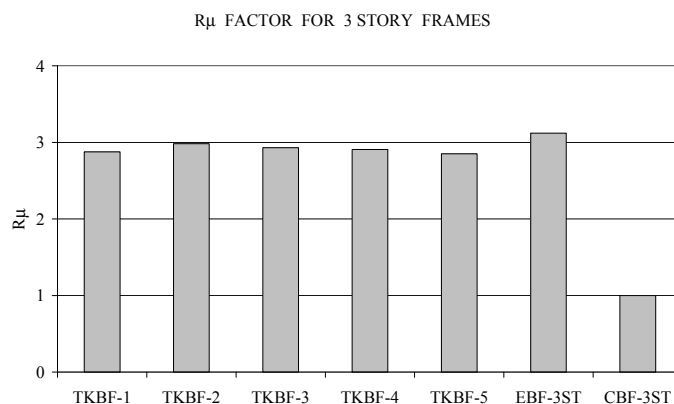
Figure 24. Rμ for the studied 3-story frames

4.2 Calculating over Strength Factor (RS)

Over strength factor is defined as the ratio of structural resistance during formation of general failure mechanism and structural resistance during formation of the first plastic joint (Eq. 3) (Chopra, 2000).

$$R_S = F_1 . F_2 . F_3 . \frac{C_{ym}}{C_s}$$

(3)

where,

F1   : Real yield tension to nominal yield tension ratio; value about 1.05 is recommended;

F2   : Effect of loading velocity on yield tension; value about 1.1 is recommended;

F3   : Effect of non-structures, which is considered about 1.2

This coefficient depends on factors such as redistribute ability of internal forces due to degrees of uncertainty, resistances higher than the specified levels for used materials, strain hardening, minimum procedural regulations for sizes and details of parts, and the effects of different loads and non-structural members (Niknam, Sanaei, Hashemi, & Baji, 2002).

RS is calculated for three, five and eight-story models using Nonlinear Static Pushover (NSP) analyses and Eq. 3 (Tables 5 to 7). As an example, changes in RS are shown in Figure 25 for the studied five-story frames.

OVERSTRENGTH FACTOR FOR 5 STORY FRAMES
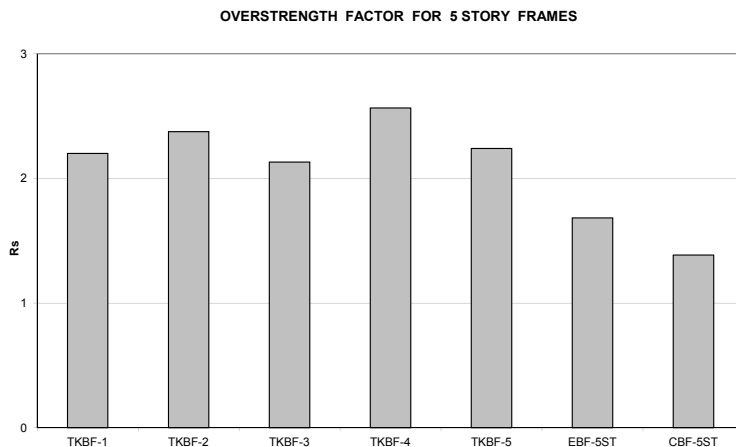
Figure 25. Over strength factor, RS, for the studied 5-story frames

4.3 Calculating Behavior Factor (R)

Behavior factor of the structure is defined as the ratio of structure's elastic strength (Celastic) to its design strength (Cdesign), according to Eq. 4 (Niknam, Sanaei, Hashemi, & Baji, 2002).

$$R = \frac{C_{elastic}}{C_{design}}$$

(4)

Since designing is common in two levels including: (a) load factors and final strength, and (b) allowed tension; C_{design} can be either CS or CW, as defined in Fig. 23. Thus, Eq. 4 can be written as: (Niknam, Sanaei, Hashemi, & Baji, 2002)

$$R_U = \frac{C_e}{C_S} = \frac{C_e}{C_{ym}} \times \frac{C_{ym}}{C_S} = R_\mu \times R_S$$

(5)

$$R_W = \frac{C_e}{C_w} = \frac{C_e}{C_{ym}} \times \frac{C_{ym}}{C_S} \times \frac{C_S}{C_w} = R_\mu \times R_S \times Y$$

(6)

where, RU is the behavior factor based on extreme tensions, and RW is the behavior factor based on the allowed tensions. The following equation can be considered between the two design levels: (Niknam, Sanaei, Hashemi, & Baji, 2002)

$$Y = \frac{R_W}{R_U} = \frac{C_S}{C_W}$$

(7)

where, Y is a factor determined according to the design codes (yield tension and allowed tension). UBC 97 Code suggested its value = 1.4 (UBC, 1997).

The RU coefficients for three-, five- and eight-story models are calculated using Nonlinear Static Pushover (NSP) analyses and Eq. 5 (Tables 5 to 7). As an example, changes of RU are shown in Fig. 26 for the studied eight-story frames. The average values for RU for three-, five- and eight-story TKBFs are 7.237, 6.065 and 5.197, respectively. Disregarding to the number of stories, the average values for TKBFs are RU = 6.166 and RW =8.879. Therefore, RU = 6 and RW = 8.5 can be conservatively used for TKBFs.
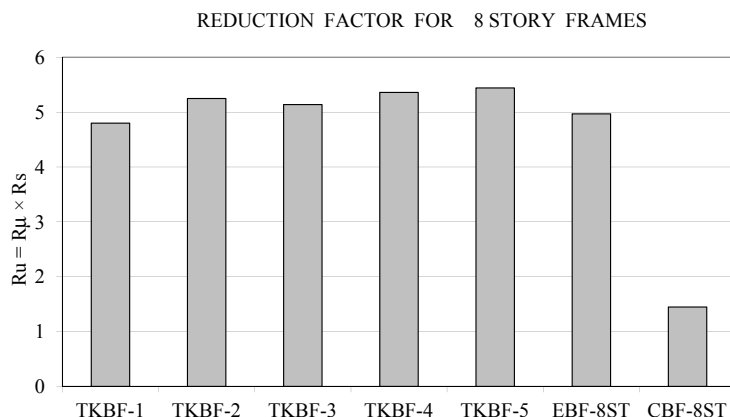
Figure 26. Behavior factor, RU, for the studied 8-story frames

Table 5. Results of nonlinear static analyses for the studied 3-story frames

Model	VS (N)	Vym (N)	Ve (N)	Rμ	RS	RU
TKBF-1	291915	478199	1375057	2.875	2.270	6.526
TKBF-2	239519	427353	1275176	2.984	2.473	7.379
TKBF-3	239446	426560	1250224	2.931	2.468	7.234
TKBF-4	220903	410389	1193434	2.908	2.575	7.488
TKBF-5	210873	403163	1149945	2.852	2.650	7.558
EBF-3ST	285966	381681	1191739	3.122	1.850	5.776
CBF-3ST	501595	501595	501595	1.000	1.386	1.386

Table 6. Results of nonlinear static analyses for the studied 5-story frames

Models	VS (N)	Vym (N)	Ve (N)	Rμ	RS	RU
TKBF-1	384971	611426	1660309	2.715	2.201	5.976
TKBF-2	344296	590300	1585298	2.685	2.376	6.379
TKBF-3	383077	589173	1594246	2.706	2.132	5.769
TKBF-4	313487	580349	1396427	2.406	2.565	6.171
TKBF-5	333755	539600	1452268	2.691	2.241	6.030
EBF-5ST	377173	458100	1321215	2.884	1.683	4.854
CBF-5ST	663963	663963	663963	1.000	1.386	1.386

Table 7. Results of nonlinear static analyses for the studied 8-story frames

Model	VS (N)	Vym (N)	Ve (N)	Rμ	RS	RU
TKBF-1	605849	896000	2097430	2.341	2.050	4.799
TKBF-2	549987	849300	2082665	2.452	2.140	5.247
TKBF-3	543027	840200	2013078	2.396	2.144	5.137
TKBF-4	513524	862290	1986315	2.303	2.327	5.359
TKBF-5	487988	801482	1916808	2.391	2.276	5.442
EBF-8ST	519555	649697	1864030	2.869	1.732	4.969
CBF-8ST	908774	936610	948317	1.012	1.429	1.446

Note. VS = Base shear of structure corresponding to first yield; Vym = Maximum base shear of nonlinear structure; Ve = Maximum base shear of linear structure.

5. Conclusion

The present study examined the lateral stiffness of multi-story TKBFs using linear static analyses. Ductility-related seismic force reduction factor, over strength factor, and behavior factor of traditional

multi-story TKBFs were calculated by nonlinear static analyses, and were compared with the corresponding EBFs and CBFs. According to our study, the results can be summarized as follows:

The best area of $\frac{b}{B}$ and $\frac{h}{H}$ can be shown as $\left(\frac{b}{B} + \frac{h}{H}\right) < 0.6$, $0.1 < \left(\frac{b}{B}, \frac{h}{H}\right) < 0.4$ for TKBFs to achieve the proper stiffness (Fig. 10).

Lateral stiffness of TKBFs increases rapidly by increment of cross-section of braces in a small range of $\frac{A}{A_K}$ ($\frac{A}{A_K} < 1$). However, stiffness increases slowly for the larger values of $\frac{A}{A_K}$ and is limited to a certain extent.

Lateral stiffness of TKBFs increases rapidly by increment of moment of inertia for knee member in a small range of $\frac{I_K}{I_C}$ ($\frac{I_K}{I_C} < 0.07$). However, stiffness increases slowly for larger values of $\frac{I_K}{I_C}$ and is limited to a certain extent.

Ductility control modes for TKBFs and EBFs are exceed the relative displacement between two stories in the code. However, ductility control modes for CBFs are brace buckling because of a ductile element (knee member and link beam) in TKBFs and EBFs that prevents buckling.

Reduction factor, Rµ, of TKBFs is almost in the same level of EBFs and more than CBFs.

Over strength factor of TKBFs are more than EBFs and CBFs; because, uncertainty degrees are higher in TKBFs. As a result, redistribution of internal forces increases in them.

Behavior factors of TKBFs are more than those in EBFs and CBFs. According to the calculations, RW = 8.5 can be conservatively used for ordinary flexural framing system plus knee member.

6. Future Scope of Work

This research is part of the PhD thesis of Mr. M. Anoushehei in Tarbiat Modares University.

These studies show that the seismic behavior of KBF system is better than the analogous CBF and EBF systems. Another method that has been the subject of many studies in the recent decades, is the idea of control structures. Among the various methods of control structures that have been used, passive energy dissipation systems have been widely used in recent years. Over the past two decades, use of passive energy dissipation dampers in seismic applications has been noticed. But so far, little researches have been done about use of passive energy dissipation dampers on knee bracing system. Additionally, many of the researches are theoretical, and experimental work is rare. Given that previous research shows use of passive energy dissipation dampers and use of knee bracing system, is effective in improving the seismic behavior of structures during earthquakes. Perhaps the seismic behaviors of steel structures will be perfected by both of them. This issue will be investigated in the PhD thesis of Mr. M. Anoushehei in Tarbiat Modares University. This research will try to study the seismic behavior of structures using a passive damper on knee braced steel frame.

Different ideas of installing a damper on knee bracing system is shown in Figure 27. The best position of the damper on knee bracing system will be determined after further investigation.
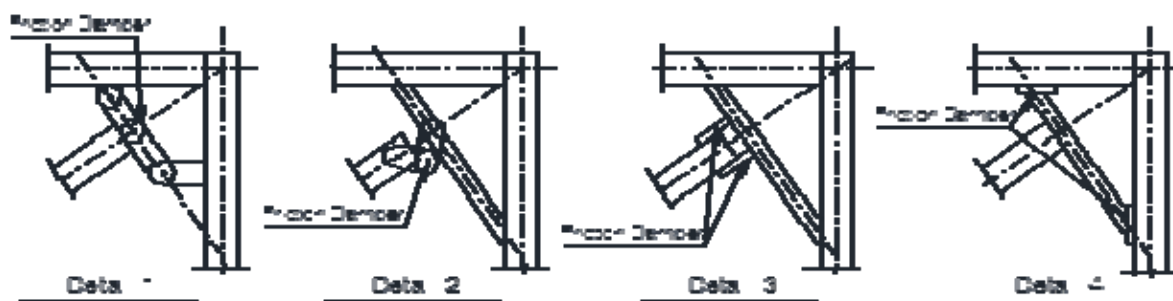
Figure 27. Different ideas of installing a damper on knee bracing system

References

Anoushehei, M., & Daneshjoo, F. (2005). *Seismic Behavior of Multi-Story Knee-Braced Steel Frames*. MS Thesis in Tarbiat Modares University, Tehran, Iran.

Balendra, T., Sam, M. T., & Liaw, C. Y. (1990). Diagonal Brace with Ductile Knee Anchor for Aseismic Steel Frame. *Earthquake Engineering and Structural Dynamics, 19*, 847-858. http://dx.doi.org/10.1002/eqe.4290190606

Balendra, T., Sam, M. T., Liaw, C. Y., & Lee, S. L. (1991). Preliminary Studies into the Behavior of Knee Braced Frames Subject to Seismic Loading. *Engineering Structures, 13*, 67-74. http://dx.doi.org/10.1016/0141-0296(91)90010-A

Chopra, A. (2000). *Dynamics of Structures and Determination of Seismic Forces (Theory and Application)* (2nd ed.). Tehran: Elm-o-Adab Press.

Daneshjoo, F., & Asgari, J. (2003). Nonlinear Analysis of Knee-braced Frames under Earthquake Loadings. *Esteghlal, 22*, 103-116.

FEMA273. (1997). *NEHRP Guidelines for the Seismic Rehabilitation of Buildings, Prepared by the Applied Technology Council for the Building Seismic Safety Council*. Washington, DC: Federal Emergency Management Agency.

Iranian National Building Code-Part 6 (INBC-6). (2013). *Design Loads for Buildings*. Ministry of Road and Urban Development, Tehran, Iran

Nateghi Elahi, F., & Akbarzadegan, H. (1996). *Seismic Behavior and Design of Eccentric Frames* (1st ed.). International Institute of Seismology and Earthquake Engineering, Tehran, Iran.

Niknam, A., Sanaei, E., Hashemi, J., & Baji, H. (2002). *Behavior and Regulation of Seismic Design for Steel Buildings* (1st Ed.). Publication of Hormozgan University, Hormozgan, Iran.

Standard No. 2800. (2014). *Iranian Code of Practice for Seismic Resistant Design of Buildings* (4th ed.). Building & Housing Research Center, Tehran, Iran.

UBC. (1997). *Uniform Building Code*.

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Extremism in the Islamic Country and Its Relationship with the International Policy

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Abstract

Extremism is one of themes that do not comply with all the established beliefs and healthy ideas because man is naturally built on moderation, and not extremism or militancy. The human communities are constituted throughout cooperation to keep the sustainability of life. The extremism happening today, particularly in Islamic countries, is only a result of internal reasons within Muslim societies, and the relationship of the dominant international policies on the capabilities of the peoples. In turn, this led to stick extremism to the Islamic approach and religion, because of the docility of some ignorant people of what is being plotted by those countries' policies and the shortening of some leaders of this matter in general. The present study has used the descriptive analytical approach to these issues. It concludes that there are negative reasons within Islamic countries, such as ignorance, economic and social aspects, Internet channels, some scientists' shortage in the preaching side, and the major role of the international politics in fomenting and supporting extremism in these countries. This role is represented in the unlawful interference, military support, and law legislation which are not suitable with the provisions of the Islamic religion that rejects all kinds of extremism through its legislation used from generation to generation.

Keywords: extremism, countries, relationship, policies, international

1. Introduction

The Almighty God sent His Prophet Mohammed, peace be upon him, with a clear message of tolerance, compassion and the rejection of violence and extremism in all its forms and harassment. This is expressed by prophet's saying, "The religion which Allah loves most is the tolerant Hanifiyya" (natural unitary belief and correct behavior) (Al-Bukhari, 2001). This saying is followed, without change, by all Islamic societies throughout the ages up to this day. What is done by some of the extremist groups like, the attacks on Islamic and non-Islamic societies carrying the thought of extremism is not Islamic. These groups do not represent Islamic religion known with its moderation in all of its provisions. Rather, they are representing the owners of deviant ideas and trends, that the Prophet, peace be upon him, and his followers warned against. At the present time these groups have fed on errors and shortening inside Muslim societies, and on international policies that support directly or indirectly. These groups are invoked by the attacks carried out on the Islamic communities, as the American occupation of Afghanistan and Iraq, and the occupation of Palestine by Zionists. The media statements issued by prominent characters in their communities like attacking the ideology and methodology of the Islamic religion, and the failure of scientists so as not to alarm and warn people of the danger of extremism, leads to the disintegration of communities and rivalry among them, and disability of the Daawa (invitation) for this religion as they are nowhere near to it.

2. Reasons of Extremism

Extremism is not an Islamic approach or a doctrine of the Islamic religion. Its attribution to the Islamic societies belongs to the following reasons**:**

(A) Ignorance

The nowadays ignorance spread in some Muslim societies is one of the causes of extremism which is given an Islamic feature and seen as a truly Islamic by the owners of the artificial vision. It's noted that those ignorant

people cling strongly to their ignorance and do not accept any renewal palatable religiously, and call the opposite as apostate from the religion and out of Islamic Millia, an innovator or lost of all right approach.

When we analyze the reasons of ignorance we find it due to lack of understanding and awareness of the texts that allow multiple aspects of analysis. The presence of other evidences make those ignorant people missed their understanding of these texts. In addition to what is clearly mentioned in these texts, their inability to return and connect the parts to the whole, their lack of understanding the similarities and throwback to the arbitrator, and not accepting the different issues among scholars as things which may not be misleading and heresy. Moreover, ignorance had been achieved on their parts, through counting themselves as scholars and diligence, particularly in the crucial issues for which the security and stability of Islamic societies are urgently needed particularly in the present era.

If we look at the psychological reasons that make the ignorant people cling to their ignorance and lack of command to return to scientists, we will find the showmanship especially among some young people. For this reason, we see those young people adopt extremist ideas, which neither Sharia approves nor sound mind accepts. The main feature of these extremist ideas is that they draw the attention of the people. The Prophet, peace be upon him, had warned of this group of young people, when he said: « سَيَخْرُجُ قَوْمٌ فِي آخِرِ الزَّمَانِ أَحْدَاثُ الْأَسْنَانِ سُفَهَاءُ الْأَحْلَامِ يَقُولُونَ مِنْ خَيْرِ قَوْلِ الْبَرِيَّةِ لَا يُجَاوِزُ إِيمَانُهُمْ حَنَاجِرَهُمْ يَمْرُقُونَ مِنْ الدِّينِ كَمَا يَمْرُقُ السَّهْمُ مِنْ الرَّمِيَّةِ » [البخاري، 2001م

("There will be people who will recite the Quran but it will not go beyond their throats, and they will go out of Islam as an arrow goes out through the game").

Nowadays, this has been achieved as told by the prophet, peace be upon him, as they became extremists and fought in the most important issues that led to the instability of the Islamic societies and on which do depend the survival and non-disintegration of communities. For example, they were longing in a matter of the blasphemy of rulers and the matter of going out on them which is lead, according to them, to the unbelief of peoples. These issues show their ignorance to apply the provisions in its real place. Accordingly, we see them today engaged in bombings of the public places without taking into account the unarmed people, as it happens, and watched on TV channels in many Muslim countries such as Iraq, Afghanistan, Syria and others.

(B) Economic Factor

The economic factor plays a fundamental role in supporting the case of extremism in the communities, as it has a real impact on the human psyche, which is inherent to reject poverty and love money, as stated in sayings of the Almighty: (وَتُحِبُّونَ الْمَالَ حُبًّا جَمًّا) [Qur'an, Surah Al-Fajr: 20]. Because of this, cases of organized and non-organized crimes of killing and kidnapping have been emerged. Thus, the Prophet, peace be upon him, has sought a refuge from poverty by saying: « اللهم إني أعوذ بك من الكفر والفقر » (Al Nassae, 1986), (O Allah! I seek refuge with You from the disbelief and poverty). Disbelief was collected to poverty, because of the effects of poverty that lead to the disbelief. It is a means of causing poverty, in addition to the abuse of extremism in general communities.

So, Islamic religion dealt with this aspect and made Zakat as a primary principle of its doctrine, through which the scourge of poverty is eliminated. In addition, the carrot in the alms incites the social solidarity even with non-Muslims, who live in the shadow of Islam. When Omar bin Al khattab (may Allah be pleased with him) saw an old Jewish man begs people, Omar asks him about that. Omar knew that the old man's need is because of his inability and his age. He took the old man to his house and gave him of what he had. Then he sent him to the charge of the house of money and said to him: See this and order to him and to his ilk, as they have enough of the Muslim's House of Finance. Omar also adds: "It is not fair to take Jizya from him when he was a young man, and then we fail him when he got old." [Abu Yousef, 2010]. When poverty outbreaks in the communities it will generate a state of hatred among the poor people. Also, it will cause a psychological instability among the poor people and will have them formatted to avenge the society to which they belong. Consequently poor people will lose their sense of patriotism, and be an easy prey for foreign organizations and agendas that drive them in accordance to their interests and which have hostility against Islamic countries. Then the gap of extremism grows up.

Examples of cases of extremism due to the economic factor, is what is happening now in Iraq of the emergence of the militias and extremist groups that circulate death among all of its sects Islamic and non-Islamic. International Transparency reports showed that the poverty rate reached 28% of the total population which is a dramatic proportion of concern [Herak Network, 2014]. If we look at the most important reasons that led to the spread of poverty in Iraq as shown by the international and local reports, we can see that Iraq occupies an advanced position among the countries [Agency N. News, 2011]. The poverty is caused due to the large-scale corruption that gets in all aspects of the state, without the presence of strict laws that prohibit as well as the

sectarian conflicts. The extremists exploited this factor in winning the poor and needy people to get them to their parts.

(C) Social Status

The conservative family that maintains the noble values and principles is the core of the emergence of potable communities. The prevalence of mental illness and criminal extremist will be raised in that kind of family dominated by disintegration and lack of harmony. This will be reflected in the society which is the foundation of secure and stable countries**.** So the enemies of Islam have realized this role and they have all the means to introduce anything that may lead to the collapse of the Islamic communities, through broadcast intellectual and moral decay to meet instincts, particularly among young people. This is clearly seen in some communities and through video and audio channels. These changes are extremely rejected by the others who are opponents to these channels. The inordinate and extremist refusal goes through the adoption of disbelieving ideas and approaches to address these problems. These ideas and approaches are incompatible with the tolerance of Islam, and do not concur with the legislation, provisions, principles and values of the Islamic religion in addressing these problems.

As it has happened with some of the armed groups in killing of young people, women, children and foreign tourists in Egypt, and Nigeria, by the extremist organization of Boko Harram and the Islamic State in Iraq and al-Sham (Daesh) in a way that has not been of the Islamic religion in any link. A special idea is the question of giving safety to the innocent people and covenanters in Islamic countries and maintaining their safety. So that the Egyptian Fatwa condemns these practices, describing that the real meaning of these crimes is to undermine the Islamic religion as well as other targets [Dar al-Ifta, Egypt 2009] through what is attributed to Islam by such acts as well as the infringement of its people. In addition, some groups are making use of the bad conditions of social status, and the exploiting the displaced people; because of the wars as in Iraq and Syria; to recruit them and using them in the operations of the international forbidden and illegitimate human trafficking, as in Libya (Agency of Libya Press, 2015).

(D) Shortening of some Scholars and Preachers

The preaching side has a big role in facing extremism and fanaticism, especially for those who take the legitimate texts and scholar's sayings in making the provisions misplaced. This leads some of enemies of Islam to enroll this extremism to the ideology and thought of Islam. As it has been done by the US Republican presidential candidate Donald Trump in his propaganda campaign to win elections of the United States who takes advantage of what is carried out by extremist groups like al-Qaeda and the organization of the state of Iraq and al- Sham (Daesh) and militias, especially in Iraq and Syria, when he claims that Islam is hostile to all non-Muslim countries even though they are peaceful (Arabic, CNN 2016).

Today we can see the great failure by some scholars and preachers in a stating the right direction of these groups, which practice extremism and in reflecting the reality of the Islamic religion in rejecting extremism and fanaticism, as well as to respond to the enemies of Islam. The response may go through the great tradition of the provisions of Islamic legislation and stories that passed in successive periods of time in generation after generation by using of all means to show the truth, whether through lectures, speeches or through social media channels and networks, video and audio. These are the real duties entrusted to them by Almighty God when He said: (فَاسْئَلُوا أَهْلَ الذِّكْرِ إِن كُنتُمْ لاَ تَعْلَمُونَ) (Quran & Anbiya, 2007)

It is notable that the extremists had practiced their extremism depending on deviant ideas and approaches. Therefore, the change of this thought can only be through proper and counter thought as it had been done by the great companion Abdullah bin Abbas, may Allah be pleased with him, in Nahrawan. When he argued with Khawarij he returned with four thousands of them repentant (AlHakim, 1990). Taking into consideration the reasons that led to their return to the right, we can note that the texts quoted by Ibn Abbas, may Allah be pleased with him, in his argument are the same ones that they keep and study. These texts were hidden from them because of their lack of understanding although these texts are in their hands. His use of the means of mental evidence leads to the way of understanding, and these means are not owned but for firmly grounded in science who Almighty God opened for them in this field.

(E) International telecommunications Network (Internet)

The global network has a big role in the present era of the deployment of the poisons of extremism because of the plains of information delivery to all corners of the earth. On the other hand, most of the users of the information network are the young people, and they are the most inclined to accept the thought of disbelief and extremism than the other categories because of their enthusiasm and vitality of an innate love of excitement and

emergence. The Regional Centre for Strategic Studies defines the proportion of young people involved in this field for the reasons and motives that explained above (Regional Center for Strategic Studies, 2014). If we look at the motives that made those young people receptive and attracted to what occasionally published by extremist ideology we can see that the extremists spread their subjects in an excited manner pulling young people to their parts through the presentation of their characters like a hero savior of the nation. The cinematic way, such as those carried out by some of the films in the legendary figures in Hollywood, supported by legitimate texts ostensibly backed and it really is a contradiction, citing the march of the leaders of the Islamic nation over the centuries, although the difference between the two in terms of thought and approach, but ignorance, excitement, love of adventure, and love of vanity drawback appearing in discrimination are all basic reasons for extremism.

3. The Relationship between International Policy and Extremism

The current events and international surveys and reports reveal the relevance and large relationship of the major international policy and its dealings with the Third World countries, particularly with Islamic countries, in supporting extremism. The most important aspects of this relationship are:

(A) Direct Military Support: is the support of some countries to the armed groups of intellectual extremist character which based on the thought of disbelief. This support is exemplified in what the United States of America had done with the armed groups, particularly al Qaeda, led by Osama bin Laden. The support was in the form of weapons and everything they need after the occupation of the Soviet Union to Afghanistan in 1979. The support started in 1984 and completed at the year 1998. This is what was said by former US Secretary of State Hillary Clinton, who has rocked Arab and Muslim world, recognizing that America is the real creator of al Qaeda, which is fighting today. She adds that this is due to reasons related to global conflict with the former Soviet Union (Al-Arab, 2014). If we analyze the reasons of the Islamic world's surprise of these actions, we can see the duplicity of the United States as a main feature of its policy. From a hand the USA created and supported the organization of al Qaeda and on the other hand USA fought it. As a result we can conclude that America uses the organization for her interests and benefits. These benefits are military, economic, strategic and other future targets with its competitors. American deals are based on fixed interests and variable policies.

A nowadays example of supporting extremism is what the Russian troops are making in Syria. They support the extremist groups of Hezbollah, the Iranian militias and others underneath, by supplying them with whatever weapons they need. In addition this support includes bombing planes and the participation of some Russian special forces in some battles. As well as its diplomatic support through the use of the right to veto any decision taken in support of the Syrian rebels Syrian by the Security Council against the government of Bashar and his extremist militias (Arabic Center for Research and policy Studies, 2015). As for the motive that called for Russian intervention in Syrian affairs and support for extremist groups is that Russia seeks to restore its lost role after the collapse of the Soviet Union. Also, Russia seeks economic gains and strategic sites to compete with its rivals as the United States and the European Union.

(B) Intervention in the countries: The hostile behavior and the use of violence generate negative effects in the communities, especially in those who overwhelmed with enthusiasm against controls of religion, belief, and humanitarian sense. The example of the occupation of countries in modern age is what was done by the United States to occupy Afghanistan and Iraq. The reasons of occupation are not convincing for Muslim and non-Muslim as well. As a result, these countries suffered murder, destruction of the infrastructure of their countries, and displaced to different countries. So, these tragedies arise some extremist groups who resist these occupations in an extremist manner without adhere controls of the Islamic religion. This is reflected in their extremism on Muslim societies to which they belong, as happened in Iraq and Afghanistan. The involvement of some enthusiastic young people to extremist groups such as al-Qaeda, the state of Iraq and the Levant (Daesh), and the militias of disbelief is argued as a support of religion and doctrine.

These extremist groups have killed all of their opponents in thought and act even from the same doctrine that they claim affiliation to it. In addition, they adopt the killing and displacement of people of non-Muslim religions such as Christian, Sabians, and Yazidis as well as the demolition of their temples [Human rights report on Iraq, 2010]. It is very important to say that these extremist groups were not exist prior to the occupation of those countries and the colonization of them is the one which raised the ire of some young people. Extremism and fanaticism attributed to the Islamic religion are generated by this kind of colonization. Further, this extremism is not absolutely related to the doctrine and methodology of the Islamic religion and its legislation of soft and good treatment of the Muslim community with the non-Muslims. This is stated in the Almighty saying: (وَلا تُجَادِلُوا أَهْلَ الْكِتَابِ إِلاَّ بِالَّتِي هِيَ أَحْسَنُ) [Qura'n, Al- Ankabut Surah, 46]. In this Qur'anic text, the tolerance of Islam with non-Muslims is reflected in terms of affirmative good treatment with them. The Messenger of Allah, peace be

upon him, embodies this tolerance in several positions. When a delegation of Najran came to him in his mosque and it was the time of Asir prayers, the delegation starts praying in the Muslim mosque, so some people wanted to stop them, but Prophet, peace be upon him: said to them (Let them). The delegation turned toward the east, which is their Qibla direction. They turned themselves to a different Qibla because they were Christian to do their prayers (Al- Dahabi, 1987).

Taking this accident into account, we will find it in the top of good handling and tolerance with those who are different in thinking and approach. This cannot be found in other non-Muslim religions of past and present. Can Muslims do their worship in churches and temples? and do they allow a muslim to do so? German Orientalist D. Sigrid Hunke has expressed the justice and tolerance of Islam when she said: this is truly wonderful, such things did not occur before. Who is the human being who does not breathe the breeze of freedom after the unjust Byzantine? And after this heinous persecution that took place in Spain, and continuous persecutions that Jews suffered lots of its horrors? The new Muslims are the protectors of country and its rulers. They did not intervene in the internal matters of their subjects: they were just. Thus, the Patriarch of Jerusalem wrote in the nineteenth century to the Patriarch of Istanbul - and Muslims do not oppress or persecute us. They give different members of their flock of other faiths all the freedom in performing religious duties or civil rights as long as they paid Jizya (tribute) and obey the rulers (Hoeneker 1964).

In this connection, al-Mawardi said in the theme of the necessity to protect non-Muslims in the Islamic country that "it is a commitment of any Imam, to give two rights for them: one: to defend them, the second is their protection: to be safe and protected"; (Al- Mawardi, 2010).

© International laws and legislations: legislation and international laws are represented by the Association of the United Nations and human rights organizations, the Security Council and others. The resolutions of these associations are created by certain countries, namely the five permanent members which dominate the rest of the world. Some of the laws have resulted in the occupation of sovereign countries by directing military strikes against these countries under false and incorrect pretenses as the decision to strike Iraq and the recognition of its occupation by the United States (Haseeb, 2006). Later, it turns out that the evidence on which they based their strike was incorrect. Iraq did not possess nuclear weapons and there is not any kind of relationship between Iraq and Al-Qaeda. This is what was found through the American and British intelligence reports after the occupation (Ahmad, 2004). These decisions that benefit America and the Western interests have caused sectarian and ethnic conflicts. Also, the emergence of extremist groups which fed on those wrong international policies caused the destruction of Iraq, led to the dismantling of the social fabric between the sects, and the occurrence of tragedies in all areas up to now as seen on TV channels.

The other reason is the subordination of some Islamic countries to the International Law issued by associations and international organizations like the United Nations and the Security Council, human rights organizations and the like. These associations control the decisions of the permanent members where they formulated the laws according to their interests. The laws stipulated an absolute freedom of doctrine and worship of non-Muslim minorities in Muslim countries and this in itself is inconsistent with the provisions of Islamic laws that allow freedom of belief and worship for non-Muslims within certain specific controls. These controls are well- known in the books of Islamic Fiqh (jurisprudence). The documents of the United Nations stipulated the most important of the International Covenants on Civil and Political Rights, Economic and Cultural Rights in 1966. These documents are followed by the Universal Declaration of the Rights of Persons Belonging to National or Ethnic, Religious and Linguistic Minorities 1992 which stated: "The promotion and protection of the rights of persons belonging to minorities national or ethnic, religious and linguistic minorities contribute to political and social stability of States in which they live". This is the most popular United Nations documents that dealt with minorities and their rights in a separate document. Also, it was the announcement which is more directly based on (Article 27) of the International Covenant on Civil and Political Rights, which states:

In those States in which ethnic, religious or linguistic minorities exist, persons belonging to such minorities shall not be denied the right, in community with the other members of their group, to enjoy their own culture, to profess and practise their own religion, or to use their own language (UN document, 1993).

Notably, these resolutions did not take into account the Islamic provisions of legislation and the feelings of Muslims. Therefore, some missionary groups had taken advantage of these laws by taking churches as a springboard for them and that raised the ire of some extremist groups to attack the non-Muslims. In this way they go against the controls and provisions of the Islamic religion in the killing and displacement of people and the destruction of churches and temples through detonating them as in Iraq, which is one of the biggest arenas for sectarian fighting (Iraqi Ministry of Human Rights, 2011).

These legislation and international laws caused in the formation of internal and external forces and groups to support both parties according to their beliefs. This led to the affliction of strife and bloodshed. Thus, because of these policies, the foreign countries had actually participated in the fighting and became military and political influential forces in the affairs of the countries as seen now in Iraq, Syria and Afghanistan.

4. Conclusions

In accordance to the above mentioned information about the theme of extremism, we can explain the following isuues:

(A) The theme of extremism is one of the important topics that should be studied and given a special significance since it's related to the approach and ideology of the Islamic religion. The extremists' acts and statements are contradictive to the principles and values of the Islamic religion. These actions lead to repel non-Muslims against Islam and disable the Da'wa (invitation) to it. In addition, what is produced by extremism is the lack of security and stability of countries.

(B) The principles and values of the Islamic religion are rejecting extremism and all things contradictive to tolerance and moderation. Islam calls to the good relation between Muslims and non-Muslims, in accordance to the Qur'an, Sunnah and the Muslim scholars and leaders who followed that along over the centuries.

(C) One of the most important things that caused extremism is ignorance especially of legal issues, as well as the economic factor and the social environment in which the individual is created. Also, it is important to refer to the shortening of some scholars and preachers to warn against extremism, especially after the connections development between the countries through the Internet networks which have a great role in the present era -.

(D) Military support by the major powers helps in the spread of extremism, as the United States did in supporting of al-Qaeda in Afghanistan during its occupation by the former Soviet Union and Russian support in all fields for extremist groups like the Iranian militias and Hezbollah in Syria.

(E) The unjust occupation of the safe countries under false pretenses was one of the reasons for the spread of extremism. It raised the ire of some undisciplined groups which are contrary to the principles and values of the Islamic religion.

(F) Legislation and international laws initiated by the Permanent Members, which provides an absolute freedom to practice the rituals and rites of non-Muslim minorities living in a Muslim country without taking into account the provisions of the Islamic religion. The exploitation of such legislations and laws by some missionary groups raised the ire of some extremist groups against non-Muslim minorities unjustly.

Acknowledgments

References

Abu-Yusuf-Yaqub, I. I. I. H. B. S. B. H., Al-Ansari, & Al-Kharaj (Taxation in Islam). (2010). *Cairo: Al-Azhar Library Heritage, investigated by: Taha Abdel Raouf Saad, 1*, 139.

Ahmed, & Mohammed (2004). *The US - British invasion in 2003*, The causes and results, 4/29/2016.

Al-Arab (2014). Retrieved from http://www.alarab.co.uk/?id=28244

Al-Bukhari, & Muhammad, B. I. A. A. A. (2001). *Sahih al-Bukhari. Investigated by: Mohammed Zuhair bin Nasser al-Nasser*, Publisher: Beirut: Dar Tawq al-Najat. *Hadith, 38*(1), 16.

Al-Dhahabi, S. A. M. I. A. I. U. (1987). *Tarikh al-Islam al-kabir. (Major History of Islam), 2*, 695.

Al-Hakim, A., al-Mustadrak, A., & Mohammed, B. A. A. A. (1990). *Investigated by: Mustafa Abdel Qader Atta*, Beirut: Books Dar, Hadith No., 2657. 2, 162.

Al-Mawardi. (2010). *Al-Ahkam al-Sultania w'al-Wilayat al-Diniyya (The Ordinances of Government)*, Cairo: Dar al-Hadith, 1, 223.

Al-Nasa'i, A. A. A., & Bin Syu'aib, R. A. (1986). *Sunan al-Nasa'i. Aleppo: Islamic Publications Office*, Hadith No. 5465 to seek refuge from poverty, 8, 262.

Arab Center for Research and Policy Studies. (2015). *The study of the Russian borders renunciation in Syria and prospects,* 1-2. Retrieved from http://www.dohainstitute.org/file/Get/6ac2c2c8-d3b9-4bc4-89a4-86164d3cd0bb.pdf

CNN Arabic. (2016). Retrieved from http://arabic.cnn.com/world/2015/12/08/

    donald-trump-muslim-ban-immigration

Dar Al-Iftaa –Egypt. (2009). Fatwa No. 1252. Retrieved from http://www.dar-alifta.org/

Hasseib, & Khairuddin. (2006). Iraq from occupation to liberation Beirut, Center for Arab Studies, 1, 10.

Herak Network. (2014). Retrieved from http://www.herak.info/10342

Human Rights Report on Iraq. (2010). *Human Rights Office of the United Nations Assistance Mission for Iraq (UNAMI)*, the High Commissioner for Human Rights Office of Baghdad, 1, 30.

Hunke Sigrid. (1964). (Shams al Arab on the West), Cairo: Dar Arabic renaissance, 1, 141-142.

Libyan Newsagency. (2015). Retrieved from http://www.lananews.com/ar/2015/02/2015-02-14-08-33-43/

Non News Reporting Agency. (2011). Retrieved from http://www.non14.net/13041/

The Iraqi Ministry of Human Rights. (2011). The sects of Iraq, a source of national richness, 1, 27-28.

The Regional Center for Strategic Studies. (2014). Retrieved from http://www.rcssmideast.org/Article/2908/

UN document – General association for Human Rights. (1993). *The sixteenth session, 6,* 1.

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A Survey on Evolutionary Computation: Methods and Their Applications in Engineering

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Abstract

Evolutionary computation is now an inseparable branch of artificial intelligence and smart methods based on evolutional algorithms aimed at solving different real world problems by natural procedures involving living creatures. It's based on random methods, regeneration of data, choosing by changing or replacing data within a system such as personal computer (PC), cloud, or any other data center. This paper briefly studies different evolutionary computation techniques used in some applications specifically image processing, cloud computing and grid computing. These methods are generally categorized as evolutionary algorithms and swarm intelligence. Each of these subfields contains a variety of algorithms and techniques which are presented with their applications. This work tries to demonstrate the benefits of the field by presenting the real world applications of these methods implemented already. Among these applications is cloud computing scheduling problem improved by genetic algorithms, ant colony optimization, and bees algorithm. Some other applications are improvement of grid load balancing, image processing, improved bi-objective dynamic cell formation problem, robust machine cells for dynamic part production, integrated mixed-integer linear programming, robotic applications, and power control in wind turbines.

Keywords: evolutionary computation, swarm intelligence, cloud computing, signal processing, power control

1. Introduction

Evolutionary computation, abbreviated as EC, is a subfield of artificial intelligence (AI), machine learning, and smart systems. The EC is almost a new and interesting area of research which uses biological evolution principles in order to solve computational problems with different complexities. A *computational problem* that must be solved by EC often requires the system to follow some convergence criteria expressed by the problem or its conditions. *Evolution* is defined as optimization process that tries to advance the ability of an organism to live longer in rapidly changing and unstable environments. Now if systems with computational models of evolutionary environments and processes are solved by a systematic approach, hence it's referred to as EC. The processes are: natural selection, reproduction, and survival. The theory of natural selection means that all living creatures on earth are the result of adaptation (and upgrade) to the demands of environment to date. If an organism has a successful adaptation to such environments, then it has higher fitness as it has more chance to exit and to outlast. Survival of fitness also shows that entities that are more fit to fluctuations of environment have more chances to survive longer, therefore more chances to spread their genotype to future generation by reproduction (Eiben & Smith, 2003; Fogel, 2007).

Evolutionary computation in this case employs some procedures based on evolutionary principles and techniques as the soul of EC. Generally, solutions of many problems are searchable in a domain—for example large integer factorization—but the problem is that covering the whole range of solutions and probably testing them for verification can be challenging. Clearly, optimum solution is achieved when the number of possible correct solutions is less, and on the other hand, if search space is not limited, the findings are based on exhaustive searches that may either lead to an answer or not. This is not just for EC, and many other topics such as

mathematics, signal processing, artificial neural networks (ANNs) and more suffer from such conditions that lead to many answers verifiable after extensive searches (Rahmati, Yar, Khalilpour, & Malekijavan, n.d.; Vahid Rahmati, Yar, & Malekijavan, 2014). Search is one way to find the solution, therefore, a collection of different searching methods developed with regard to the extent of spaces. Among these searching methods, the natural evolution methods—usually using meta-heuristic procedures—are the best choices at the moment. Despite applications, many of the resources categorize methods into two main branches: 1- evolutionary algorithms (EAs) 2- swarm intelligence (SI) (Back & Schwefel, 1996; Fogel, 2007; Wierstra, Schaul, Glasmachers, Sun, & Schmidhuber, 2011).

This paper introduces both of these categories briefly with current real world examples and algorithms that show promising future for such methods. Management of immense amount of information available on PCs and web servers, use of cloud/grid computing, and efficient signal/image processing are among top applications of EC. The subfields for the EA are therefore: 1- differential evolution and search, 2- evolutionary strategy and programming, and 3- genetics (expressing) programming and algorithm. SI also includes: 1- ant colony, 2- bees algorithm, 3- cuckoo bird algorithm, and 4- particle swarm (Eberhart & Yuhui, 2001; Eberhart & Kennedy, 1995; Fogel, 2007; Guo, Zhao, Shen, & Jiang, 2012; Marinos & Briscoe, 2009; Sun, Wierstra, Schaul, & Schmidhuber, 2009).

2. Main Applications of EC

As mentioned in introduction, smarter image and signal processing are among important applications of EC where some regions in the image must be extracted in order for later processing. However, filtering and de-noising are also done by some algorithms. These applications are also introduced in this paper (Felzenszwalb & Huttenlocher, 2004; Horng, 2010; James & Eberhart, 1995; Kirchmaier, Hawe, & Diepold, 2013).

The most important and recently introduced concept in the ever growing field of information industry is cloud computing (CC) that gives privilege of request sending to some immense computational resources available on the web. The main fact proposed by CC states: *it's not necessary for every organization or company to build up its own data centers and high-tech infrastructures while it's possible to use CC on a pay per use basis*. The main problem for companies was building and maintaining such infrastructures, which without any doubt needs expenditure of money with too much efforts for future benefits of the companies. High amounts of investment are not feasible for middle to low income companies permitting them to use CC instead. This makes a brighter future for CC, thereupon a better prospect for upcoming EC methods and techniques (Arya & Verma, 2014; Ma & Wang, 2012; Subrata, Zomaya, & Landfeldt, 2007; Younge, Laszewski, Wang, Lopez, & Carithers, 2010).

Data centers with (super) computers provide different types of resources and services for CC, accordingly different types of CC services appeared in the market. Abbreviation paradigm of such services uses the suffix –aaS which represent "*as a service*". These are: 1- API[1] as a service (AaaS) 2- Data... (DaaS) 3- Infrastructure... (IaaS) 4- Platform... (PaaS) 5- Software... (SaaS) 6- Storage... (SEaaS) 7- Security... (SECaaS) 8- Test environment... (TEaaS). Some CC service suppliers are Amazon EC2, Google compute engine, Google app engine (GAE), Microsoft Azure, Google apps, IBM blue cloud, and more that provide public, private (enterprise), hybrid, and community clouds (Furht & Escalante, 2010).

Although CC is growing and transfer of data done by secure communication protocols with public key encryptions, there are some companies and individuals that are still reluctant to use CC services. In the question of *"high cost or high risk?"* many of them reply *high risk* as the data is available to CC providers (Shaikh & Haider, 2011; Zissis & Lekkas, 2012).

Despite cluster computing, if local and global resources together are used at the same time to solve a particular problem, then such a method is called grid computing (GC) which is itself a kind of distributed computing (DC). However, it's useful to use local and global computing units concurrently in order to compute, but this itself makes some problems arose from mismanagement of nodes in such networks which are solvable via genetic algorithms (Berstis, 2002; Furht & Escalante, 2010).

EAs can also be employed in military applications (Vahid, Tal, & Ghasem, 2014), however, there are few papers considering such growing number of applications in smart electronic warfare capabilities. Another application of EAs and ANNs can be software's developments total cost evaluation (Vahid, 2016b).

3. Evolutionary Algorithms (EAs)

The motivation behind EAs is essentially to employ the natural mechanisms of life, biological evolution including mutation, selection, and more—that are used by living creatures to solve a problem—in a computational manner. EAs are part of a broader algorithm set (EC) and are based on random searches and

meta-heuristics. The accuracy of optimized candidate solution by using EAs are generally improved by more iterations. However, more iteration cannot always reduce error (Fogel, 2007).

3.1 General Steps in an EA

EAs usually follow some steps in each iteration to find the best solution (Eiben & Smith, 2003; Fogel, 2007). This is as:

1-   Fitness of population of individuals grows after natural selection due to environmental pressures.

2-   Evaluation of each individual is done by a fitness function (given by the problem).

3-   Parents are selected among individuals based on fitness values.

4-   New individuals are generated from the parents (step 3) by recombination.

5-   The fitness value of new individuals and old candidates are compared to select next generation.

6-   If error of solution is more than expected go to step 1 else finish iteration.

Now that the main steps in an EA are known, it's useful to review some of the most famous algorithms.

3.2 Differential Evolution (DE)

Minimization and maximization of functions are generally a mathematical topic. Minimization of several variable functions can be very complex but practical as it can exhibit error function. DE algorithm thus, as a stochastic optimization method, invented to minimize an objective function under certain given constraints. DE is capable of finding true global solution by few control parameters and fast convergence (Bäck & Schwefel, 1993; Das, Abraham, & Konar, 2008; Vahid, 2015; Vahid, 2016a).

3.3 Differential Search Algorithm (DSA)

DSA utilizes migration of super organism by stable motioning for real valued numerical optimization problems. This multi way method uses the mid-point in journey of the migrating super organism (Das et al., 2008).

3.4 Genetic Programming (GP)

Specific user tasks on computers can be discovered or evaluated by biological evolution methods. GP works because it's possible to optimize a computer population (by fitness function) in order to perform user tasks. GP cannot solve all problems as it's complex, however, it has produced excellent outcomes in computing (Kumar, Husian, Upreti, & Gupta, 2010; Whitley, 1994).

3.5 Evolutionary Programming (EP)

Unlike GP that follows fixed structures, EP doesn't obey any constant pattern because all parents are generators due to extension of membership concept in this method (Bäck & Schwefel, 1993).

3.6 Evolution Strategy (ES)

In ES, mutation and selection are searchers, and normal parameters of problems are used for representations. Evolution of generations in an iterative manner where it's stopped by termination criterion (usually, the expected level of accuracy) forms this strategy (Wierstra, Schaul, Peters, & Schmidhuber, 2008).

3.7 Genetic Algorithm (GA)

Process of natural selection with a heuristic search forms GA by natural evolution characteristics that has applications such as automatic electronic circuit generating (Fogel, 2007; Whitley, 1994; Sachs, Russell, & Hollowell, 2002; Vahid & Ghashghavi, 2016).

3.8 Gene Expressing Programming (GEP)

Tree structures are used in data compression, searching and information processing algorithms. GEP also uses complex trees in order to make adaptable programs by changing almost all properties. Because GEP can use its genome to distribute genetic information, it's called genotype. Ability of adapting to the new environment also classifies GEP as phenotype (Kumar et al., 2010).

4. Swarm Intelligence Algorithms (SIAs)

Previous part briefly discussed EAs and their properties. This part focuses on SI algorithms including 1- ant colony 2- bees algorithm 3- cuckoo bird algorithm 4- particle swarm (Krause, Cordeiro, Parpinelli, & Lopes, 2013; Kennedy & Eberhart, 1995a).

4.1 Ant Colony Optimization (ACO)

ACO is a meta-heuristic optimization procedure primary invented for finding an optimal path in a graph which is based on observations of ants seeking colonies and sources of food. In summary, when one of the members of the colony discovers a short (and possibly safe) path according to its experience, other members converge to that path—as they have already tested and benefited from that path—which results in concentrated rally of ants (Kennedy & Eberhart, 1995b; Mahor, Prasad, & Rangnekar, 2009).

4.2 Bees Algorithm (BA)

Similar to ACO, BA is inspired by bees searching for food and sharing secret places as sources of food with other members as long as they contain enough food. Clearly, these bees will stop advertising those discovered locations if the source of foods has neither enough high quality nor richness (optimized). Therefore, BA is a population-based search algorithm used for combinatorial and continuous optimizations using neighborhood and global searches simultaneously (Kennedy & Eberhart, 1995a).

4.3 Cuckoo Bird Search Algorithm (CSA)

CSA is a simple optimization algorithm inspired by the way tricky cuckoos fighting to reproduce by laying their eggs in the nests of other birds with similar patterns on eggs exploiting the host birds to protect all eggs and therefore increase the chance of Cuckoos' eggs to become chicks (Poli, Kennedy, & Blackwell, 2007).

4.4 Particle Swarm Optimization (PSO)

PSO is an iterative meta-heuristic computational method that solves a problem by improving the possible correct solution (known as candidate solution) with respect to a measure of quality that leads to searching very large spaces of possible solutions with even no assumption about the problem. PSO was largely inspired by birds and fishes. Population of candidate solutions corresponds to swarm of particles that change their position according to some formulas in order to guide the whole swarm for an uncertain and possibly optimized solution. Indeed, swarms try to move to center while trying to match the neighbors' velocities and avoiding collisions (Poli et al., 2007).

5. Classic Real World Applications of EAs and SIAs

However, there exist many real world applications for EC, in this part, some real world contributions of EAs and SIAs are provided in compliance with definitions and statements presented already.

5.1 CC Scheduling by GA

In CC, scheduling is vital for balancing the loads between virtual machine (VM) resources (Vahid & Hedayat, 2016). Usual schedulers in CC follow a static manner considering only current status of the system bringing about imbalances and unequal distribution of tasks and finally failures. GA chooses the best solution, with regard to past and current states of data, resulting in migration's cost reduction (Gan & Huang, 2010).

5.2 CC Scheduling by ACO and BA

Similar to GA based task scheduling in CC, ACO has been proven to be a good load balancer algorithm (LBACO). However, combing ACO and BA, as their swarm structures suggest, can lead to less operational costs as power consumption is also minimized. In fact, the mixture of these two results in more efficient resource management. In such methodologies, service rescheduling which is the appropriate management of under-loaded CPUs is done by BA, and power consumption management which controls idle CPUs is done by ACO.

When several (mostly independent and unrelated to initial) tasks are waiting in a queue in a CC, the loads are not uniformly balanced over all VMs. In this case, honey bee behavior for load balancing (HBB-LB) invented to reduce waiting and execution times (Kun, Gaochao, Guangyu, Yushuang, & Wang, 2011; Dhinesh & Venkata, 2013; Vahid & Hedayat, 2016).

5.3 Grid Load Balancing by ACO

ACO has been used for grid load balancing which protects the nodes from being overloaded by distributing the loads uniformly among all nodes. It means that similar groups of ants (loads) are absorbed by corresponding colonies (nodes) (Ma & Wang, 2012), (Ludwig & Moallem, 2011).

5.4 Image Processing by ACO and BA

Obtaining image features, reducing image segmentation computations, and enhancing signal to noise ratio (SNR) are among applications of ACO and BA (Huang, Cao, & Luo, 2008; Akay, 2013). Transform-invariant pattern recognition by EAs and ANNs is also studied already by the authors in Vahid & Hedayat (2014).

6. Newly Introduced Trends

Last part introduced some of the main and some-how well established applications of EC, but there are some other applications and improvements of older algorithms used in newly introduced trends.

6.1 Improved Image Segmentation via K-Means Clustering and PSO

Image segmentation can be very practical when data mining procedures need to extract specific features and information from a set of images. Vast amount of visual resources available arises the need to use smart methods on these information as quickly as possible. K-means clustering is a fast algorithm that can build up enough clusters for image segmentation using implementation with low complexities at expense of lower visual qualities. Recently, the use of both dynamic PSO—as a global optimizer—with K-means resulted in better enhancements compared to usual PSO with K-means (PSOK). This method is called dynamic PSOK (DPSOK) (Li, He, & Wen, 2015).

6.2 Scheduling Algorithm for Load Balancing (SALB) in CC Based on ACO

It's possible to enhance grid load balancing via ACO explained already, however the classic algorithm can be improved by some various parameters. SALB tries to improve ACO by considering SLA violation, minimum overhead, and power consumption in multiple nodes balancing of dynamic workloads (Khan & Sharama, 2014).

6.3 Improved Bi-Objective Dynamic Cell Formation Problem (DCFP) by Non-Dominated Sorting GA (NSGA-II)

Dynamic cellular manufacturing system (DCMS) is an important production system fulfilling the needs of flexibility, quickness and efficiency in Industrial Revolution 4.0 standards, however, DCMS ignores some social and other factors. Recently, an innovative method (NSGA II-MOSA) to tackle such issues developed using both hybrid meta-heuristic based on the NSGA-II plus multi-objective simulated annealing (MOSA) is proposed (Deb, Pratap, Agarwal, & Meyarivan, 2002).

6.4 Improvement of Robust Machine Cells for Dynamic Part Production (RMCDPP) by GA

A GA based heuristic can be used for cost reduction by several industrial parameters; for instance, capacity of production, different development routes, working systems ability, and more (Deep & Singh, 2015).

6.5 Integrated Mixed-Integer Linear Programming (MILP) Model to DCMS Problem with Uncertainty

Many of the parameters in control systems, manufacturing, and engineering are well known which may be referred to as deterministic parameters—that were mostly considered in early versions of swarm and other smart methods (Clerc, 1999)—however, there exit multi stochastic parameters with much uncertainty studied in recent papers that can change the path of system completely to failures, high system breakdown and relocation costs, and etc. To deal with such latent parameters in DCMS, MILP model can be employed to assess different levels of uncertain factors and protection during system planning (Sakhaii, Tavakkoli, Bagheri, & Vatani, 2015).

6.6 Robotic Applications

Many tasks assigned to robots include ordinary man's obligations that must be done efficiently by faster means. Industries use robotic arms, smart measuring arrangements, and integrated manufacturing course of decision making processes. These processes are instrumentally interdependent, for that reason, deliberating multi-task considerations can be complicated even by human designer or smart robotic tools. SIAs are employed to handle the processes in different categories, but main studies concern applications on solving by a group of independent robots in a distributed (and not centrally managed similar to swarm) situations. Main lines of control in this case are: 1- accumulation, 2- grouping, 3- searching, 4- object clustering and sorting, 5- system navigation, 6- path shaping, 7- task assigning (Bayindir, 2016). The communication in industries may suffer from noise and other disturbances, particularly when heavy machines with inductors are used such as rotary motors. This problem is solvable by localizing regions in the factory and acquiring data from nearby sensors (Bayindir, 2016; Li, Xu, & Zhao, 2015).

6.7 Power Control in Wind Turbines by GA and PSO

Using wind power as a promising source of alternative energy—by constructing wind farms and appropriate positioning of the turbines in order to maximize capturing of wind energy and generating electricity—is now a well-recognized green method (Lindman & Söderholm, 2015). The art of designing such wind farms is based on minimizing the number of turbines used and maximizing output power by GA and PSO (Lindman & Söderholm, 2015). Wind variations and turbine vibrations during the conversion of wind energy to the electricity can cause resonations leading to unsmooth DC voltage and, because of the reason given, incompatible sinusoidal current on the grid side. More recently, the task of smooth controlling assigned to grid side converter (GSC) can be done

by PSO to engage in On-Off controlling scheme based on maximum power point tracking for the rotator side (Kahla, Soufi, Sedraoui, & Bechouat, 2015). Other conventional control mechanisms methods (Ghasem Khani, Tal'ati, & Rahmati, 2014; Vahid Rahmati, 2013, 2014) can also be done using GA and PSO by means of optimization algorithms.

7. Conclusion

This paper introduced EC, which includes EAs and SIAs, as an important computational tool currently being used largely. It also presented a summary for different EAs and SIAs together with their real world applications that mainly deal with cloud computing, distributed computation, image processing, power control, robotic applications, DCMS, RMCDPP, and DCFP problems. Finally, the paper discussed classic and new ways of applying these algorithms to specific problems such as service scheduling in CC, load balancing in grids, and image segmentation and enhancements.

References

Akay, B. (2013). A study on particle swarm optimization and artificial bee colony algorithms for multilevel thresholding. *Applied Soft Computing*, *13*(6), 3066–3091. http://doi.org/10.1016/j.asoc.2012.03.072

Arya, L. K., & Verma, A. (2014). Workflow scheduling algorithms in cloud environment - A survey. *Engineering and Computational Sciences (RAECS), 2014 Recent Advances in*, *2*(5), 1–4. http://doi.org/10.1109/RAECS.2014.6799514

Bäck, T., & Schwefel, H. P. (1993). An Overview of Evolutionary Algorithms for Parameter Optimization. *Evolutionary Computation*, *1*(1), 1–23. http://doi.org/10.1162/evco.1993.1.1.1

Back, T., & Schwefel, H. P. (1996). *Evolutionary computation: An overview*. IEEE International Conference on Evolutionary Computation, Vol. 30, pp. 593–616. http://doi.org/10.1109/ICEC.1996.542329

Bayindir, L. (2016). A review of swarm robotics tasks. *Neurocomputing*, *172*, 292–321. http://doi.org/10.1016/j.neucom.2015.05.116

Berstis, V. (2002). Fundamentals of grid computing. *IBM Redbooks Paper*, 1–28.

Clerc, M. (1999). The swarm and the queen: Towards a deterministic and adaptive particle swarm optimization. *Proceedings of the 1999 Congress on Evolutionary Computation, CEC 1999* (Vol. 3, pp. 1951–1957). http://doi.org/10.1109/CEC.1999.785513

Das, S., Abraham, A., & Konar, A. (2008). Particle swarm optimization and differential evolution algorithms: Technical analysis, applications and hybridization perspectives. *Studies in Computational Intelligence*, *116*, 1–38. http://doi.org/10.1007/978-3-540-78297-1_1

Deb, K., Pratap, A., Agarwal, S., & Meyarivan, T. (2002). A fast and elitist multiobjective genetic algorithm: NSGA-II. *IEEE Transactions on Evolutionary Computation*, *6*(2), 182–197. http://doi.org/10.1109/4235.996017

Deep, K., & Singh, P. K. (2015). Design of robust cellular manufacturing system for dynamic part population considering multiple processing routes using genetic algorithm. *Journal of Manufacturing Systems*, *35*, 155–163. http://doi.org/10.1016/j.jmsy.2014.09.008

Dhinesh, B. L. D., & Venkata, K. P. (2013). Honey bee behavior inspired load balancing of tasks in cloud computing environments. *Applied Soft Computing Journal*, *13*(5), 2292–2303. http://doi.org/10.1016/j.asoc.2013.01.025

Eberhart, & Yuhui, S. (2001). Particle swarm optimization: developments, applications and resources. Evolutionary Computation, 2001. *Proceedings of the 2001 Congress on*. http://doi.org/10.1109/CEC.2001.934374

Eberhart, R., & Kennedy, J. (1995). A new optimizer using particle swarm theory. *MHS'95. Proceedings of the Sixth International Symposium on Micro Machine and Human Science* (pp. 39–43). http://doi.org/10.1109/MHS.1995.494215

Eiben, A. E., & Smith, J. E. (2003). *Introduction to Evolutionary Computing. Evolutionary Computation* (Vol. 12). http://doi.org/10.1162/evco.2004.12.2.269

Felzenszwalb, P. F., & Huttenlocher, D. P. (2004). Efficient graph-based image segmentation. *International Journal of Computer Vision*, *59*(2), 167–181. http://doi.org/10.1023/B:VISI.0000022288.19776.77

Fogel, D. B. (2007). Introduction to Evolutionary Computation. *Modern Heuristic Optimization Techniques:*

Theory and Applications to Power Systems, 1–23. http://doi.org/10.1002/9780470225868.ch1

Furht, B., & Escalante, A. (2010). *Cloud Computing Fundamentals*. Handbook of Cloud Computing. http://doi.org/10.1007/978-1-4419-6524-0

Gan Guo Ning, & Huang Ting Iei, G. S. (2010). Genetic Simulated Annealing Algorithm for Task Scheduling based on Cloud Computing Environment. *Iciss*, 60–63.

Ghasem, K. B., Tal'ati, S., & Rahmati, V. (2014). *Distance Measurment by Delay Pulse* (Vol. 10, pp. 40–50). In Shahid Sattari University Exihibition on Electronic Warfare, Tehran, Iran.

Guo, L., Zhao, S., Shen, S., & Jiang, C. (2012). Task scheduling optimization in cloud computing based on heuristic Algorithm. *Journal of Networks*, *7*(3), 547–553. http://doi.org/10.4304/jnw.7.3.547-553

Horng, M. H. (2010). A multilevel image thresholding using the honey bee mating optimization. *Applied Mathematics and Computation*, *215*(9), 3302–3310. http://doi.org/10.1016/j.amc.2009.10.018

Huang, P., Cao, H., & Luo, S. (2008). An artificial ant colonies approach to medical image segmentation. *Computer Methods and Programs in Biomedicine*, *92*(3), 267–273. http://doi.org/10.1016/j.cmpb.2008.06.012

Kahla, S., Soufi, Y., Sedraoui, M., & Bechouat, M. (2015). On-Off control based particle swarm optimization for maximum power point tracking of wind turbine equipped by DFIG connected to the grid with energy storage. *International Journal of Hydrogen Energy*, *40*(39), 13749–13758. http://doi.org/10.1016/j.ijhydene.2015.05.007

Kennedy, J., & Eberhart, R. (1995). Particle Swarm Optimization. *Engineering and Technology*, 1942–1948.

Kennedy, J., & Eberhart, R. (1995a). Particle swarm optimization. Neural Networks, 1995. *Proceedings IEEE International Conference on*, *4*, 1942–1948. http://doi.org/10.1109/ICNN.1995.488968

Kennedy, J., & Eberhart, R. (1995b). *Particle swarm optimization*. IEEE International Conference on Particle Swarm Optimization. http://doi.org/10.1109/ICNN.1995.488968

Khan, S., & Sharama, N. (2014). Effective Scheduling Algorithm for Load balancing (SALB) using Ant Colony Optimization in Cloud Computing. *International Journal of Advanced Research in Computer Science and Software Engineering*, *4*(2), 966–973.

Kirchmaier, U., Hawe, S., & Diepold, K. (2013). A Swarm Intelligence inspired algorithm for contour detection in images. *Applied Soft Computing Journal*, *13*(6), 3118–3129. http://doi.org/10.1016/j.asoc.2012.07.017

Krause, J., Cordeiro, J., Parpinelli, R. S., & Lopes, H. S. A. (2013). A Survey of Swarm Algorithms Applied to Discrete Optimization Problems. *Swarm Intelligence and Bio-Inspired Computation*, 169–191. http://doi.org/10.1016/B978-0-12-405163-8.00007-7

Kumar, M., Husian, M., Upreti, N., & Gupta, D. (2010). Genetic Algorithm: Review and Application. *International Journal of Information Technology and Knowledge Management*, *2*(2), 451–454. Retrieved from http://www.csjournals.com/IJITKM/PDF 3-1/55.pdf

Kun, L., Gaochao, X., Guangyu, Z., Yushuang, D., & Wang, D. (2011). Cloud Task Scheduling Based on Load Balancing Ant Colony Optimization. *Chinagrid Conference (ChinaGrid), 2011 Sixth Annual*, 3–9. http://doi.org/10.1109/ChinaGrid.2011.17

Li, H., He, H., & Wen, Y. (2015). Dynamic Particle Swarm Optimization and K-means Clustering Algorithm for Image Segmentation. *Optik - International Journal for Light and Electron Optics*, *126*(24), 4817–4822. http://doi.org/10.1016/j.ijleo.2015.09.127

Li, S., Xu, L. Da, & Zhao, S. (2015). The internet of things: a survey. *Information Systems Frontiers*, *17*(2), 243–259. http://doi.org/10.1007/s10796-014-9492-7

Lindman, Å., & Söderholm, P. (2015). Wind energy and green economy in Europe: Measuring policy-induced innovation using patent data. *Applied Energy*. http://doi.org/10.1016/j.apenergy.2015.10.128

Ludwig, S. A., & Moallem, A. (2011). Swarm Intelligence Approaches for Grid Load Balancing. *Journal of Grid Computing*, *9*(3), 279–301. http://doi.org/10.1007/s10723-011-9180-5

Ma, Y., & Wang, Y. (2012). *Grid task scheduling based on Chaotic Ant Colony Optimization Algorithm*. Computer Science and Network Technology (ICCSNT), 2nd International Conference on, 2012. http://doi.org/10.1109/ICCSNT.2012.6525979

Mahor, A., Prasad, V., & Rangnekar, S. (2009). Economic dispatch using particle swarm optimization: A review. *Elsevier*, *13*(8), 2134–2141. http://doi.org/10.1016/j.rser.2009.03.007

Marinos, A., & Briscoe, G. (2009). Community cloud computing. *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 5931 LNCS*, 472–484). http://doi.org/10.1007/978-3-642-10665-1_43

Poli, R., Kennedy, J., & Blackwell, T. (2007). Particle swarm optimization. *Swarm Intelligence*, *1*(1), 33–57. http://doi.org/10.1007/s11721-007-0002-0

Rahmati, V. (2013). *A New PID Based Mechanism to Control Velocity and Direction of DC Motors*. Islamic Azad University Tehran South Branch.

Rahmati, V. (2014). *A Novel Low Complexity Fast Response Time PID Controller Based on Fuzzy Logic for DC Motors*. C4I Conference in Shahid Sattari University, Tehran, Iran, pp. 36–45.

Rahmati, V. (2015). *Improvement of the Approximation Error for Reconstruction of Signals by Asymmetric Sampling with Presentation of a New Turbo Code*. Shahid Sattari University.

Rahmati, V. (2016a). Improved Interpolation and Approximation through Order Manipulation. *International Journal of Emerging Computing Methods in Engineering*, *1*(1), 1–10. Retrieved from http://icdst.org/OAJ/index.php/IJECME/article/view/4/5

Rahmati, V. (2016b). Software Development's Total Cost Evaluation by Applying Complexity Function of Different Orders. *International Journal of Modern Engineering Technologies*, *1*(1), 1–5. Retrieved from http://www.icdst.org/OAJ/index.php/IJMET/article/view/5

Rahmati, V., & Ghashghavi, M. (2016). *Intelligent Methods for Analogue Electronic Circuit Design by GA*. Ayandeh Samin Electronics Group.

Rahmati, V., & Hedayat, A. (2014). A Transform-invariant Pattern Recognition by Evolutionary Algorithms and Artificial Neural Networks. *Simorgh Institute Journal of Intelligent Methods*.

Rahmati, V., & Hedayat, A. (2016). *How to Manage VM's Resources by GA, ACO, and BA*. Ayandeh Samin Electronics Group.

Rahmati, V., Tal'ati, S., & Ghasem, K. B. (2014). *New Technologies in Electronic Warfare* (Vol. 10, pp. 11–20). Shahid Sattari University Exihibition on Electronic Warfare, Tehran, Iran.

Rahmati, V., Yar, M. H., & Malekijavan, A. R. (2014). Neural Networks New Capacity Factor Measurement for Improvement of SOM. *International Journal of Innovative Technology and Exploring Engineering (IJITEE)*, *3*(12), 7–10. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.685.7664&rep=rep1&type=pdf

Rahmati, V., Yar, M. H., Khalilpour, J., & Malekijavan, A. R. (n.d.). *Back Propagation Artificial Neural Network Structure Error Reduction by Defined Factor of Capacity and Algorithm Reinforcement Method*. Retrieved from https://www.academia.edu/26603028/Back_Propagation_Artificial_Neural_Network_Structure_Error_Reduction_by_Defined_Factor_of_Capacity_and_Algorithm_Reinforcement_Method

Sachs, J. L., Russell, J. E., & Hollowell, A. C. (2002). *Evolutionary Electronics: Automatic Design of Electronic Circuits and Systems by Genetic Algorithms*. PloS one (Vol. 6). http://doi.org/10.1371/journal.pone.0026370

Sakhaii, M., Tavakkoli Moghaddam, R., Bagheri, M., & Vatani, B. (2015). A robust optimization approach for an integrated dynamic cellular manufacturing system and production planning with unreliable machines. *Applied Mathematical Modelling*, *40*(1), 169–191. http://doi.org/10.1016/j.apm.2015.05.005

Shaikh, F. B. F., & Haider, S. (2011). *Security threats in cloud computing*. International Conference for Internet Technology and Secured Transactions, December, 2011, 214–219. http://doi.org/10.1016/j.sbspro.2011.08.063

Subrata, R., Zomaya, A. Y., & Landfeldt, B. (2007). Artificial life techniques for load balancing in computational grids. *Journal of Computer and System Sciences*, *73*(8), 1176–1190. http://doi.org/10.1016/j.jcss.2007.02.006

Sun, Y., Wierstra, D., Schaul, T., & Schmidhuber, J. (2009). *Efficient natural evolution strategies*. Genetic And Evolutionary Computation Conference, pp. 7. Retrieved from http://portal.acm.org/citation.cfm?id=1569901.1569976

Whitley, D. (1994). A genetic algorithm tutorial. *Statistics and Computing*, *4*(2), 65–85. http://doi.org/10.1007/BF00175354

Wierstra, D., Schaul, T., Glasmachers, T., Sun, Y., & Schmidhuber, J. (2011). Natural Evolution Strategies. *arXiv*, 1–52. Retrieved from http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=4631255/

Wierstra, D., Schaul, T., Peters, J., & Schmidhuber, J. (2008). *Natural Evolution Strategies*. 2008 IEEE Congress on Evolutionary Computation (IEEE World Congress on Computational Intelligence), pp. 3381–3387. http://doi.org/10.1109/CEC.2008.4631255

Younge, A. J., Von Laszewski, G., Wang, L., Lopez Alarcon, S., & Carithers, W. (2010). Efficient Resource Management for Cloud Computing Environments. *International Conference on Green Computing*, 357–364. http://doi.org/10.1109/GREENCOMP.2010.5598294

Zissis, D., & Lekkas, D. (2012). Addressing cloud computing security issues. *Future Generation Computer Systems*, *28*(3), 583–592. http://doi.org/10.1016/j.future.2010.12.006

Note

Note 1. API (Application Program Interface): interface which enables an application to communicate with the OS and other services provided by it or to create similar user interfaces within computer programs.

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A Barycentric Interpolation Collocation Method for Linear Nonlocal Boundary Value Problems

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Abstract

This paper is devoted to the numerical treatment of a class of higher-order multi-point boundary value problems(BVPs). The method is proposed based on the Lagrange interpolation collocation method, but it avoids the numerical instability of Lagrange interpolation. Numerical results obtained by present method compare with other methods show that the present method is simple and accurate for higher-order multi-point BVPs, and it is effective for solving six order or higher order multi-point BVPs.

Keywords: barycentric interpolation, reproducing kernel, multi-point boundary value problems, higher-order

1. Introduction

Collocation method as a numerical calculation method for solving differential equations, it has many merits, such as calculation formula is simple, program implementation is convenient. Use Lagrange interpolation collocation method to solve differential equations, when select too many nodes, Lagrange collocation formula will be not numerical instability, the famous Runge phenomenon illustrates the problem[1]. But barycentric interpolation collocation method has excellent numerical instability[2]. In this paper, we select suitable number of the second kind Chebyshev point as interpolation nodes, use barycentric interpolation collocation method establish the dierential matrix of function to solve multi-point boundary value problems(BVPs).

As we know, boundary value problems(BVPs) arise in many fields(see[11-16]). In[3], Henderson and Kunkel proved the uniqueness of solutions for the following linear differential equations with nonlocal boundary conditions:

$$\begin{cases} u^{(m)}(x) + \sum_{i=0}^{m-1} a_i(x)u^{(i)}(x) = f(x) \\ u^{(i-1)}(x_j) = b_{ij}, 1 \le i \le m_j, 1 \le j \le k \\ u(x_{k+1}) - u(x_{k+2}) = b_m \end{cases} \tag{1}$$

where $a_i(x) \in C[a, b]$, m_j are positive integers such that $\sum_{i=1}^{k} m_i = m - 1, a < x_1 < x_2 < \ldots < x_{k+2} < b, b_m, b_{ij}$ are real numbers.

In [4],[5], Lin and Wu use the reproducing kernel to solve the following boundary value problems(BVPs). In [6], Li use another reproducing kernel method to solve this problem.

$$\begin{cases} u^{(4)}(x) + \sum_{i=0}^{3} a_i(x)u^{(i)}(x) = f(x) \\ u^{(i-1)}(\xi_1) = b_i, 1 \le i \le 3, u(\xi_2) - u(\xi_3) = b_4 \end{cases} \tag{2}$$

In this work, we use barycentric interpolation to solve (1) , several numerical examples are given to demonstrate the efficiency of the present method. The present method compared with the others methods, reveals that the present method is more effective and convenient.

2. Barycentric Interpolation

2.1 The Differential Matrix Of Barycentric Interpolation

According to the ideas of the collocation method, the all-order derivatives of function at nodes can be approximate as linear weighted sum of the function value at node. Consider the function $u(x)$ which defined in interval $[a, b]$, the values of function $u(x)$ at nodes, $a = x_1 < x_2 < \ldots < x_n = b, u_i = u(x_i), i = 1, 2, \ldots, n$, and the all-order derivatives of $u(x)$ at the nodes can be expressed as the linear weighted sum of the function value,

$$u_i^{(m)} = u^{(m)}(x_i) = \frac{d^m u(x_i)}{dx^m} = \sum_{j=1}^{n} D_{ij}^{(m)} u_j, m = 1, 2, \ldots \tag{1}$$

Written in matrix form is,

$$u^{(m)} = D^{(m)} u \tag{2}$$

There, $u^{(m)} = [u_1^{(m)}, u_2^{(m)}, \ldots, u_n^{(m)}]^T$ is the column vector of the m order derivatives m of unknown function at nodes, matrix $D^{(m)}$ is m order differential matrix of unknown function, the element of $D^{(m)}$, $D_{ij}^{(m)}$ is the weighted coefficient, $u^{(m)} = [u_1^{(m)}, u_2^{(m)}, \ldots, u_n^{(m)}]^T$ is the value of unknown function at nodes.

Barycentric interpolation primary function is denoted by $L_j(x)$, the barycentric interpolation of $u(x)$ can be expressed as,

$$u(x) = \sum_{j=1}^{n} L_j(x) u_j \tag{3}$$

So, the one order and two order derivatives of $u(x)$ can be expressed as,

$$u'(x) = \sum_{j=1}^{n} L'_j(x) u_j, u''(x) = \sum_{j=1}^{n} L''_j(x) u_j \tag{4}$$

Barycentric interpolation primary function is,

$$L_j(x) = \frac{\frac{w_j}{x - x_j}}{\sum_{k=1}^{n} \frac{w_k}{x - x_k}} \tag{5}$$

There, $w_j = \frac{1}{\prod\limits_{j \neq k} x_j - x_k}, j = 1, 2, \ldots, n$ is barycentric interpolation weight, it based on the distribution of interpolation nodes. Multiply $x - x_j, (i \neq j)$ at both sides of (5) at the same time, after deformation is,

$$L_j(x) \sum_{k=1}^{n} w_k \frac{x - x_i}{x - x_k} = w_j \frac{x - x_i}{x - x_j} \tag{6}$$

To facilitate, let,

$$s(x) = \sum_{k=1}^{n} w_k \frac{x - x_i}{x - x_k} \tag{7}$$

Calculate derivative about x at both sides of (6) at the same time, we get,

$$L'_j(x) s(x) + L_j(x) s'(x) = w_j (\frac{x - x_i}{x - x_j})' \tag{8}$$

$$L''_j(x) s(x) + 2L'_j(x) s'(x) + L_j(x) s''(x) = w_j (\frac{x - x_i}{x - x_j})'' \tag{9}$$

Calculate derivative about x at both sides of (7) ,

$$s(x_i) = w_i \tag{10}$$

$$s'(x_i) = \sum_{k \neq i} \frac{w_k}{x_i - x_k} \tag{11}$$

$$s''(x_i) = -2 \sum_{k \neq i} \frac{w_k}{(x_i - x_k)^2} \tag{12}$$

Take formula (10)~(12) into the formula (8) and (9), we know $L_j(x_i) = 0 (i \neq j)$, so we can get,

$$L'_j(x_i) = \frac{\frac{w_j}{w_i}}{x_i - x_j}, \ j \neq i \tag{13}$$

$$L''_j(x_i) = -2 \frac{\frac{w_j}{w_i}}{x_i - x_j} \left(\sum_{k \neq i} \frac{\frac{w_k}{w_i}}{x_i - x_k} + \frac{1}{x_i - x_j} \right), \ j \neq i \tag{14}$$

If $i = j$, we know $\sum_{j=1}^{n} L_j(x) = 1$, calculate derivative about x at both sides, we get $\sum_{j=1}^{n} L_j^{(m)}(x) = 0$, so,

$$L'_i(x_i) = - \sum_{j \neq i} L'_j(x_i) \tag{15}$$

$$L''_i(x_i) = - \sum_{j \neq i} L''_j(x_i) \tag{16}$$

Now, we can get one and two order differential matrix,

$$D_{ij}^{(1)} = L'_j(x_i), D_{ij}^{(2)} = L''_j(x_i) \tag{17}$$

Using mathematical induction, we can get the recursion formula of m order differential matrix,

$$\begin{cases} D_{ij}^{(m)} = m \left(D_{ii}^{(m-1)} D_{ij}^{(1)} - \frac{D_{ij}^{(m-1)}}{x_i - x_j} \right), i \neq j \\ D_{ii}^{(m)} = - \sum_{j=1, j \neq i}^{n} D_{ij}^{(m)} \end{cases} \tag{18}$$

2.2 The Barycentric Interpolation Collocation Formula of Multi-Point BVPs

Think about fuction (**??**)

$$\begin{cases} u^{(m)}(x) + \sum_{i=0}^{m-1} a_i(x) u^{(i)}(x) = f(x) \\ u^{(i-1)}(x_j) = b_{ij}, 1 \leq i \leq m_j, 1 \leq j \leq k \\ u(x_{k+1}) - u(x_{k+2}) = b_m \end{cases} \tag{19}$$

Where $a_i(x) \in C[a, b]$, m_j are positive integers, such that $\sum_{i=1}^{k} m_i = m - 1, a < x_1 < x_2 < \ldots < x_{k+2} < b, b_m, b_{ij}$ are real numbers.

Let interval $[a, b]$ dispersed as $a = x_1 < x_2 < \ldots < x_n = b$, let $u_1, u_2 \ldots, u_n$ as the value of function $u(x)$ at disperse nodes $x_1, x_2 \ldots, x_n$, using the barycentric interpolation collocation can get approximate function $u(x)$,

$$u(x) = \sum_{j=1}^{n} L_j(x) u_j \tag{20}$$

Take formula (20) into the differential equation, we can get,

$$\sum_{j=1}^{n} L_j^{(m)}(x) u_j + \sum_{j=1}^{n} \sum_{i=0}^{m-1} a_i(x) L_j^{(i)}(x) u_j = f(x) \tag{21}$$

Let (21) accurate established at disperse nodes, we can get n equations,

$$\sum_{j=1}^{n} L_j^{(m)}(x_k)u_j + \sum_{j=1}^{n} \sum_{i=0}^{m-1} a_i(x_k)L_j^{(i)}(x_k)u_j = f(x_k), k = 1, 2 \ldots, n \tag{22}$$

i.e.

$$\sum_{j=1}^{n} D_{kj}^{(m)}u_j + \sum_{j=1}^{n} \sum_{i=0}^{m-1} a_i(x_k)D_{kj}^{(i)}(x_k)u_j = f(x_k), k = 1, 2, \ldots, n \tag{23}$$

Writ (23) in matrix form is

$$LU = F$$

There

$$L = D^{(m)} + A_i D^{(i)}, U = [u_1, u_2, \ldots, u_n]^T, A_i = diag[a_i(x_k)]$$
$$F = [f_1, f_2, \ldots, f_n], D^{(m)} = [D_{kj}^{(m)}]_{n*n}, k, j = 1, 2, \ldots, n$$

Take formula (20) into initial conditions,

$$\begin{cases} \sum_{k=1}^{n} D_{jk}^{(i-1)}u_k = b_{ij} \\ \sum_{j=1}^{n} L_j(x_{k+1})u_j - \sum_{j=1}^{n} L_j(x_{k+2})u_j = b_m \end{cases} \tag{24}$$

2.3 Applying Method of Initial Boundary Conditions

Use collocation method to solve the differential equation problem, the key is how to use the initial conditions. There are three method. The first method is displacement method. That is, we use the functions of (24) displace from the first to m functions of (23). The second method is supplemental method. That is, the functions of (24) add after functions of (23).The third method is elimination method. That is, we get u_1, u_n from (24), i.e. use $u_2, u_3 \ldots, u_{n-1}$ express u_1 and u_n, and then take them into from the second to $n - 1$ functions of (23). About multi-point BVPs,we always use displacement method and supplemental method.

3. Numerical Experiment

In this section, six numerical examples are studied to demonstrate the accuracy of the present method.

Example 1[4−6] Considering following fourth-order boundary value problems.

$$\begin{cases} u^{(4)}(x) - e^x u^{(3)}(x) + u(x) = 1 - e^x coshx + 2sinhx \\ u(\frac{1}{4}) = 1 + sinh(\frac{1}{4}), u'(\frac{1}{4}) = cosh(\frac{1}{4}), u''(\frac{1}{4}) = sinh(\frac{1}{4}) \\ u(\frac{1}{2}) - u(\frac{3}{4}) = sinh(\frac{1}{2}) - sinh(\frac{3}{4}) \end{cases}$$

The exact solution is $u_T(x) = 1 + sinhx$. The numerical results are presented in Table 1. Figure 1.

Example 2[6] Considering following fifth-order boundary value problems.

$$\begin{cases} u^{(5)}(x) + sin(2x)u'''(x) - u'(x) + cos(2x)u(x) = -sinx. 0 \le x \le 1 \\ u(0.1) = sin(0.1), u'(0.1) = cos(0, 1), \\ u(0.4) = sin(0.4), u'(0.4) = cos(0.4), \\ u(0.7) - u(0.9) = sin(0.7) - sin(0.9). \end{cases}$$

The exact solution is $u_T(x) = sinx$. The numerical results are presented in Table 2. Figure 2.   Example 3[7] Considering following fourth-order boundary value problems.

$$\begin{cases} u^{(4)}(x) + u^{(3)}(x) = f(x). 0 \le x \le 1 \\ u(0) = 0, u(\frac{1}{4}) = 0, \\ u(\frac{1}{2}) = 0, u(\frac{3}{4}) - u(1) = 0, \end{cases}$$

Table 1. Comparison of absolute errors for Example 1

x		Present method	Present method	Reproducing kernel
x	$u_T(x)$	$u_{21}(x)$	$\|u_T(x) - u_{21}(x)\|$	Method in [6]
0.0000	1.0000	1.0000	2.043×10^{-11}	3.74077×10^{-7}
0.1464	1.1470	1.1470	1.290×10^{-11}	2.56562×10^{-8}
0.2061	1.2076	1.2076	9.540×10^{-12}	1.91517×10^{-9}
0.3455	1.3524	1.3524	1.610×10^{-12}	1.83869×10^{-8}
0.4218	1.4344	1.4344	2.300×10^{-12}	9.63508×10^{-8}
0.5000	1.5211	1.5211	5.500×10^{-12}	2.50467×10^{-7}
0.6545	1.7022	1.7022	7.740×10^{-12}	5.34168×10^{-7}
0.7270	1.7927	1.7927	6.010×10^{-12}	3.83703×10^{-7}
0.8536	1.9610	1.9610	3.280×10^{-12}	1.18927×10^{-6}
0.9045	2.0330	2.0330	9.890×10^{-12}	2.6199×10^{-6}
1.0000	2.1752	2.1752	2.800×10^{-11}	7.28022×10^{-6}
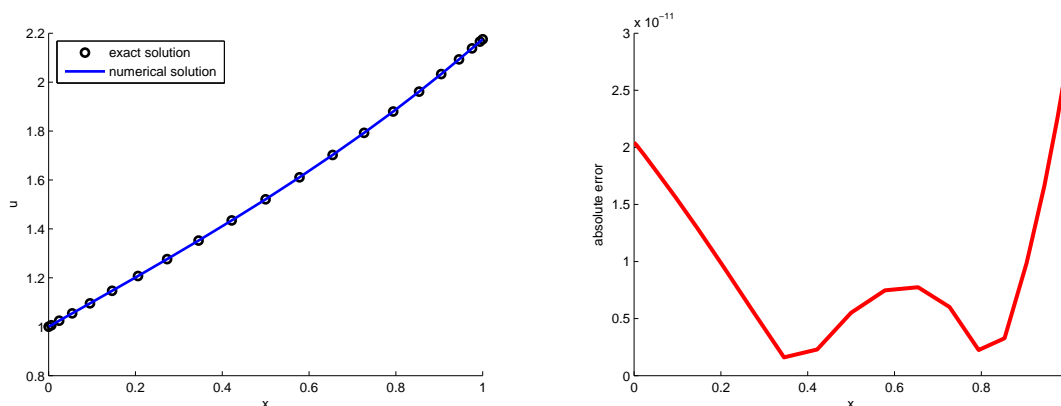
Figure 1. Present numerical method for Example 1, the first picture shows the exact solution and numerical solution, the second picture shows the numerical error when we select 21 nodes

Table 2. Comparison of absolute errors for Example 2

x		Present method	Present method	Reproducing kernel
x	$u_T(x)$	$u_{21}(x)$	$\|u_T(x) - u_{21}(x)\|$	Method in[6]
0.0000	0.0000	0.0000	3.851×10^{-10}	1.51117×10^{-9}
0.1464	0.1459	0.1459	4.139×10^{-10}	1.46647×10^{-9}
0.2061	0.2047	0.2047	3.058×10^{-10}	1.08674×10^{-9}
0.3455	0.3387	0.3387	7.290×10^{-11}	1.60481×10^{-9}
0.4218	0.4094	0.4094	3.750×10^{-11}	1.82578×10^{-9}
0.5000	0.4794	0.4794	9.570×10^{-11}	4.63265×10^{-10}
0.6545	0.6088	0.6088	4.292×10^{-10}	9.86968×10^{-9}
0.7270	0.6646	0.6646	6.019×10^{-10}	1.68006×10^{-8}
0.8536	0.7536	0.7536	6.649×10^{-10}	2.04954×10^{-8}
0.9045	0.7861	0.7861	5.213×10^{-10}	1.31484×10^{-8}
1.0000	0.8415	0.8415	2.167×10^{-10}	2.92067×10^{-8}

Table 3. Comparison of errors for Example 3

N	Present method	Method in [7]	Method in [7]
	$\|u_T(x) - u(x)\|_2$	$\|e^N(0.25)\|$	$\|e^N(0.5)\|$
16	2.4437×10^{-9}	8.3708×10^{-5}	3.6148×10^{-6}
32	8.6524×10^{-13}	2.1097×10^{-5}	8.7657×10^{-7}
64	6.0749×10^{-11}	5.2848×10^{-6}	2.1744×10^{-7}
128	3.1058×10^{-8}	1.3219×10^{-6}	5.4254×10^{-8}
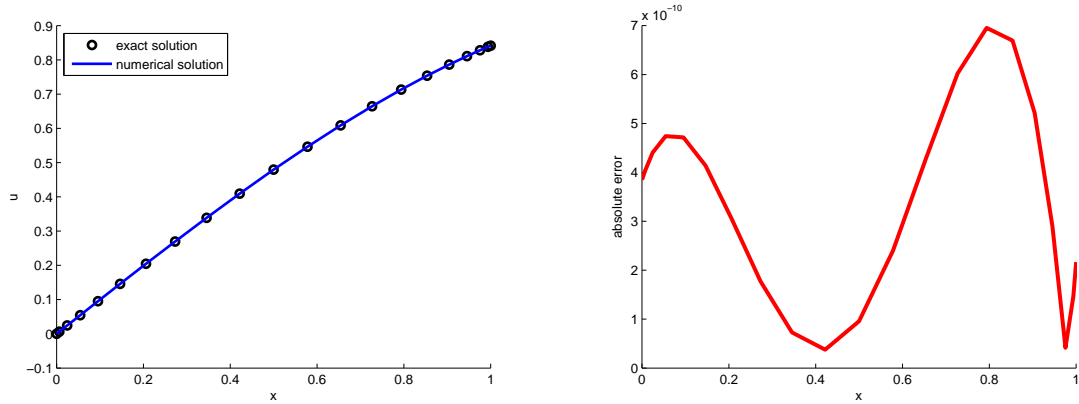
Figure 2. Present numerical method for Example 2, the first picture shows the exact solution and numerical solution, the second picture shows the numerical error when we select 21 nodes
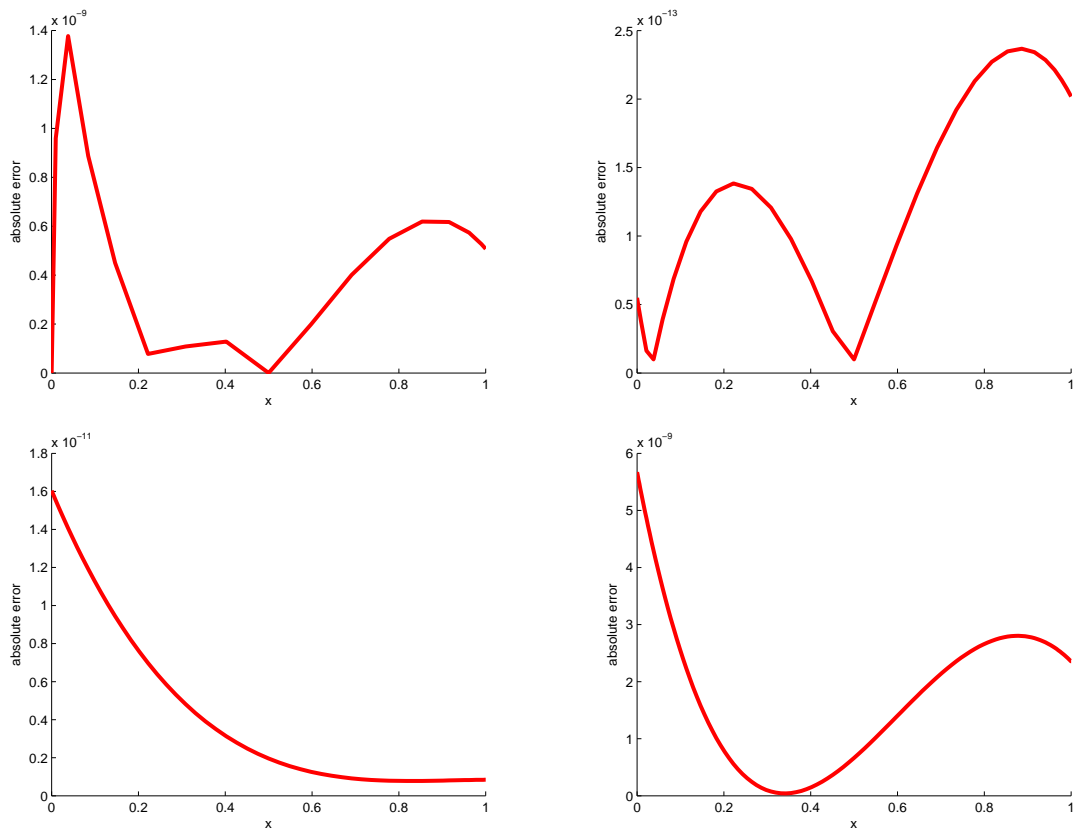
Figure 3. Present numerical method for Example 3, the first picture shows the numerical error when we select 17 nodes, the second picture is 33 nodes, the third picture is 65 nodes, the fourth picture is 129 nodes

The exact solution is $u_T(x) = x(x - \frac{1}{4})(x - \frac{1}{2})e^{-4xln4}$. The numerical results are presented in Table 3. Figure 3.

Example 4[7] Considering following fourth-order boundary value problems.

$$\begin{cases} u^{(4)}(x) + u^{(3)}(x) = f(x). \ 0 \le x \le 1 \\ u(0) = 0, u'(0) = 0, \\ u(\frac{1}{2}) = 0, u(\frac{3}{4}) - u(1) = 0, \end{cases}$$

The exact solution is $u_T(x) = x^2(x - \frac{1}{2})e^{4ln(\frac{9}{32})x}$. The numerical results are presented in Table 4. Figure 4.

Table 4. Comparison of errors for Example 4

N	Present method $\|u_T(x) - u(x)\|_2$	Method in [7] $|e^N(0)|$	Method in [7] $|e^N(0.5)|$
64	6.6165×10^{-10}	5.2848×10^{-5}	2.1744×10^{-8}
128	7.1460×10^{-8}	1.3219×10^{-6}	5.4254×10^{-8}
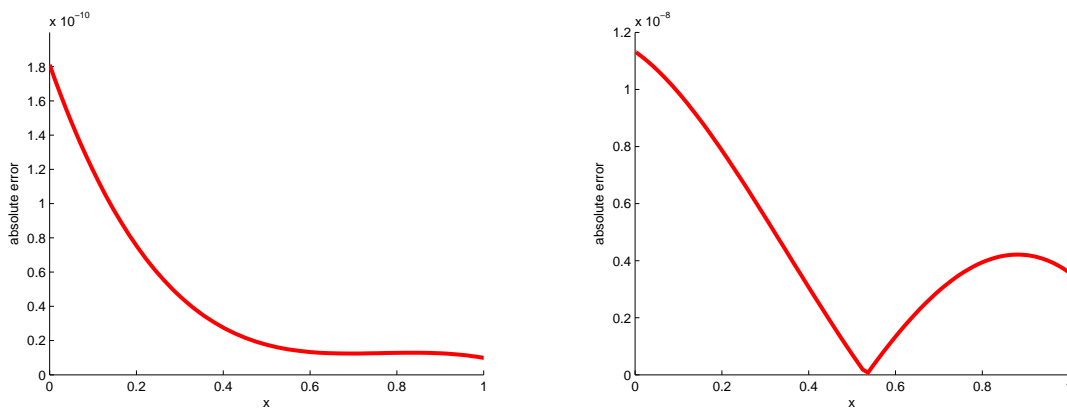
Figure 4. Present numerical method for Example 4, the first picture shows the numerical error when we select 65 nodes, the second picture is 129 nodes

Example 5 Considering following sixth-order boundary value problems.

$$\begin{cases} u^{(6)}(x) + u(x) = 12xcosx + 30sinx. \ -1 \le x \le 1 \\ u(-1) = 0, u(\frac{1}{2}) = -\frac{3}{4}sin(\frac{1}{2}), \\ u'(-1) = 2sin1, u'(\frac{1}{4}) = \frac{1}{2}sin(\frac{1}{4}) - \frac{15}{16}cos(\frac{1}{4}), \\ u''(-1) = -4cos1 - 2sin1, u''(1) = 4cos1 + 2sin1 \end{cases}$$

The exact solution is $u_T(x) = (x^2 - 1)sinx$. The numerical results are presented in Table 5. Figure 5.

Table 5. The numerical results of Example 5

error	$\|u_T(x) - u_{16}(x)\|_2$	$\|u_T(x) - u_{21}(x)\|_2$	$\|u_T(x) - u_{26}(x)\|_2$
absolute error	2.4078×10^{-11}	5.3904×10^{-10}	2.9905×10^{-9}
relative error	2.6464×10^{-11}	5.1308×10^{-10}	2.5460×10^{-9}

Example 6 Considering following eighth-order boundary value problems.

$$\begin{cases} u^{(8)}(x) - u(x) = -48e^x - 16xe^x. \ 0 \le x \le 1 \\ u(0) = 0, u(\frac{1}{2}) = \frac{1}{4}e^{\frac{1}{2}}, \\ u'(0) = 1, u'(\frac{3}{4}) = -\frac{5}{16}e^{\frac{3}{4}}, \\ u''(0) = 0, u''(1) = -4e, \\ u'''(0) = -3, u'''(1) = -9e, \end{cases}$$

The exact solution is $u_T(x) = x(1 - x)e^x$. The numerical results are presented in Table 6. Figure 6.
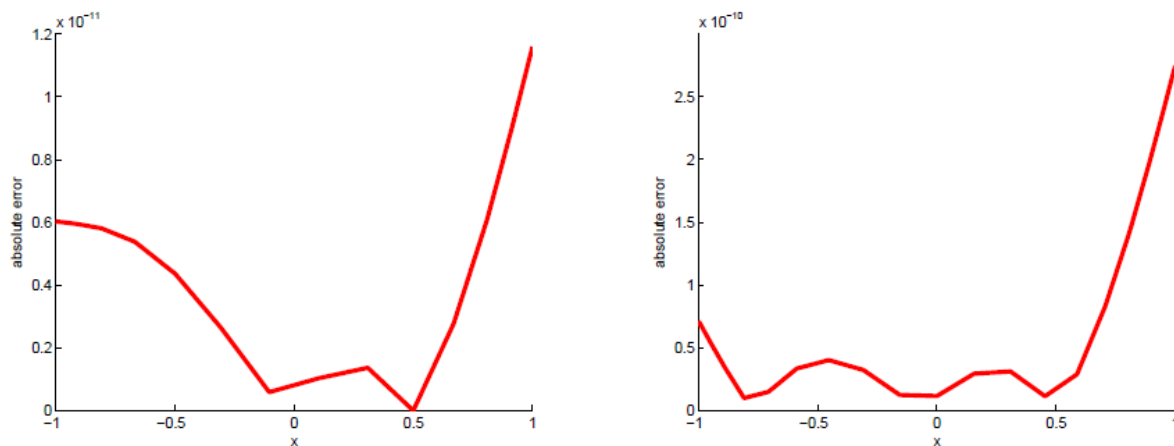
Figure 5. Present numerical method for Example 5, the first picture shows the numerical error when we select 16 nodes, the second picture is 21 nodes

Table 6. The numerical results of Example 6

error	$\|u_T(x) - u_{21}(x)\|_2$	$\|u_T(x) - u_{26}(x)\|_2$
absolute error	6.3861×10^{-9}	1.9445×10^{-8}
relative error	5.4288×10^{-9}	1.4785×10^{-8}
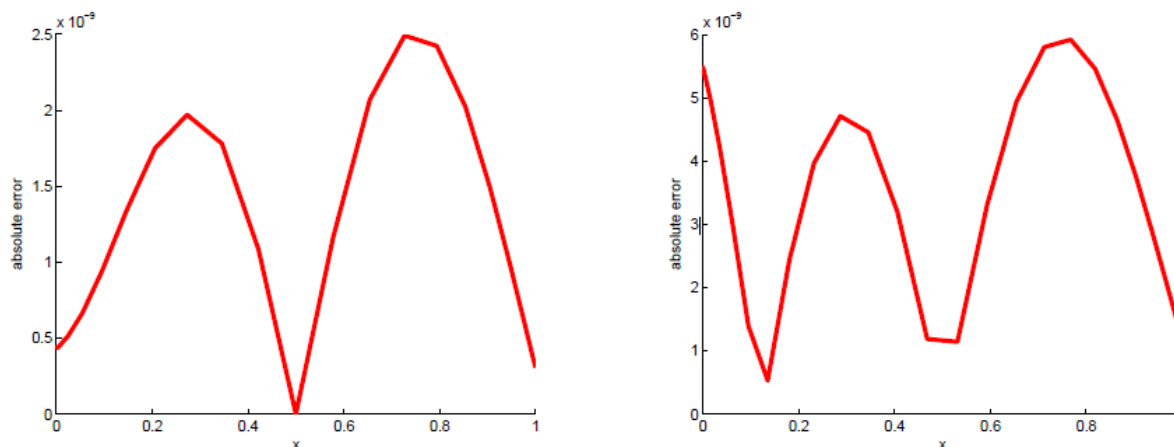
Figure 6. Present numerical method for Example 6, the first picture shows the numerical error when we select 21 nodes, the second picture is 26 nodes

4. Discussion

In this paper, we devote to the numerical treatment of a class of higher-order multi-point solving higher-order multi-point BVPs. The numerical results demonstrate that the method is quite accurate and efficient for linear higher-order multi-point BVPs. This makes it easy to solve the higher-order multi-point BVPs. It is worthy to note that this method can be generalized to more higher order BVPs. All computations are performed by the MatlabR2013a software package.

References

Abu Arqub, O., & Al-Smadi, M. (2004). Numerical algorithm for solving two-point, second-order periodic boundary value problems for mixed integro-differential equations. *Applied Mathematics and Computation, 243*(2014), 911-922.

Abu Arqub, O., & Al-Smadi, M. (2013). Solving Fredholm integro-differential equations using reproducing kernel Hilbert space method. *Applied Mathematics and Computation, 219*(2013), 8938-8948.

Cui, M., & Lin, Y. (2009). Nonlinear Numerical Analysis in the Reproducing Kernel Space. *Nova Science*.

Hu, Y., & Haiyuan, Yu. (2012). Collcocation Methods for High order nonlocal multipoint-boundary value problem. *Xiangtan University, 2012*.

Jean-Paul, B., & Lloyd, N. T. (2004). Barycentric Lagrange Interpolation. *SIAM Review, 46*(2004), 501-517.

Johnny, H., & Curtis, J. K. (2008). Uniqueness of solution of linear nonlocal boundary value problems. *Applied Mathematics Letter, 21*(2008), 1053-1056.

Jiang, W., & Chen, Z. (2014). A collocation method based on reproducing kernel for a modified anomalous subdiffusion equation. *Numerical Methods for Partial Differential Equations, 30*(2014), 289-300.

Geng, F., Qian, S. P., & Li, S. (2014). A numerical method for singularly perturbed turning point problems with an interior layer. *Journal of Computational and Applied Mathematics, 255*(2014), 97-105.

Lin, Y., & Lin, J. (2010). Numerical algorithm about a class of linear nonlocal boundary value problems. *Applied Mathematics Letter, 23* (2010), 997-1002.

Sim, V. R., & Stuart, C. (2008). Ecological Design,Washington. *Ethical standards of psychologists*. Washington, DC:Island Press.

Wazwaz, A. M. (2000). A new algorithm for calculating Adomian polynomials for nonlinear operators. *Applied Mathematics and Computation,111*(2000), 53-69.

Wazwaz, A. M. (2001). A reliable algorithm for solving boundary value problems for higher-order integrodifferential equations. *Applied Mathematics and Computation, 118*(2001), 327-342.

Wu, B. Y., & Li, X. Y. (2011). A new algorithm for a class of linear nonlocal boundary value problems based on the reproducing kernel method. *Applied Mathematics Letters, 24*(2011), 156-159.

Yao, H., & Lin, Y. (2009). Solving singular boundary-value problems of higher even-order. *Journal of Computational and Applied Mathematics, 223*(2009), 703-713.

Zhou, Y., Cui, M., & Yingzhen, Lin. (2009). Numerical algorithm for parabolic problems with non-classical conditions. *Journal of Computational and Applied Mathematics, 230*(2), 770-780.

Zhi-Yuan, L., & Yu-Lan, W. (2015). Solving a class of linear nonlocal boundary value problems using the reproducing kernel. *Applied Mathematics and computation, 265*(2015), 1098-1105.

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IKVAV-Containing Cell Membrane Penetrating Peptide Treatment Induces Changes in Cellular Morphology after Spinal Cord Injury

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Abstract

A cell membrane spanning peptide was used to increase the concentration of the IKVAV motif within damaged mouse spinal cord tissue. This peptide was injected directly to the lesion 24 hours after spinal cord compression injury. Because the membrane-spanning portion of the peptide adheres to tissue upon injection with a long half-life we hypothesized that the bioactive IKVAV sequence will provide a sustained regenerative signal at the sight of injury. Five different groups of mice were used and cellular morphology observations were undertaken using light and electron microscopy. Three surgical control groups: IKVAV, peptide and mannitol; one surgical treatment group: IKVAV-peptide; and one non-surgical control group: normal, were used in this experiment. In this study, treatment with IKVAV-peptide after SCI resulted in an increased number of protoplasmic astrocytes, large active motor neurons, and regeneration of muscle bundles followed by behavioral improvement. In this paper, we describe the cellular differences between all groups.

Keywords: IKVAV+peptide, neurons, protoplasmic astrocytes, muscle bundles, light micrographs, electron micrographs

1. Introduction

Spinal cord injury (SCI) is a debilitating condition which initiates complex cellular and molecular interactions and changes in an attempt to repair the initial tissue damage. These interactions include contributions from inflammatory cell activation, reactive astrocytes and the production of both growth- promoting and inhibitory extracellular molecules (Fitch & Silver, 2008). The use of nanostructures in medicine is an emerging field with the potential to improve a condition or cure diseases. To assess the feasibility of using a peptide-based nanostructure that increases the concentration of the IKVAV-motif (isoleucine-lysine-valine-alanine-valine) to facilitate regeneration of damaged spinal tissue, it is necessary to compare cellular changes within the lesion site with and without treatment. Biological analysis of SCI in mouse models point to both necrotic and apoptotic mechanisms of cell death after injury (Beattie et al., 2002). Neuronal and glial apoptosis after spinal cord injury contribute to the neurological dysfunction (Liu et al., 1997).Spinal cord injury results in glial reaction, leading eventually to the formation of a glial scar. The glial scar that forms following spinal injury is an evolving structure; different cells arrive and participate in the creation of a final structure that is predominantly astrocytic. Thus the astrocyte response to injury is referred to as reactive gliosis (more glia) but in fact, in most types of injury, the actual amount of glial cell division is relatively small and confined to the immediate penumbra surrounding the lesion core (Eng, Reier, & Houle, 1987; Reier & Houle, 1988; Reier, 1983). Electron micrographs of neurons in gray matter have shown fragmented nucleus and condense bodies along with shrunken cell bodies (Liu et al., 1997). Following injury, skeletal muscle atrophy is a key adaptation resulting from disuse and immobilization in both complete and incomplete SCI. A few weeks post injury, skeletal muscle

cross-sectional area (CSA) can be as low as 30% to 50% compared with able-bodied controls. Moreover, skeletal muscle atrophy has been associated with increasing infiltration of intramuscular fat (IMF) (Gorgey & Shepherd, 2010; Wu et al., 2011; Gorgey & Dudley, 2007). Skeletal muscle atrophy results in numerous other health-related complications (Gorgey & Shepherd, 2010) including: altered body composition (Spungen et al., 2003); cardiovascular disease (Bauman & Spungen, 2008); osteoporosis (Demirel et al., 1998); and increased incidence of metabolic syndrome (Nelson et al., 2007).

2. Methods

2.1 Experimental Design

All animal procedures were undertaken in accordance with the Public Health Service Policy on Human Care and Use of Laboratory Animals. All procedures were approved by the IACUC. Five groups of female Blab-c mice (10 weeks of age) were used in this study. After hemilaminectomy all groups underwent T12 spinal cord segment compression dorsoventrally by the application of a 24 g modified aneurysm clip for 1 min (Poon et al., 1976). Twenty four hours after injury, each group received different treatment: IKVAV-peptide; IKVAV; and peptide combined with mannitol. For all experiments, the experimenters were kept blind to the identity of the animals.

2.2 Animal Tissue Acquisition and Preparation

On the day 28, animals were euthanized with an overdose of intraperitoneal Beuthanasia-D (Schering-Plough Animal Health Corp., Union, NJ) and the spinal cords were removed and immediately placed in 2% buffered formalin. The spinal cords were kept at 4° C overnight and transferred to the Karnovsky fixative (J 1965) before placing at 4° C for 3 hours. Four sodium cacodylate buffer rinses were done at 30 minute intervals and the specimens were transferred into osmium tetroxide (OsO_4) for 1 hr at 25° C. The dehydration procedures were done using 50% acetone, 70% acetone twice and 100% acetone each for 30 minutes respectively. After dehydration, the spinal cords were infiltrated using acetone: Spurr's resin mixture (first with a proportion of 3:1 for 30 minutes) following by 1:1 and 1:3 each for one hour and then 100% Spurr's overnight on a rotator. After 24 hours, each spinal cord was embedded in the flat mound and kept at 63 ° C overnight. Semi-thin sections (0.5μ) were cut using a Sorvall MT2-b for light microscopic observations and then (60nm) ultrathin sections were cut with a diamond knife and put on 100 mesh copper grids for transmission electron microscopic study using Philips CM/12 STEM.

2.3 Muscle Preparation

Upper hind limb muscles were dissected from all groups and fixed in 10% buffered formalin and processed routinely for light microscopic evaluations.

2.4 Neuron and Muscle Size Quantification

The computer software ImageJ was used to measure the neuron and muscle size using their images. We used μm as a unit for measuring the surface of each neuron and each muscle bundle.

2.5 Protoplasmic Astrocytes Quantification

Astrocytes were counted in 3 fields of each semithin section for each mouse using calibrated ocular lens with Lattice lines.

3. Results

Light microscopic observations using semi-thin sections revealed that the main morphological difference between IKVAV-peptide treated mice and other three groups was the size of the motor neurons. It was interesting to observe that IKVAV-peptide treated mice had neurons even larger than the normal group. In comparison to the IKVAV-peptide treated group, the other three control groups had smaller than normal neurons with shrunken cell cytoplasm. Between the three surgical control groups, peptide group had completely shrunken neurons, however, mannitol and IKVAV both had only very small neurons (Figures 1-2). At the electron microscopic level, a survey of ultrathin sections revealed that, in the IKVAV-peptide group, all the motor neurons were active consisting of active cytoplasmic organelles such as extensive rough endoplasmic reticulum (RER), free ribosome, developed Golgi complex and mitochondria surrounding euchromatic nucleus (Fig. 3B). These ultrastructural characteristics were similar in appearance to the control untreated group (Normal) (Fig. 3A), however, IKVAV-peptide treated neurons were much larger and active confirming observations made at the light microscopic level. In treated control groups, motor neurons were nonactive with shrunken cytoplasm having dispersed segmented RER and loosely associated nuclear chromatin in their nuclei (Fig. 4). Particularly in all treated control groups the nuclear membranes were not folded compare with normal and IKVAV-peptide treated groups (Fig. 3A & B) and the outer nuclear membrane lacked ribosomal attachments in most areas.

In this experiment, counting the number of protoplasmic astrocytes in each group after 4 weeks of study demonstrated that the IKVAV-peptide treated mice had more protoplasmic astrocytes surrounding the motor neurons compared to the normal untreated, mannitol and IKVAV groups. However, the protoplasmic astrocytes were almost the same in number in both IKVAV-peptide and peptide groups. Observations on the upper hind limb muscles revealed that in IKVAV-peptide treated group, muscle bundles were thicker in comparison to IKVAV, peptide, and mannitol groups but not with normal groups. In addition, the intramuscular fat, which was also seen between bundles, occupied fewer regions in IKVAV-peptide group than others (Fig. 5).

4. Discussion

In this study, the laminin-derived IKVAV sequence has been incorporated into protoplasmic astrocytes in order to enhance neural attachment, migration and neurite outgrowth (Kikukawa et al., 1998).To explore the cellular changes related to this improvement, light and electron microscopic evaluation of neurons, protoplasmic astrocytes and muscle bundles were undertaken. Findings included that IKVAV-peptide treatment resulted in neurite reactivation in gray matter, evinced by functional improvement using the modified BBB locomotion score scale (data not shown) and morphological changes that demonstrated the slow but impressive functional progress after SCI. Neuronal death is normal during nervous system development but it is an abnormal consequence of brain and spinal cord injury with two distinct forms of cell death, apoptosis and necrosis (Mahoney et al., 2005). Microscopic observations of the neurons within the lesion sites produced in this study, is consistent with other studies, which have described apoptosis and necrotic death after spinal cord injury (Liu et al., 1997). In the present study, reactivation of neurons with euchromatic nucleus, presence of extensive RER, free ribosomes and many mitochondria seen in IKVAV-peptide treated group in comparison to other three control treated groups (IKVAV, peptide, mannitol) was clearly evident. It has been previously observed that the absence of astrocytes in both white and gray matter results in unsuccessful axon regeneration. The presence of immature fibrous astrocytes in the white matter and reactive protoplasmic astrocytes in the gray matter of the spinal cord within the injury site in the early post-injury phase are necessary for axon regeneration (Shibuya, Yamamoto & Itano, 2009; Kikukawa et al., 1998; Inoue, Kawaguchi, & Kurisu, 1998). Protoplasmic astrocyte enumeration in the IKVAV-peptide group demonstrated an increased number compared to all groups including the normal nonsurgical group. This suggests that, in the subacute phase, the existence of astrocytes is necessary for reactivation of neurons and subsequently regeneration of axons and their absence can markedly exacerbate neuron and glial cell degeneration. These results are also consistent with other studies (Faulkner et al., 2004; Okada et al., 2006; Bush et al., 1999; McDonald et al., 1998). Successful spinal cord therapies have been shown to correlate with reduced atrophy and muscle rebuilding (Mahoney et al., 2005; Adams et al., 2004; Gorgey & Shepherd, 2010). Both functional improvement was observed in IKVAV-peptide treated mice as well as confirmation at the microscopic level that revealed increases in the muscle bundle mass and decreased intramuscular fat.

5. Conclusions

To study the effects of the IKVAV-peptide treatment, a matrix of treatment and control groups of mice were blinded to investigators to evaluate the effects of this novel nanostructure and assess efficacy under microscopic and sub-microscopic level. Our findings demonstrate that IKVAV-peptide improves the functional behavior of cells within spinal cord injury since it promoted neurite reactivation and function. The neurons in IKVAV-peptide group became more active presumably to compensate for deficits following injury as evinced by more functional organelles compared to all groups including neurons found in normal spinal cord tissue. Notably, mice in IKVAV-peptide group showed an improvement in their life quality by being more conscious, active and healthier than mice in other groups. These findings revealed that a peptide that includes a cell spanning moiety and the neurite-stimulating motif IKVAV is a unique structure that has the potential to treat and improve the quality of life among patients with SCI. However, these results are preliminary and this research would benefit from larger numbers of animals and longer duration to assess a more complete understanding of the applications and limitations of this technology. Therefore, further investigation is warranted to evaluate the full potential of this treatment approach in SCI and other conditions where peptide mediated regeneration is possible.
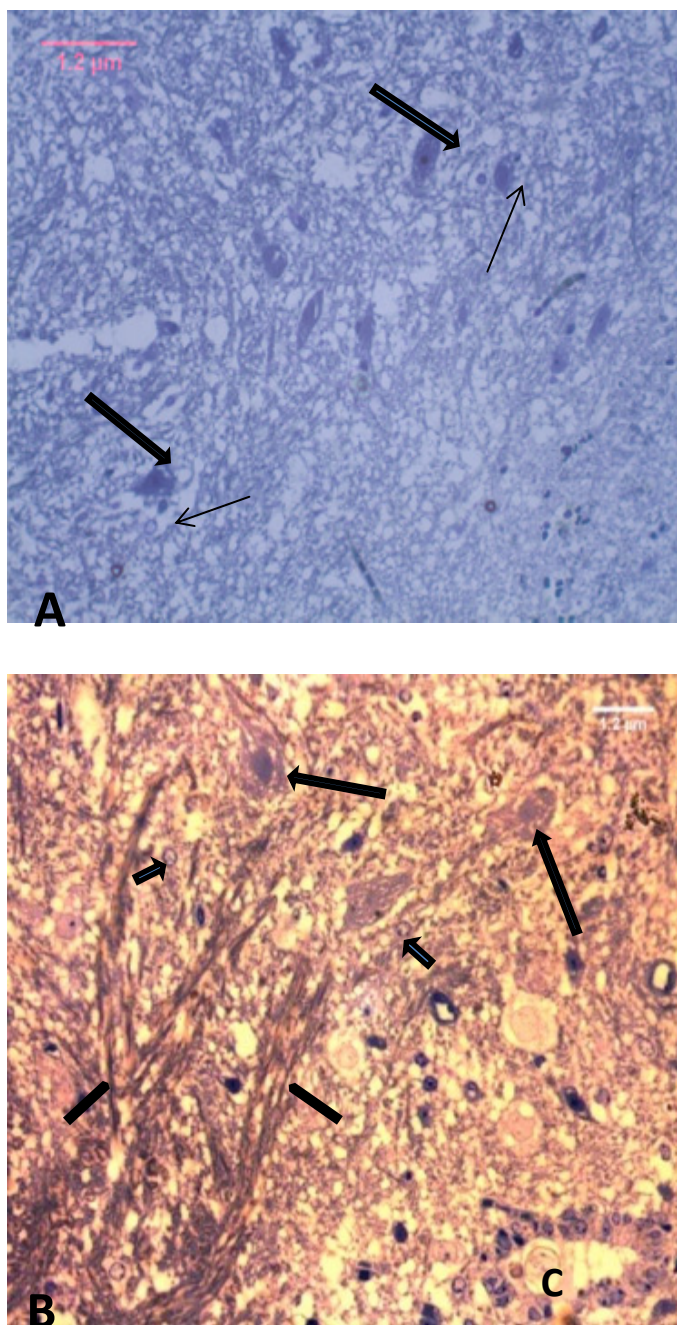
Figure 1.

Note. (A) Photomicrograph of untreated normal mouse showing a portion of ventral horn of gray matter. A few relatively large motor neurons with pale nuclei and dark nucleoli (large arrows) can be seen between cellular processes. Protoplasmic astrocytes are also evident (small arrows). (B) Photomicrograph of IKVAV+peptide treated mouse revealing very large active motor neurons (large arrows) surrounded by many nerve fibers (small arrows). Many protoplasmic astrocytes are visible (smallest arrows). A cross section of spinal canal lining by large cuboidal cells can also be seen (C). Toluidine Blue X400.
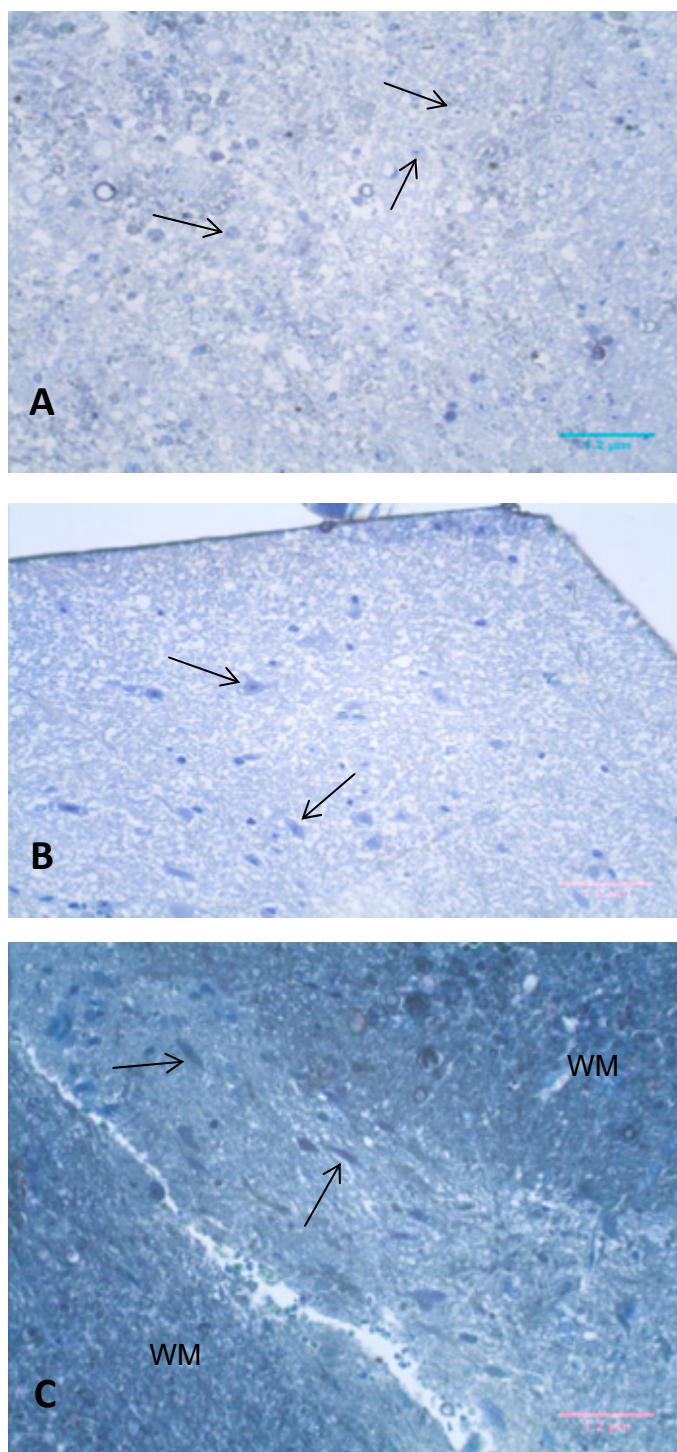
Figure 2.

Note. (A) In photomicrograph of peptide treated control mouse, most of the motor neurons are atrophied (arrows). (B) Photomicrograph showing only the gray matter portion of the spinal cord in mannitol treated control mouse. All motor neurons are again atrophied (arrows). (C) Photomicrograph shows a portion of ventral horn of gray matter between white matter (WM) from IKVAV treated control mouse. Note the atrophied motor neurons (arrows). Compare these sections with figures 1A&2B (normal and IKVAV+peptide). Toluidine Blue X400.
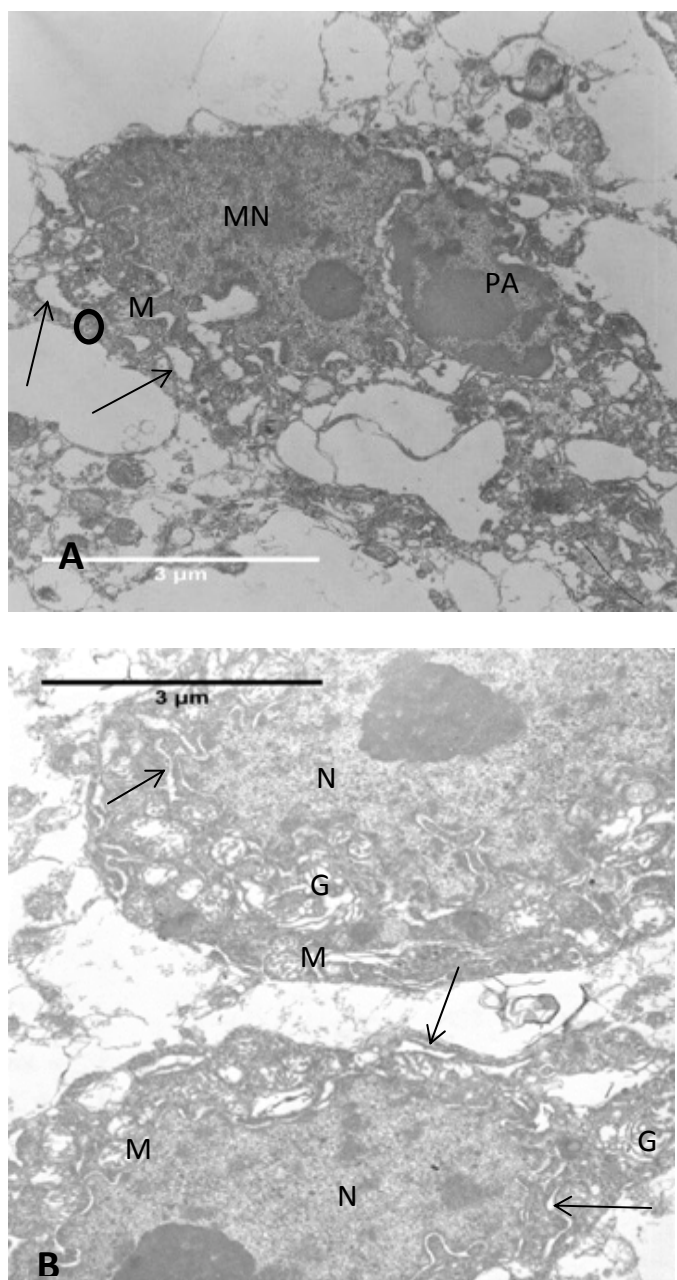
Figure 3.

Note. Electron micrograph of untreated normal mouse **(A)**. In this micrograph, a protoplasmic astrocyte (PA) can be seen in close association with a motor neuron (MN). Motor neuron has relatively a large euchromatic nucleus with prominent dense nucleolus surrounded by small portion of cytoplasm rich in Nissl substances, RER at arrows and free ribosomes (Circle). A few mitochondria (M) can also be seen. Uranyl acetate and lead citrate X7100. Electron micrograph of IKVAV+peptide treated mouse **(B)**. Two active motor neurons can be seen, each with large euchromatic nucleus (N) and prominent electron dense nucleolus. Many cisternae of RER (arrows), active Golgi complexes (G) and mitochondria (M) are also evident throughout the perikaryon. Note the highly folded nuclear membranes in both cells. Compared to untreated normal mouse **(A)**, these motor neurons are much larger. Uranyl acetate and lead citrate X7100.
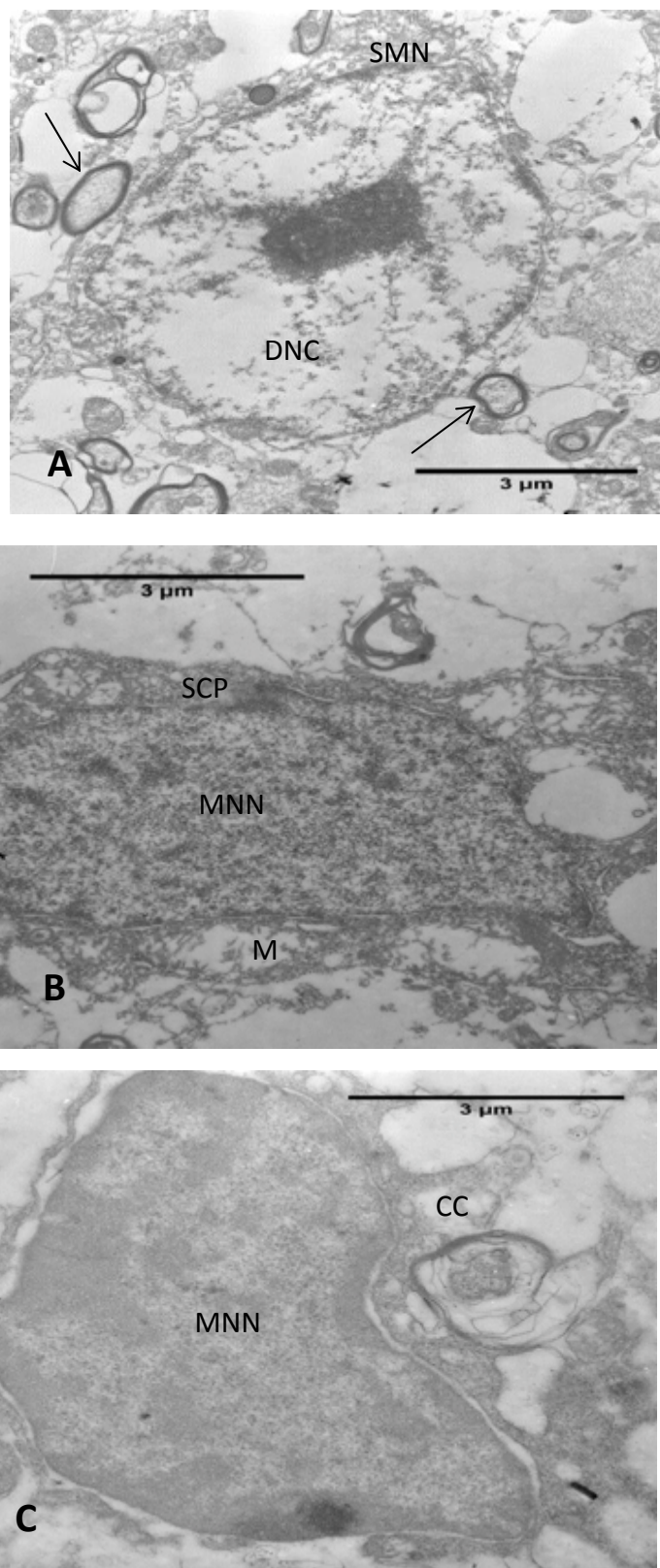
Figure 4.

Note. Electron micrograph from peptide treated control mouse (A) shows obviously a shrunken motor neuron (SMN) with dispersed nuclear chromatin (DNC). Few myelinated nerve fibers (arrows) can also be seen. Uranyl acetate and lead citrate X7100. Electron micrograph of motor neuron in mannitol treated mouse (B) revealing another atrophied neuron. The small cytoplasmic portion (SCP) is mostly occupied by degenerated mitochondria

(M). Uranyl acetate and leas citrate X8800. Electron micrograph of a shrunken motor neuron of IKVAV treated control mouse (C). Even at this magnification the cellular cytoplasm (CC) is not apparent. Uranyl acetate and lead citrate X15000. Note the lack of nuclear membrane infolding in all control groups.
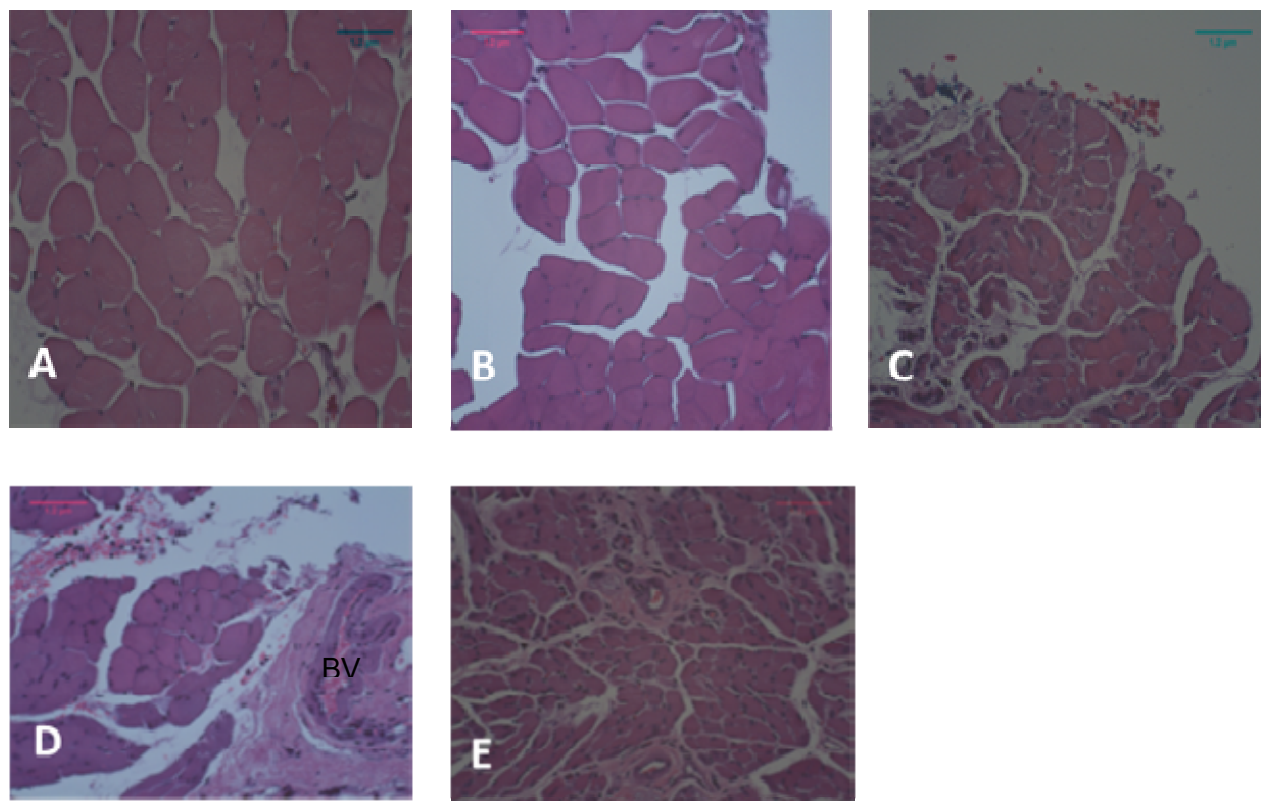
Figure 5.

Note. Comparative photomicrographs showing cross sections of the hind limb muscle in different groups, normal (A), IKVAV+peptide (B), IKVAV (C), mannitol (D), peptide (E) of mice at the same magnification. Note the presence of thicker bundles in IKVAV+peptide group compared to the other control groups. Blood vessel (BV). H & E, X400.

Acknowledgement

References

Adams, G. R., Cheng, D. C., Haddad, F., & Baldwin, K. M. (2004). Skeletal muscle hypertrophy in response to isometric, lengthening, and shortening training bouts of equivalent duration. *Journal of Applied Physiology, 96*, 1613-8. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/15075307

Bauman, W. A., & Spungen, A. M. (2008). Coronary heart disease in individuals with spinal cord injury: assessment of risk factors. *Spinal Cord, 46*, 466-76. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/18180789

Beattie, M. S., Hermann, G. E., Rogers, R. C., & Bresnahan, J. C. (2002). Cell death in models of spinal cord injury. *Progress in Brain Research, 137*, 37-47. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/12440358

Bush, T. G., Puvanachandra, N., Horner, C. H., Polito, A., Ostenfeld, T., Svendsen, C. N., … Sofroniew, M. V. (1999). Leukocyte infiltration, neuronal degeneration, and neurite outgrowth after ablation of scar-forming, reactive astrocytes in adult transgenic mice. *Neuron, 23*, 297-308. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/10399936

Demirel, G., Yilmaz, H., Paker, N., & Onel, S. (1998). Osteoporosis after spinal cord injury. *Spinal Cord, 36*, 822-5. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/9881730

Eng, L. F., Reier, P. J., & Houle, J. D. (1987). Astrocyte activation and fibrous gliosis: glial fibrillary acidic protein immunostaining of astrocytes following intraspinal cord grafting of fetal CNS tissue. *Progress in Brain Research, 71*, 439-55. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/3588961

Faulkner, J. R., Herrmann, J. E., Woo, M. J., Tansey, K. E., Doan, N. B., & Sofroniew, M. V. (2004). Reactive astrocytes protect tissue and preserve function after spinal cord injury. *Journal of Neuroscience, 24*, 2143-55. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/14999065

Fitch, M. T., & Silver, J. (2008). CNS injury, glial scars, and inflammation: Inhibitory extracellular matrices and regeneration failure. *Experimental Neurology, 209*, 294-301. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/17617407

Gorgey, A. S., & Dudley, G. A. (2007). Skeletal muscle atrophy and increased intramuscular fat after incomplete spinal cord injury. *Spinal Cord, 45*, 304-9. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/16940987

Gorgey, A. S., & Shepherd, C. (2010). Skeletal muscle hypertrophy and decreased intramuscular fat after unilateral resistance training in spinal cord injury: case report. *Journal of Spinal Cord Medicine, 33*, 90-5. http://www.ncbi.nlm.nih.gov/pubmed/20397451

Inoue, T., Kawaguchi, S., & Kurisu, K. (1998). Spontaneous regeneration of the pyramidal tract after transection in young rats. *Neuroscience Letters, 247*, 151-4. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/9655615

Karnovsky, M. J. (1965). A formaldehyde-glutaraldehyde fixative of high osmolality for use in electron microscopy. *Cell Biol., 27*, 137.

Kikukawa, S., Kawaguchi, S., Mizoguchi, A., Ide, C., & Koshinaga, M. (1998). Regeneration of dorsal column axons after spinal cord injury in young rats. *Neuroscience Letters, 249*, 135-8. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/9682835

Liu, X. Z., Xu, X. M., Hu, R., Du, C., Zhang, S. X., McDonald, J. W., … Choi, D. W. (1997). Neuronal and glial apoptosis after traumatic spinal cord injury. *Journal of Neuroscience, 17*, 5395-406. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/9204923

Mahoney, E. T., Bickel, C. S., Elder, C., Black, C., Slade, J. M., Apple, D. Jr., & Dudley, G. A. (2005). Changes in skeletal muscle size and glucose tolerance with electrically stimulated resistance training in subjects with chronic spinal cord injury. *Archives of Physical Medicine and Rehabilitation, 86*, 1502-4. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/16003691

McDonald, J. W., Althomsons, S. P., Hyrc, K. L., Choi, D. W., & Goldberg, M. P. (1998). Oligodendrocytes from forebrain are highly vulnerable to AMPA/kainate receptor-mediated excitotoxicity. *Nature Medicine, 4*, 291-7. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/9500601

Nelson, M. D., Widman, L. M., Abresch, R. T., Stanhope, K., Havel, P. J., Styne, D. M., & McDonald, C. M. (2007). Metabolic syndrome in adolescents with spinal cord dysfunction. *Journal of Spinal Cord Medicine, 30*, S127-39. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/17874698

Okada, S., Nakamura, M., Katoh, H., Miyao, T., Shimazaki, T., Ishii, K., … Okano, H. (2006). Conditional ablation of Stat3 or Socs3 discloses a dual role for reactive astrocytes after spinal cord injury. *Nature Medicine, 12*, 829-34. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/16783372

Poon, P. C., Gupta, D., Shoichet, M. S., & Tator, C. H. (1976). Clip compression model is useful for thoracic spinal cord injuries: histologic and functional correlates. *Spine, 32*, 2853-9.

Reier, P. J. (1983). The astrocytic scar as an impediment to regeneration in the central nervous system. In Kao, C. C., Bunge, R. P., & Reier, P. J. (Eds.), *Spinal cord reconstruction* (pp. 163–195). Raven Press, New York.

Reier, P. J., & Houle, J. D. (1988). The glial scar: its bearing on axonal elongation and transplantation approaches to CNS repair. *Advances in Neurology, 47*, 87-138. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/3278533

Shibuya, S., Yamamoto, T., & Itano, T. (2009). Glial and axonal regeneration following spinal cord injury. *Cell Adh. Migr., 3*, 99-106. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/19372750

Spungen, A. M., Adkins, R. H., Stewart, C. A., Wang, J., Pierson, R. N. Jr., Waters, R. L., & Bauman, W. A.

(2003). Factors influencing body composition in persons with spinal cord injury: a cross-sectional study. *Journal of Applied Physiology, 95*, 2398-407. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/12909613

Wu, Y., Zhao, J., Zhao, W., Pan, J., Bauman, W. A., & Cardozo, C. (2012). Nandrolone normalizes determinants of muscle mass and fiber type after SCI. *Journal of Neurotrauma, 29*(8), 1663-1675. http://dx.doi.org/10.1089/neu.2011.2203

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A CTF-Based Approach in Information Security Education: An Extracurricular Activity in Teaching Students at Altai State University, Russia

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Abstract

Capture the Flag (CTF) competitions are the most popular events in cybersecurity conferences where participants can demonstrate their skills. Also, the CTF is widely acknowledged as a valuable pedagogical tool for providing the students with real life problems in computer security area when dealing with CTF tasks. However, there is the possibility to go beyond treating CTF tasks only. The paper presents an approach to establish a CTF-based educational framework that allows students to gain more practical skills, knowledge and expertise in information security and related areas. The framework is implemented in Altai State University (Barnaul, Russia) in 2014 as an extracurricular club activity, and the club runs successfully up till now. Pedagogical benefits, learning methodology and educational aspects are discussed, and positive feedback shows the success of the proposed approach.

Keywords: information security, capture the flag, active learning, lab workshop, vulnerabilities

1. Introduction

Capture the Flag (CTF) exercises and competitions nowadays are regular and well-known events in various semi-professional information security conferences. Everyone can demonstrate his or her skills in practical cyber security tasks and problems. Tasks for Jeopardy-type CTFs often deal with various practical aspects of information security like stego, reverse engineering, cryptography, binary analysis, etc. Attack-Defense type CTFs require knowledge and experience with developing exploits, using hacking tools and patching vulnerabilities. These simulated real-life problems set an extremely high knowledge barrier for CTF participants. To be successful, they have to be proficient in numerous topics and possess hands-on experience. Otherwise, dealing with almost real-life problems (CTF tasks) can be "frustrating and bewildering" (Werther, Zhivich, Leek, & Zeldovich, 2011) due to complexity of problems.

In Russian Federation, higher education (and information security education is no exception) is governed by Federal State Educational Standards (FSES) – a set of mandatory requirements for a defined level of education and (or) field of study. The standards are approved by the federal executive branch responsible for public policy and legal regulation in the sphere of education. FSES regulate time limits of major and minor courses and contain requirements for implementation and results that should be achieved afterward (FSES, 2010). Following FSES, Altai State University offers a traditional curriculum in information security that is mostly aimed at providing a general scope of knowledge and basic practical experience in respective areas due to a limitation of academic hours in courses. Workshops and labs deal with pre-organized assignments that aimed at specific aspects of problem areas and understanding of principles. Thus, experience and critical skills needed for cybersecurity, such as script programming, system administration, networking, web-programming, besides many others, are often left out of consideration (Cheung, Cohen, Lo, Elia, & Carrillo, 2012). In this case, self-study and peer instruction are the only options left for students, and it requires motivation to learn and practice on their own.

Another shortcoming is that there is a regular course load for students with scheduled increase in school work. Without a thorough supervision, there is a high chance that students would quit self-studying due to the lack of extra time, and further focus on something else more interesting and important for them. Thus, they may not

retain the knowledge they gained without its regular refreshment and application.

Several papers (Werther et al., 2011; Eagle & Clark, 2004; Irvine, 2011) state that a CTF event 'as-is' offers limited educational opportunities since *a priori* knowledge and experience should already be available at hand. However, it is still possible to use them as a pedagogical tool for teaching computer security. CTF tasks are widely used to teach students to solve them directly as examples of real life problems, and specially arranged introductory lectures and classes are offered to cover task-related problems and backgrounds (Werther et al., 2011; Eagle & Clark, 2004; Ho, Mallesh & Wright, 2009). Workshops are organized to build up teamwork and provide a hands-on experience. Still, the CTF remains just a 'tool' linked to a real life-like practice.

In this paper, an approach to developing a CTF-based educational framework to provide students with knowledge and practical experience they are lacking is presented. The framework is implemented in Altai State University (Barnaul, Russia) in a form of an extracurricular activity. The proposed approach allows covering blind spots in students' knowledge, coordinating the learning process, and utilizing all steps of the CTF for educational purposes.

2. Pedagogical Aspects

To exploit the CTF to its full potential with further benefits, a form of extracurricular activities is the most advantageous one. There are several aspects that have been considered beforehand:

1) Teamwork / Group working. Application of teamwork is not limited to curriculum and management functions in education. It is a well-known approach to tackling difficult problems as well as the basis for various educational techniques (Sallis, 2002). For the CTF, to be able to work as a group in a team is crucial for students to achieve something. Since most tasks are complex, it is necessary to share the load and responsibility. Firstly, working in a team allows students to hone their good communication skills for successful interaction with other members of a group. Also, it is a way for students to compare their knowledge and skills with each other and to point out what should be learned further to be successful.

2) Active and collaborative learning. Today's working environment often includes team activities and collaborative working. Therefore, it is appropriate for students to learn how to build a team with members of different skills and work together on a common problem, utilizing each member's strength effectively. Sharing information and discussing problems, learning something together and from each other proves to be very advantageous in computer security management and provides valuable experience (Conklin, 2006).

3) Challenge based learning. This framework focuses on increasing student engagement in addressing issues and proposing solutions. It is a student-centered approach with its roots in problem-based learning technique. Challenge based learning is ideally suited for tackling cybersecurity problems. Students gather around a certain problem and try to find a way to solve it. This stimulates the development of problem-solving skills and cognitive process. Since there could be a variety of proposed solutions, students need to obtain more knowledge to provide a better one. The role of a teacher here is gradually shifted to coaching and assisting students with guiding activities and resources (Cheung et al., 2011).

4) No strict curriculum. Extracurricular activities are not regulated by educational standards and do not have to follow certain plan and schedule. There are no limitations to forms of educational activities and techniques. Therefore, it allows some liberty in providing the most effective solution and guidance to cover certain areas of knowledge for students when needed. For example, some topics are better delivered in lectures, while the others are required practical experience and workshop participation. Also, the role of a tutor for those cases is assigned to the most capable and experienced person – a student with profound knowledge and experience on the subject, a professional who deals with the subject on a regular basis, or a faculty teacher.

3. Educational Design

To exploit the CTF to its full potential, an extracurricular 'free to join' club "CTF Club" for students interested in deep knowledge and real-life experience in various areas of information security and communication technologies was established. The club has been supported by faculty administration and provides three supervised sessions per week (16 weeks in a semester). All sessions are hosted in a teaching lab equipped with switches, routers, servers, and workstations. Lab vacant hours are available for students for their self-study activities. The first session is usually a lecture or an overview of content that is necessary for dealing with the next two workshop sessions. If several problems arise during workshops, or some aspects are needed to be discussed more thoroughly, then the third workshop includes the required coverage and case studies. However, the order could be changed freely according to the particular situation.

Since every step in a CTF competition could be treated as a source of valuable knowledge and experience, it is

wise to identify primary CTF 'elements' that should be covered by the "CTF Club" in its educational framework (Figure 1).
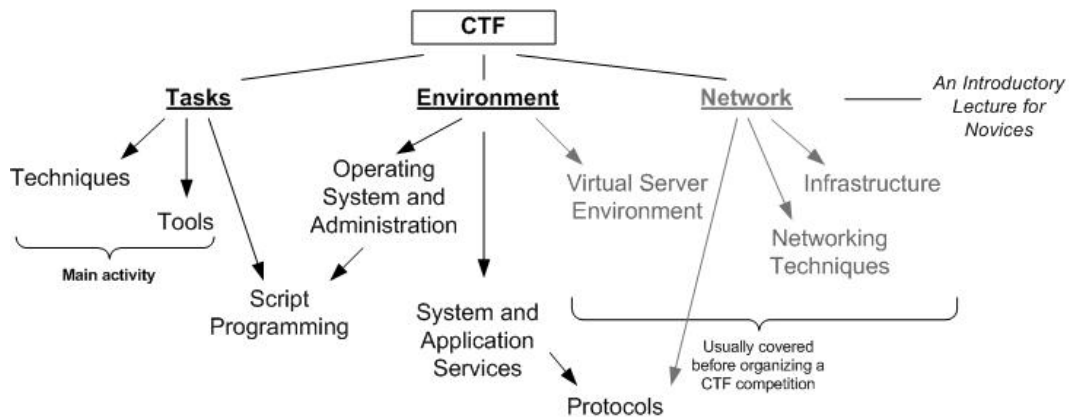
Figure 1. CTF-based framework structure

Usually, an introductory lecture is delivered for novices on their first session. It provides an overview of the CTF events and what the CTF is 'made of', i.e. kinds of CTF competitions, types of tasks, working environment, and networking. This session allows novices to understand better what it is expected them to do and what knowledge and skills are required.

Several topics related to networking and setting up the working environment are covered separately when students decide to organize their own CTF competitions. Since most of the content is not about the cybersecurity problems, it is not on the main club agenda. Still, it helps students to brush up their skills on deploying network configurations and managing virtual servers and services.

Dealing with tasks, performing attacks and providing defensive measures are the most interesting activities, and a major amount of time is devoted to these problems. To successfully solve a CTF task and to learn something from it, a lot of additional areas of expertise should be involved. They are placed within the scope of the '*Environment*' section on Figure 1. Here, the '*Environment*' means not only the working environment of CTF competitions like scoreboards or a group of virtual servers, but the environment for the task or the real life-like problem that introduced to students. Therefore, it is necessary to understand 'how it works' and 'why it is happening.' Covering the mentioned areas and choosing the most suitable form for it (a self-study, a study in a group, a case study, or a lecture) depend on a particular problem and are completely up to the students. Since different tasks can bring up the same areas of expertise repeatedly, it significantly contributes to mastering these areas by students and retaining their knowledge and skills.

3.1 CTF Tasks

There is a variety of CTF tasks, and each task is linked with a certain area of knowledge, skills, and expertise. Schematically, this can be illustrated as follows (Figure 2):
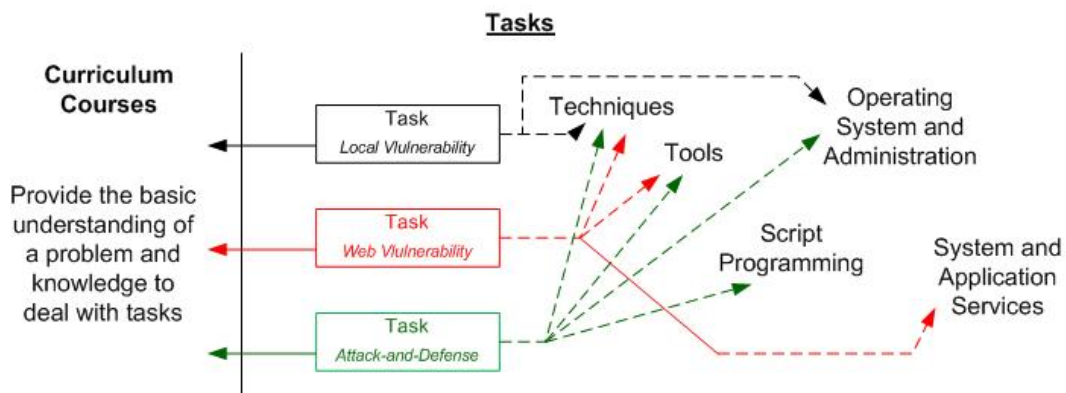
Figure 2. CTF tasks linked with respective areas of knowledge and expertise

Generally, a solution for a task is vastly based on *a technique* that should be applied and *a tool* to execute the technique. However, applying a technique or using a tool require knowledge and skills to back up the actions. Since the goal of the club is to provide knowledge and skills, task solving procedure needs to be analyzed for what knowledge and skills are exactly required and to which area they belong. The next step is to clarify whether students / club members are familiar with what required or not. When this step is covered, and blind spots are revealed, the next action is to get rid of the blind spots by providing the necessary teaching and explanation. Thus, each task appears to be linked with more than just techniques and tools and carries a lot more than just practical experience. Students learn not just how to deal with a problem, but what stands behind it and how it could be prevented. Additionally, they get insights on how to use tools better and how their work can be improved.

Local vulnerability tasks often exploit workarounds and malfunctions in elements and system services of operating systems (OS) that lead to violation of access rights policies. They are directly linked to *aspects of OS functioning and OS administration*. Besides the 'know-how', *a tool* or an exploit might be needed to successfully exploit the vulnerability. Also, it is important to understand what steps should be done to prevent someone from exploiting it in the future.

Web vulnerability tasks originate in misprogrammed Web-based applications and misconfigured Web-services. Often they rely on SQL injections, cross-site referencing and code injection. Obviously, much attention should be paid to the functioning of *system and application services*, as well as aspects of safe *programming* and source code analysis.

Attack and defense tasks deal with protecting your own services while exploiting the vulnerabilities of the services of others. Thus, besides aspects of *system administration*, source code analysis and patching rely heavily on *programming* skills, and effective use of *tools* (exploits, scanners, etc.) includes *script programming*. All of this is governed by a set of techniques for effective discovery of vulnerabilities and matching them with respective tools.

Binary exploit and reversing tasks are based on deep understanding of how compiled code executes and performs. Those are the most difficult tasks for students because they address to skills of low-level programming, disassembling and program tracing. Unfortunately, a lot of self-study and self-devotion that is needed is not admired by students, and those tasks are not very popular in the club.

Forensic, steganography and cryptography tasks require the knowledge of techniques, algorithms, and protocols. This knowledge is usually provided by curriculum courses and exploited during club sessions.

Naturally, dealing with all tasks is mandatorily linked with the knowledge that students get from their curriculum courses. It greatly helps to keep their knowledge at hand and to revisit parts of courses that have already been forgotten. If some course yet to be studied, students are advised to learn what they need to solve the task either on their own or in one of the club session that provides teaching and explanation. In the future, it allows students to reduce the course load and to improve greatly while studying the mentioned course in their curriculum. What is not covered in curriculum courses (like, for example, aspects of *OS administration* and *script programming*) can be mastered during the club sessions.

Tasks for club sessions are obtained from the Internet. There are many Web resources about CTF activities (e.g., '*The Practice CTF List*' - *http://captf.com/practice-ctf/*) where anyone can find a set of pre-arranged tasks for their liking. Students who are already experienced in the CTF try to develop their own tasks for club sessions and their own CTF competitions. This requires good programming skills and essential knowledge about security aspects that should be incorporated in self-made tasks.

Quests are also very popular among club members. The quest includes a set of tasks linked with each other with a clearly defined final goal. A great source of ready to use quests is the '*Vulnerable by Design*' resource (*https://www.vulnhub.com/*). An already prepared virtual machine (VM) image can be downloaded and run during club sessions or by students individually for their self-study. Additionally, there are 'walkthroughs' - step by step guides on how to solve all the tasks, what techniques and tools should be used for each step. They are of great importance for educational process of the "CTF Club". Each step can be analyzed and explained besides being simply repeated in practice. Repeating the steps of a 'walkthrough' allows students to gain practical skills, while analyzing and explaining of what have been done and what have been used allow to obtain the knowledge necessary to back up skills and build up the experience.

There are no strict regulations on what tools (exploits, libraries, scanners, traffic analyzers, etc.) should have been used. The main goal of club sessions is to provide education while tools are just necessities that may come,

evolve and go. Also, club sessions do not teach programming languages since these details could be mastered by students in self-study.

3.2 CTF Environment

Typical CTF working environment should be scalable, manageable and reliable. The most common approach that meets those criteria is the Virtual Server Environment. Virtualization is quite handy for workshops and practices. Students use freeware products *VMware Workstation Player* (*http://www.vmware.com/products/player/*) and *Oracle VM VirtualBox* (*http://www.virtualbox.org/*) for running and working with already prepared VMs or their own Linux server. However, production virtualization solutions are more complex, and many questions should be addressed concerning their security, management, and reliable operations. Students can practice and get additional expertise on:

- hypervisors and aspects of their functioning;
- aspects of security and reliability of virtual servers;
- configuration and management of virtual servers in a virtualization environment;
- providing security and reliability for services and applications running on a virtual server.

For educational purposes, freeware solutions like *KVM* (*http://www.linux-kvm.org/*), *OpenVZ* (*http://openvz.org/*) and *vSphere Hypervisor* (*http://www.vmware.com/products/vsphere-hypervisor/*) are used and studied in club sessions. Students also work with *Docker* containers (*http://www.docker.com/*) to get familiar with another architectural approach for resource isolation and investigate matters of security and protection of applications.
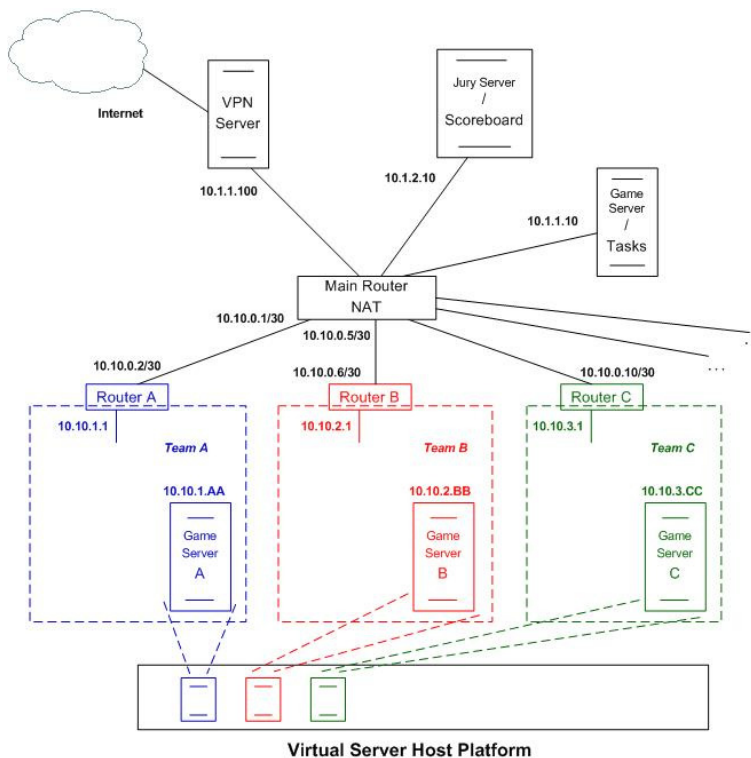
Figure 3. Typical network configuration for CTF events

3.3 Networking

A typical network configuration for CTF events is presented on Figure 3. Networks of each team are connected through respective routers to the Main router that enables overall connectivity. There is a separate game server for each team for Attack and Defense CTFs. The main router in Attack and Defense CTFs also performs NAT on team network links to prevent players from identifying the source of attacks. The game server with tasks is deployed for task/quest based CTF events. There is the Jury Server that monitors the event and displays the scoreboard with points. The virtual private network (VPN) server is needed for external players that wish to join

the action. Thus, an isolated network is created, and aspects of security for global and corporate university network are ensured.

There are also many opportunities for students to become more proficient in networking. Setting up the network configuration in Figure 3 requires an understanding of networking technologies, routing, and configuration of network equipment like switches and routers. Most of these aspects are usually covered in respected curriculum courses, but here is a real network that should be deployed and maintained in operation. Thus, it becomes handy for students to refresh their knowledge and gain practical experience. For advanced steps, technologies like VRF (Virtual Routing and Forwarding) or problems like route leaking can be studied and discussed.

3.4 OS Administration

There are many things that need to be studied and experienced in practice in *OS administration*, especially in administration of Unix-like OSes. Dealing with tasks, deploying servers and configuring services allows to enhance the students' knowledge in this area and to develop quite a number of skills. Also, many aspects of OS security mechanisms are studied thoroughly (for example, behavior of suid programs or SELinux configuration) and kept within reach. Besides, the use of services and applications that run on OS like proxies, firewalls and scanners for border control and inspection of traffic is quite beneficial for future computer security specialists.

Another point in studying *OS administration* more deeply is *script programming*. It is required for convenience and work automation. Since it deals with programming, a teaching of writing scripts is usually omitted from curriculum courses. However, it is widely used in real life practice, and students have to use scripts to develop their own tasks and improve their performance when solving tasks. Basic aspects of shell programming and usage of Perl, Python, and other script languages are generally covered in one of the club sessions and are further mastered by students in their self-study.

4. Operating the Club

The "CTF Club" in Altai State University started its work in 2014. At first, there were only a handful of people enough to form a single team. The club got more popular in the next year, and it was possible to start running own CTF competitions and participate in others due to a number of students who already have an experience and those who have a desire to test their skills. Nowadays, there is a group of students who are closely engaged in club activities while other students prefer to attend only those sessions that they are interested in. However, a brief survey conducted in March 2016 shows the following results:
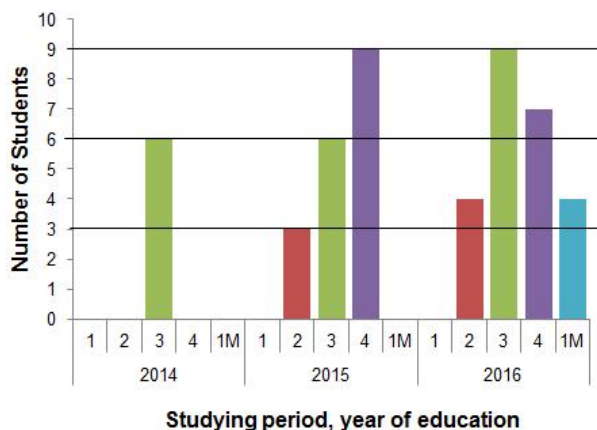
Figure 4. Number of student members of the club

Figure 4 shows the increase of interest in club activities among students. From six students at the beginning in 2014, there are students of almost all years of education who joined the club activities. In 2016, four first-year master's students who were formerly graduate bachelor students decide to stay in the club and continue to participate in club sessions. Being the most experienced ones they provide the assistance and coaching in various aspects to other students as well as sharing their experience.
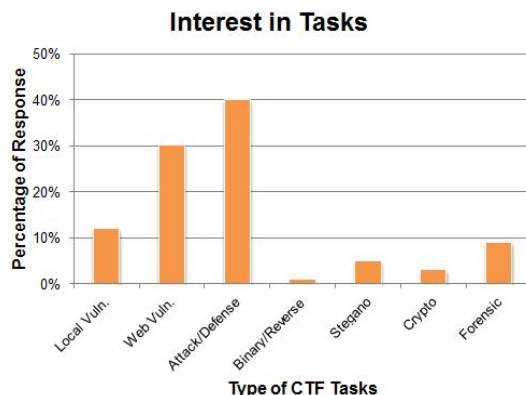
Figure 5. Students interest in CTF tasks

Figure 5 demonstrates the interest in CTF tasks among students. As it was mentioned earlier, the most popular are tasks of 'Attack and Defense' type. Naturally, they are the most realistic and competitive ones and require good teamwork and offensive/defensive skills. Next in popularity are tasks dealing with Web and local vulnerabilities. They offer an immediate satisfaction by displaying the results of work and can be done both in teams or singlehandedly. The least popular are binary reversing and cryptography tasks due to their complexity and a huge amount of meticulous work.
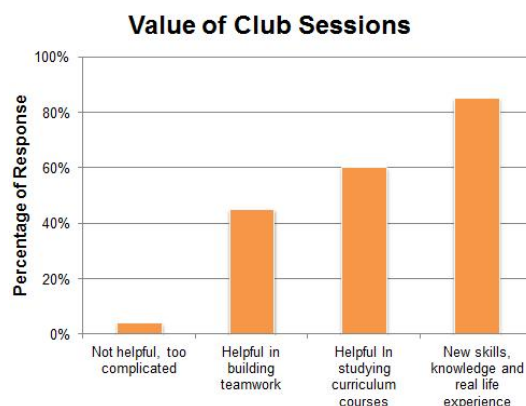
Figure 6. The value of club sessions for students

Figure 6 shows the results of a multiple choice question about the value of club sessions for students. Almost all of the student members believe that the most valuable thing for them is the opportunity to get news skills, knowledge and real life experience in cybersecurity problems. Also, they praise club activities for being helpful in building teamwork and studying their curriculum courses. Obviously, dealing with tasks and catching up with others were quite overwhelming for someone. However, the overall results clearly demonstrate the successfulness of club sessions and students appreciation for usefulness of club activities.

4. Conclusion

This paper presented the CTF-based educational framework to provide students studying information security with additional skills, knowledge and real life experience. The proposed framework is implemented in Altai State University in 2014 in a form of an extracurricular activity that coexists well with the curriculum and has several pedagogical benefits. Being student-centered and allowing the liberty in acquiring the needed knowledge and skills 'on demand' are of great advantage for the proposed framework. Besides, there are no limitations to dealing with CTF tasks only, so, other aspects concerning system administration, script programming, virtualization environment, networking, and protocols are studied and practiced. This also helps students a lot with studying their curriculum courses and getting more proficient in practical aspects of their future work. There is a clearly demonstrated interest among students and positive feedback that shows the success and

usefulness of the proposed approach.

References

Cheung, R., Cohen, J., Lo, H., & Elia, F. (2011). Challenge based learning in cybersecurity education. *Proceedings of the 2011 International Conference on Security & Management*. Las Vegas, Nevada, USA. Retrieved from http://josephpcohen.com/papers/cbl.pdf

Cheung, R., Cohen, J., Lo, H., Elia, F., & Carrillo Marquez Veronica (2012). Effectiveness of Cybersecurity Competitions. *Proceedings of International Conference on Security and Management*. Las Vegas, Nevada. Retrieved from http://josephpcohen.com/papers/seccomp.pdf

Conklin, A. (2006). Cyber Defense Competition and Information Security Education: An Active Learning Solution for a Capstone Course. *Proceedings of the 39th Annual Hawaii International Conference on System Sciences (HICSS'06)*. http://dx.doi.org/10.1109/HICSS.2006.110

Eagle, C., & Clark, J. L. (2004). Capture-the-Flag: Learning Computer Security Under Fire. *Proceedings of the Sixth Workshop on Education in Computer Security (WECS)* (pp. 17-21). Monterey, CA. Retrieved from http://calhoun.nps.edu/bitstream/handle/10945/7203/wecs6_ch04.pdf

FSES for Information Security. (2010). *Higher Education FSES Portal* (in Russian). Retrieved from http://fgosvo.ru/fgosvpo/7/6/1/9

Ho, J. W., Mallesh, N., & Wright, M. (2009). The Design and Lessons of the ASCENT Security Teaching Lab. *Proceedings of the 13th Colloquium for Information Systems Security Education* (pp.124-132). Seattle, WA. Retrieved from https://www.asee.org/public/conferences/8/papers/4887/download

Irvine, C. (2011). The value of capture-the-flag exercises in education: An interview with Chris Eeagle. *IEEE Security & Privacy*, *9*(6), 58–60. http://doi.ieeecomputersociety.org/10.1109/MSP.2011.177

Sallis, E. (2002). *Total Quality Management in Education*. Psychology Press.

Werther, J., Zhivich, M., Leek, T., & Zeldovich, N. (2011). Experiences in cyber security education: The MIT Lincoln laboratory capture-the-flag exercise. *Proceedings of the 4th Cyber Security Experimentation and Test* (pp. 12-12). Retrieved from https://www.ll.mit.edu/mission/cybersec/publications/publication-files/full_papers/2011_08_08_Werther_CSET_FP.pdf

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Investigating the Relationship between Theory of Mind Ability and Academic Achievement and Self-Efficiency of Students with Conduct Disorder in Ardabil

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Abstract

The aim of this study was to determine the relationship between theory of mind ability and academic achievement and self-efficacy of students with conduct disorder in Ardabil. This descriptive study is correlational type, and the population of study consisted of all students with conduct disorder in high schools (secondary levels of 7, 8, 9) of Ardabil in March, 2015. Multi-stage cluster sampling method was used which covered 384 person and then Rutter's behavioral disorders questionnaire form B was put at the disposal of teachers, and among people who were diagnosed with conduct disorder a total of 60 students with conduct disorder were selected as the sample group. Data were collected by the use of a questionnaire regarding self-efficiency in children and adolescents, Hopi's theory of mind, behavioral disorder questionnaire by Rutter form B and academic records. Obtained information was analyzed by using Pearson correlation coefficient test and regression test. The results showed that there is a significant relationship between theory of mind with academic achievement, self-efficiency, social self-efficiency, academic self-efficiency and emotional self-efficacy ($05/0>p$). Regression analysis showed that theory of mind can predict significantly about 38% of the variances of academic achievement, 29% of the variances of self-efficiency, 26% of the variances of social self-efficiency, 41% of the variances of academic self-efficacy, and 28% of the variances of emotional self-efficiency in students. Accordingly, it can be concluded that theory of mind can predict academic achievement and self-efficiency in students with conduct disorder and it shows the relationship between these variables.

Keywords: theory of mind abilities, academic achievement, self-efficiency, conduct disorder

1. Introduction

One of the problems that has effects on children and was widely considered by clinicians and psychologists, is conduct disorder. Conduct Disorder is a sustainable collection of behaviors that forms over time and often "characterized by aggression and violate regarding the rights of others (Saduk & Saduk, 2007; Rezaei, et al., 2011). Children and adolescents with this disorder insist in the refusal of the rules at home, school or community and are inconsistent in school and disobey from the orders of authorities, and have many destructive behaviors. These students are impulsive, have poor judgment and they take risk in dangerous and incorrect occasions. They don't think about the consequences of their actions and always fail, they aren't responsible for their bad behaviors and aren't sensitive about the feelings, thoughts and needs of other people (Janksmy et al., 2000). Unlike many childhood problems that decreases with aging, anti-social behaviors with aging, are established; approximately 2- 7 % of the entire community are affected by conduct disorder (Levinson et al., 2004). Conduct disorder cause many interpersonal problems among people due to having disruptive and reckless behaviors. Many factors may be involved in causing these symptoms which can also affect people's self-efficiency. Self-efficacy is defined as judgments about what one thinks, not what someone has done (Abolghasemi & Narimani, 2005). Bandura, in his book titled "foundations of thought and social behavior suggests that people usually have a system of self-efficiency which is effective in controlling their thoughts, feelings and actions. This system includes a structure which brings about to some extent stability in human behavior. In other words it's the

amount of people's ability to control their performances and environmental impacts (Bandura, 2001). The most important motivational variable relating to achievement goals from the perspective of researchers is self-efficacy beliefs (Liem et al., 2008). Factors such as self-efficiency beliefs and goals have an important role in understanding self-regulation and motivational processes in people (Seo, Barrett, & Bartunek, 2004). It causes to the formation of deep processing and stability in doing homework (Finny, Pieper, & Barron, 2004; Vanyperen, Elliot, & Anseel, 2009).

Academic achievement is a growing curve which goes higher everyday by learning new things and it's the result of active mental processes that includes understanding the significant correlation between new information and prior knowledge of the learner (Aminabadi, 2011). Learning achievement means the amount of academic learning of individuals which was measured by different course exams such as dictation and mathematics (Anderson, 2002). Studies have shown that specific learning and self-efficiency difficulties are in close relationship with theory of mind (Jomepoor et al., 2015). Theory of mind is a vast structure that forms the foundation of social interaction in human. All people often during their natural growth and until age four, acquire the ability of distinguishing their mental states such as beliefs, desires, intentions and emotions towards others. Of course, in these abilities some changes occur in the growth process and part of these changes are related to cognitive growth (the cognitive abilities are done during the growing age of children and in aging time) and the other part relates to the experiences of children (which is formed in interaction with others) (Yazdi, 2012). Theory of mind is mental states, beliefs, intentions, hopes, prays and knowledge of self and others and it also refers to understanding the fact that other's beliefs and intentions are different from the beliefs and intentions of us. Having a theory of mind allows one to consider thoughts, wishes and intentions of other people and be able to predict or describe them and understand their intentions (Hayes et al, 2008). Studies have shown that theory of mind is relevant with self-understanding (Nejati et al., 2012; Beta et al., 2003), self-regulation and problem-solving skills (Sperling et al., 2009). On the other hand research results have shown that, aggressive children in theory of mind tasks act weaker than normal people. This study seeks to answer the question that: can theory of mind predict self-efficiency and academic achievement of students with conduct disorder in Ardabil?

2. Methodology, Community and Method of Sampling

This study is correlational, and academic achievement and self-efficiency are criterion variables and theory of mind was considered as the predictor variable. The number of students have been reported 28137 people. The study population consisted all students with conduct disorder in first grade of high school (secondary levels of 7, 8, 9) in Ardabil, in 2015. Multi-stage cluster sampling method was used. For this purpose, four schools were selected from regions 1 and 2 of Ardabil, following that 3 classes from each school and 32 person from each class were selected, the total of participants were 384 person. This number of sample size was selected based on Morgan's sampling table and more behavioral disorder questionnaires by Rutter form B, was placed at the disposal of teachers. After answering, people with conduct disorder were diagnosed and 60 people were selected as a sample group. Minimum of 25 people is ideal for correlational research (Delavar, 2006). This number of sample size was selected to enhance external validity and generalizability with more confident.

The following tools were used for data collection:

1) Self-Efficiency Questionnaire for Kids and adolescents: This questionnaire was prepared by Morris (2001) to assess self-efficiency in children and adolescents in social, educational and emotional aspects, and it includes 23 articles and three sub-tests. Social self-efficiency sub-test includes 8 first articles (questions 1 to 8) and it measures the ability to communicate with peers, determination and achieving to social norms. Academic self-efficiency subtest includes second 8 articles (questions 9 to 16), and it measures sense of empowerment in the management of learning behaviors, mastering the curriculum and proof expectations in academic achievement. Emotional self-efficacy sub-test includes the last 7 articles (questions 17 to 23) and it measures individuals' sense of ability in facing with and controlling negative emotions. Reliability of this test is good and its internal consistency is 0.80. Factor analysis, shows three-factor structure in three areas of social, academic and emotional aspects (Morris, 2001) and its validity is based on appropriate and acceptable content and context validity. Reliability of three factors was reported 0.70, reliability of social self-efficacy was 0.78, reliability of academic self-efficacy was 0.87, and for emotional self-efficacy it was reported 0.80 (Morris, 2001; quoted by Ardalan & Hossein, 2011).

2) Hopi's theory of mind test: In this study to evaluate children's theory of mind, theory of mind questionnaire by Hopi will be used. This questionnaire was made in 1995, and it contains 12 stories regarding pretense, white lies, exaggeration, persuasion, forgetting, appearance, conscience, jokes, innuendo, misunderstanding, speech format and agitation of the opposition. This questionnaire for the first time in Iran was used by Razavieh et al. (1385).

Arefi has reported validity coefficient and reliability of the questionnaire desirable (validity coefficient is 0.89 and reliability is 0.98). This test performed individually and scoring was on the basis that score zero is rewarded to errors subject to the reality of story or the presented condition of mind in the story. Score one is awarded to the answers which don't refer to the state of mind clearly but they considered the reality of story and score two is rewarded to answers which consider the story and refer to the state of mind clearly (Samadi, 2013).

3) Rutter's behavioral disorder questionnaire form B: Rutter' questionnaire form B, includes 26 phrases. The teacher in each of the 26 phrase chooses one of the phrase from "not true" to "absolutely right". Scores for responding to 26 phrases, will have a maximum of 52 score, and is considered as the distinction criterion. The time required for completing this questionnaire will be about 7 minutes. In a study by Abolqasemi (1383) this questionnaire was conducted on 60 ordinary students and who had problems. Reliability coefficient in making half and Cronbach's alpha were reported in this questionnaire respectively, 0.83 and 0.91. Pearson's correlation coefficients showed that, there is a significant relationship between Rutter's questionnaire and questionnaire of behavioral problems by Shahim et al. The t test results showed a significant difference between mean scores of normal children and who have problems in questionnaire by Rutter (Narimani & Abolghasemi, 2006).

4) Academic achievement: In this study for investigating academic achievement of students, their mean score in the first term exams (January) was used.

3. Procedure

In this research, data were gathered by field study (data collection through questionnaire) and library method (collecting theoretical subjects), respectively. For data collection in questionnaire, the necessary licenses were obtained. By the use of multi-stage clustering sample method 4 schools were selected in Ardebil from regions 1 and 2, then 3 class from each school and 32 person from each class were selected, the total of participants were 384 person. This number of sample size was selected based on Morgan's sampling table. Then Rutter's behavioral disorder questionnaire form B was placed at the disposal of teachers and then 60 people who were diagnosed with conduct disorder, were selected as the sample group. After determining the sample group, self-efficacy and theory of mind questionnaires were put at the disposal of the people, and then first innings average was received and after answering questions, the gathered data were analyzed. To analyze the data, descriptive statistics such as frequency distribution table, mean and standard deviation to describe the data were used. To examine the hypothesis, Pearson correlation coefficient was used and Regression analysis was used to evaluate the research question and the results are reported in the following tables.

4. Results

Total respondents of the study were 60 people, (33.38 percent were female and 66.61 percent were male). And 30% of students aged 13 years, 33.38% aged 14, and 66.31% aged 15. The results also showed that 35 percent of students were in the first year of high school (secondary level of 7), 33.33% of students were in junior high school (secondary level of 8) and 31.66% of them were of junior high school (secondary level of 9) who were enrolled in the study and have responded to the mentioned questionnaire. The results of data analysis is reported in the following tables.

In this study, data analysis was done both by descriptive (mean and standard deviation) and inferential (Pearson correlation coefficient test and regression analysis) methods. The gathered results is reported below.

Table 1. The mean and standard deviation of scores related to self-efficiency, academic achievement and theory of mind

Variable	Mean	Standard Deviation
Self-efficiency	87.03	9.43
Social self-efficiency	24.16	5.32
Academic self-efficiency	21.11	3.29
Emotional self-efficiency	22.03	3.50
Academic Achievement	17.14	1.01
Theory of mind	30.48	7.73

Results in Table 1 shows the mean and SD for self-efficiency was obtained 87.03 and 9.43, respectively. For social self-efficiency it was 24.16 and 5.32, for academic self-efficiency was 21.11 and 3.29, for emotional self-efficiency was 22.03 and 3.50, for academic achievement was 17.14 and 1.01 and for theory of mind it was

reported 30.48 and 7.73, respectively.

Table 2. Correlation coefficient of theory of mind with self-efficiency and academic achievement

Variable	Statistics	Theory of mind
Academic Achievement	correlation coefficient	0.31
	Significance level	0.01
Self-efficiency	correlation coefficient	0.27
	Significance level	0.03
Social self-efficiency	correlation coefficient	0.25
	Significance level	0.04
Academic self-efficiency	correlation coefficient	0.27
	Significance level	0.03
Emotional self-efficiency	correlation coefficient	0.30
	Significance level	0.01

Note. * ($p<0.05$) **($p<0.01$)

According to Table 2, Pearson correlation coefficient shows in the significant level of 0.05 and confidence coefficient of 0.95. So, there is a significant relationship between theory of mind with academic achievement (r=0.31), Self-efficiency (r=0.27), Social self-efficiency (r=0.25), academic self-efficiency (r=0.27), and emotional self-efficiency (r=0.30). ($p<0.05$).

Table 3. Multivariate regression analysis results related to theory of mind in predicting academic achievement

Model	Ss	Df	Ms	F	P
Regression	9.28	1	9.28	10.29	0.002
Remained	52.27	58	0.90		
Total	61.55	59			
	R Rs	ARS			
Predicator variables			Non-standardized	standardized coefficients	T Sig coefficients
constant			B Se	Beta	
Ability of theory of			15.64 0.52	-	29.56 0.000
Mind	0.38 0.15	0.13	0.05 0.01	0.38	3.20 0.002

To determine the effect of theory of mind as a predictive variable and academic achievement as criterion variable, they were analyzed in the regression equation. As shown in Table (3), the amount of observed F is significant ($p<0.002$) and 15% of the variances in academic achievement is explained by the theory of mind. According to Beta values (β=0.38), theory of mind can predict significantly changes on the student's academic achievement.

Table 4. Multivariate regression analysis results related to theory of mind in predicting self-efficiency

Model	Ss	Df	Ms	F	P
Regression	499.99	1	499.16	5.52	0.02
Remained	5241. 56	58	90.37		
Total	5740.73	59			
	R Rs	ARS			
Predicator variables			Non-standardized	standardized coefficients	T Sig coefficients

			B Se	Beta	
constant					
Ability of theory of			7511 5.30	-	14.17 0.000
Mind	0.28 0.08	0.07	0.39 0.16	0.29	2.35 0.02

To determine the effect of theory of mind as a predictive variable and self-efficiency as criterion variable, they were analyzed in the regression equation. As shown in Table (4), the amount of observed F is significant (p<0.02) and 8% of the variances in self-efficiency is explained by the theory of mind. According to Beta values (β=0.29), theory of mind can predict significantly changes on the student's self-efficiency.

Table 5. Multivariate regression analysis results related to theory of mind in predicting social self-efficiency

Model	Ss	Df	Ms	F	P
Regression	120.14	1	120.14	4.49	0.03
Remained	1548.78	58	26.70		
Total	1668.93	59			
		R Rs	ARS		
Predicator variables			Non-standardized	standardized coefficients	T Sig coefficients
constant			B Se	Beta	
Ability of theory of	18.18	2.88	-	6.31	0.000
Mind	0.26 0.07	0.05	0.19 0.09	0.26	2.12 0.03

To determine the effect of theory of mind as a predictive variable and social self-efficiency as criterion variable, they were analyzed in the regression equation. As shown in Table 5, the amount of observed F is significant (p<0.03) and 7% of the variances in social self-efficiency is explained by the theory of mind. According to Beta values (β=0.26), theory of mind can predict significantly changes on the student's social self-efficiency.

Table 6. Multivariate regression analysis results related to theory of mind in predicting academic self-efficiency

Model	Ss	Df	Ms	F	P
Regression	94.41	1	94.41	12.10	0.001
Remained	452.43	58	7.80		
Total	546.58	59			
	R Rs	ARS			
Predicator variables			Non-standardized	standardized coefficients	T Sig coefficients
constant			B Se	Beta	
Ability of theory of	15.78	1.55	-	10.13	0.000
Mind	0.47 0.17	0.15	0.17 0.04	0.41	3.47 0.001

To determine the effect of theory of mind as a predictive variable and academic self-efficiency as criterion variable, they were analyzed in the regression equation. As shown in Table (6), the amount of observed F is significant (p<0.001) and 17% of the variances in academic self-efficiency is explained by the theory of mind. According to Beta values (β=0.41), theory of mind can predict significantly changes on the student's academic self-efficiency.

Table 7. Multivariate regression analysis results related to theory of mind in predicting emotional self-efficiency

Model	Ss	Df	Ms	F	P
Regression	65.93	1	65.93	5.17	0.02
Remained	739.71	58	12.75		
Total	805.65	59			
	R Rs	ARS			
Predicator variables			Non-standardized	standardized coefficients	T Sig coefficients
constant			B Se	Beta	
Ability of theory of	17.44	1.99	-	8.76	0.000
Mind	0.28 0.08	0.06	0.14 0.06	0.28	2.27 0.02

To determine the effect of theory of mind as a predictive variable and emotional self-efficiency as criterion variable, they were analyzed in the regression equation. As shown in Table 7, the amount of observed F is significant (p<0.02) and 8% of the variances in emotional self-efficiency is explained by the theory of mind. According to Beta values (β=0.28), theory of mind can predict significantly changes on the student's emotional self-efficiency.

5. Discussion and Conclusion

The obtained results in this study are consistent with results in studies by Jomehpoor et al. (2015), Ali Akbari et al. (2013), Perner et al. (2002), Beta et al. (2003), Petnik (2008), Aylin et al. (2011), and Serna et al. (2014). Childhood and adolescence are the most important and most critical periods in the formation of personality and neglecting them will result in irremediable consequences because the foundation of tomorrow's society are today's children. In a society with less attention to children and adolescents, more and more social problems, abnormal children and delinquency can be observed. According to importance of children, it is noteworthy to consider their problems and fix them. One of the problems afflicting children and was widely considered by clinicians and psychologists, is conduct disorder. Conduct disorder has always attracted the attention of experts in different fields. On the one hand, this is perhaps due to the complexity and diversity of the causes of conduct disorder and on the other hand, variety of behavioral issues and their consequences in various fields could be important. Conduct disorder is a set of consistent behaviors that forms with the passage of time and is identified with symptoms such as cruelty to animals and people, destruction of properties, deceit, deception, lying, stealing, violating to the rights of others. Such problems will create serious problems for patients, families and communities (Boris & Dalton, 2004; Hill, 2002). The aim of this study was to determine the relationship between theory of mind ability and academic achievement and self-efficiency of students with conduct disorder in Ardabil.

The first hypothesis of this study was: theory of mind ability has a relationship with academic achievement of students with conduct disorder in Ardabil. To verify this hypothesis the Pearson correlation coefficient test was used. The results showed that, there is a positive and significant relationship between theory of mind ability and academic achievement of students (p<0.05). The obtained results in this study are consistent with the results in studies by Jomehpoor et al. (2015), Petnik (2008), Aylin et al. (2011), and Serna et al. (2014). Theory of mind makes people enable to make relations between external mental status (protests, gestures, signs, etc.) and the inner states of mind (beliefs, feelings, intentions, etc.). And regarding this ability they will be able to predict the behavior of others in different social situations. Theory of mind or the ability to identify emotions, intentions and thoughts of others can be considered as one of the most important skills in a series called social intelligence skills (Goopink & Meltezof, 1997; quoted by Mohammad, 2014). Social perception component is the ability to decode mental status of others by the use of visible and accessible information and social cognition component is the ability of receiving and inferring to the mental state of others in order to predict their behaviors (Wang et al., 2010). Theory of mind is a prerequisite for understanding the social environment, and it's needed for involving in competitive social behaviors. This ability helps students in the classroom and in relationship with teachers and classmates to communicate effectively and useful and they will be able to understand and learn easily the presented subjects by teacher. So, when this ability is stronger in students, they can be more successful and they will have better academic achievement.

The second hypothesis of this study was: theory of mind ability has a relationship with self-efficiency (social, academic and emotional) of students with conduct disorder in Ardabil. To verify this hypothesis the Pearson correlation coefficient test was used. The results showed that there is a positive and significant relationship between theory of mind ability and self-efficiency (social, academic and emotional) of students ($p<0.05$). The obtained results in this study are consistent with the results in studies by Kakojoibari (2012), Perner et al. (2002), Beta et al. (2003) and Sperling et al. (2009). Self-efficiency is the "judge of people on their ability to organize and implement a series of actions to achieve specified types of operations" (Shahraray, 2007). Self-efficiency means personal conviction and based on that a person can do some behaviors to achieve the desired result. Self-efficiency can be referred to the idea that the person can dominate a situation and produce positive outcomes. Bandura believed that, self-efficiency has a powerful influence on behavior (Bandura, 2001). Self-efficiency is a person's conviction and according that a person can successfully execute the necessary behaviors to produce the desired results and also it reflects the overall confidence of a person about his or her ability to control and dominating over the environmental requests (Dadfar, 2011). Self-efficiency is applied regarding the judgments of people about their abilities for completing designed levels of performance (Moradi & Taj, 2007). Meanwhile, theory of mind ability causes people act better about social situations and mental states of oneself and others and also about individual or general allocation of themselves, and it will increase their abilities to recognize their abilities and their function, so they will have higher levels of self-efficiency. In general, mental states involve a wide range of intentions, hopes, fears, expectations, desires, ideas, and etc and three of these states are the main factors for interpretation and prediction of the people's behaviors (Kazdin, 2000). So it increases the ability of perception in a person in relation with self-efficiency and self-understanding. This is an explanation for the relationship between self-efficiency and theory of mind.

Research question was: can theory of mind predict self-efficiency and academic achievement of students with conduct disorder in Ardabil? Regression analysis was used to examine this question and results showed that theory of mind can predict significantly about 38% of the variances of academic achievement, 29% of the variances of self-efficiency, 26% of the variances of social self-efficiency, 41% of the variances of academic self-efficiency and 28% of the variances of emotional self-efficiency in students. Theory of mind is defined as the power of the human mind to imagine himself and others modes (Leslie, 1988). Schafer (2000) considers theory of mind for distinguishing "public self" and "private self" that implies the acquisition of theory of mind, and understanding the fact that people have mental states, beliefs, desires and intentions, which often guide their behaviors. Hepeh (1994) believes that the theory of mind helps individuals regarding the feelings, beliefs, and intentions of others, and offers a good explanation and description of their behaviors. So people who have higher levels of theory of mind, can perceive mental abilities and aspirations of other people and this can improve academic performance and self-efficiency of people. Researches on their way encounter with some limitations. This study was also associated with some limitations such as limitation to choose statistical sample in Ardebil, limited sample of high school students with conduct disorder (secondary 7, 8, 9), lack of access and allowance for researchers to control variables related to the individuals (family variables, environment, school, etc.) and lack of control for comorbidity of other mental disorders in the study group. It is recommended to the interested researchers in this field that theory of mind, academic achievement and self-efficiency of students will be investigated with considering other psychological variables. It is suggested that in future research confounding variables such as family and cultural factors will be controlled in groups. According to the positive relationship between theory of mind and emotional, social and academic self-efficiency and academic achievement in students, it is recommended to school counselors and psychologists to use educational methods based on promotion of theory of mind to enhance self-efficiency and academic achievement of students with conduct disorder. It is suggested that training should be offered some in service trainings for teachers regarding conduct disorder, theory of mind, self-efficiency and academic achievement. Also some programs should be designed to increase knowledge of parents and it would be helpful for students with conduct disorder. At the end we should thank all those who helped us to complete this research.

References

Amin, Y. A. (2004). Transmission of "theory of mind" in children. *Journal of Education and Psychology, 5*(1), 41-49.

Aminabadi, Z. (2011). *Comparing the effectiveness of two methods of metacognitive strategies and teaching by the use of software to improve cognitive functions and academic progress of students with dyslexia* (Master's Thesis in Psychology). University of Mohaghegh in Ardebil.

Anderson, C. A., & Bushman, B. J. (2002). Human aggression. *Annual Review Psychology, 53*(3), 27-51.

Ardalan, E., & Hossein, C. M. (2011). Predicting academic adjustment based on communicational skills through self-efficacy beliefs. *Journal of Educational Psychology, 17*, 28-1.

Arjmand, M., Rezaei, F., Foghani, J. N. (Trans.). (2011). *Clinical Psychiatry* (2nd ed.). Arjmand Publications, pp. 436-439.

Aylin, L., & Rosario, T. (2011). *Impact of executive functions and the theory of mind on academic achievement. A longitudinal study, Neurosis*. Conference Abstract: XI International Conference on Cognitive Neuroscience (ICON XI).270. 263

Bandura, A. (2001). *Social cognitive theory: Annul review of psychology*. Palo Alto, CA: Annul review s. Belmont, CA: Wadworth.

Beate, S., Christian, H., & Claudia, T. (2003). The self and action in theory of mind research. *Journal of Consciousness and Cognition, 12*, 777–782.

Dadfar, S. (2011). *The effectiveness of social problem solving on self-control, self-efficiency and impulsivity of students with addiction potential* (Master's thesis in clinical psychology). Ardebil Islamic Azad University.

Delavar, A. (2006). *Research methods in the humanities*. Tehran: Roshd Publications.

Finny, S., Pieper, S., & Barron, K. (2004). Examining the psychometric properties of the achievement goal questionnaire in a general academic context. *Journal of Educational and Psychological Measurement, 64*(2), 365-382.

Hayes, S. C., Barnes, H. D., & Roche, B. (2008). Relations frame theory. *Journal A Post- Developmental Disorders, 31*, 589-599.

Hill, J. (2002). Biological, psychological and social process in the conduct disorders. *Journal of Child Psychology & Psychiatry, 43*(1), 133-164.

Jomehpoor, M., Mohammadpoor, H., & Dastjerdi, R. (2015). Compare theory of mind development in children with and without specific learning difficulties. *Journal of Exceptional Education, 15*(4), 23-13.

Jongsmy, A., Deterson, M., & Mclnnis, W. (2000). *The child psychotherapy treatment planner*. John Wiley Sons/ Inc.

Lewinsohn, P., Rohde, P., & Farrington, D. (2000). *The OADP-CDS: A Brief screener for adolescent conduct disorder. Child and Adolescent Psychiatry, 39*, 888-889.

Liem, A. D., Lau, S., & Nie, Y. (2008). The role of self-efficacy, task value, and achievement goals in predicting learning strategies, task disengagement, peer relationship, and achievement outcome. *Journal of Contemporary Educational Psychology, 33*(2), 486-512.

Moradi, T. (2013). Investigating the relationship of general self-efficiency and scientific view in academic achievement of pre-university students in majors physics, biology and chemistry (Master's thesis, General Psychology). Tabriz University.

Narimani, M., & Abolghasemi, A. (2006). *Psychological tests*. Ardebil: Baghe Rezvan Publications.

Nejati, V., Zabihzadeh, A., Nikfarjam, M. R., Pournaghdali, A., Naderi, Z., & Tajmir, R. M. (2012). Self as a social cue: Evidence for reading mind from eyes test. *Jurnal of Procedia - Social and Behavioral Sciences, 32*, 82-88.

Perner, J, Lang, B., & Kloo, D. (2002). Theory of mind and self-control: more than a common problem of inhibition. *Child Dev, 73*(3), 752-67.

Razavieh, A., Latifian, M., & Arefi, M. (2006). The role of theory of mind and empathy on predicting obvious aggressive communicational behaviors and prosocial behaviors in students. *Journal of Psychological Studies, 2*(4), 25-38.

Samadi, & Sahar (2013). Comparing ability of theory of mind and self-understanding in juvenile offenders of Ardabil city (Master's Thesis in Clinical Psychology). Islamic Azad University, Ardabil.

Seo, M., Barrett, L., & Bartunek, J. M. (2004). The role of affective experience in work motivation. *Journal of Academy of Management, 29*, 423-439.

Serena, L., Marcella, C., & Adriano, P. (2014). Long-term effect of theory of mind on school achievement: The role of sensitivity to criticism. *European Journal of Developmental Psychology, 11*(3), 305-318.

Shahraray, M. (2006). Theory of research and Applications (Johan, Pintrich, Artin, & Shang, Trans., 2002).

Tehran: Arjmand Publications.

Sperling, R. A., Walls, H., & Hill, A. (2009). Early relationships among self-regulatory constructs: Theory of mind and preschool children's problem salving. *Journal of Child Study, 30*(4), 233-252.

Van Yperen, N. W., Elliot, A. J., & Anseel, F. (2009). The influence of mastery avoidance goals on performance improvement. *European Journal of Social Psychology, 39*, 932-943.

Wang, Y. G., Wang, Y., Chen, S., Zhua, C., & Wang, K. (2010). Theory of mind disability in major depression with or without psychotic symptoms: A componential view. *Journal of Psychiatry Research, 161*(2), 153–61.

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Effectiveness *Trichoderma asperellum* on the Growth Cocoa Seeds under the Old Cocoa Trees

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Abstract

This study aimed to determine the effect of *Trichoderma asperellum* on the growth of cocoa seedlings under cocoa stands around 20 years old, so that cocoa seedlings to be used as rootstock on approach grafting for the rehabilitation of the roots of cocoa plants are old, growing well. Research compiled by randomized block design with frequency variation application *T. asperellum* that, once, twice and three times application respectively of4 $gr.L^{-1}$ each plant. The results of the research, granting *T. asperellum* on cocoa seedlings planted under old cocoa trees and is still productive, able to help overcome competition in the utilization of nutrients and water as well as other growth inhibiting factors, and the influential on the vegetative growth of cocoa seedlings. Frequency of the best is three times the application that provides the most effective results for growing cocoa seeds, the seed growing percentage of 100% and an average plant height of 144.45 cm; number of leaves 37 strands; stem diameter 12.22 mm; and total leaf area 1388.30 cm2.

1. Introduction

Cocoa (*Theobroma cacao* L.) is the essential raw commodity for the world's chocolate industry, which was worth $150bn in 2014. By 2016, the global chocolate market will be worth $98.3 billion. Indonesian is the world's third leading producer of cocoa beans after Ghana and Ivory Coast, growing 740.500 tonnes in 2012, according to the FAO (Worldatlas, 2015).

West Sulawesi contributed 20% of the national cocoa production, and is the largest cocoa producer in Indonesia, with the area planted in 2014 is 172,000 hectares with a production of 110-115 thousand tons per year (Anonymous, 2014). These data indicate that cocoa is the backbone of the economy in West Sulawesi, but ironically in West Sulawesi cocoa productivity continues to decline. Several factors are significant on the level of productivity of cocoa, besides extensive cocoa plantations, varieties, pests and diseases, climate anomalies, the plant canopy is damaged, as well as age older plants cause less productive plants (Anaeani & Frimpong, 2013). In addition, the dominant limiting factors increasing of cocoa productivity is soil fertility including low organic matter content, low exchange able minerals nutrients such as K and low soil CEC (Ololade, 2010).

Side-grafting is the introduction of cultivation technology that quickly spread among farmers, which initially gives hope bright enough in order to improve the productivity of cocoa. However, after the results are satisfactory side-grafting produce multiple harvests, further crop losses in production and productivity. This is likely caused by an imbalance of the capability of the plant canopy to produce, with the condition that the old plant root system in supplying the needs of nutrients and water from the roots.

The work can be done to fix the root system of the tree cacao side grafting is a technique of approach-grafting, by utilizing the cocoa seeds that have been aged for at least 6 months, so that plant roots can be rehabilitated and is expected cocoa productivity can be improved. The success of this effort is especially if the cocoa seedlings that will be continued to grow well. Cocoa seedlings were planted under old cocoa stand side grafting productive results, will have competition in the use of water and nutrients to the vegetative growth.

One functional microorganism that is widely known as a biological fertilizer the soil is *Trichoderma* sp.These

microorganisms are fungi occupants of the land that can be isolated from plant roots field, including cocoa. Species *Trichoderma* as well as decomposing organisms, can also function as biological agents and plant growth stimulator (Okoth et al., 2011; Anad & Reddy, 2009; Saba et al., 2012). For example *Trichoderma harzianum*give the same response to auxin in improving the cocoa plant roots extension (Nurahmi et al., 2012). Trichoderma also produce phytohormones ET and IAA, which plays a role in the sustainability of the growth of plants and plant resistance to disease control and adverse environmental conditions (Hermosa et al., 2012).

Based on this, *Trichoderma* sp. is expected to help overcome the competition to get water and nutrients and factors inhibiting the growth of other, so the cocoa seedlings to be used as rootstock on approachgraftingfor the rehabilitation of the roots of cocoa plants are old, can grow well.

The results of research on the role *of Trichoderma sp.* of the cocoa plant is a lot, especially as disease control in cocoa, such as leaf blight, pod disease and cancer stem caused by *Phytophthorapalmivora* (Asti et al., 2013; Adebola & Amadi, 2012). Bae et al. (2009) reported that *Trichoderma sp.* resulted in cocoa seedlings are more tolerant to drought. Technology of *Trichoderma sp.* is growing rapidly, but the information about the role of *Trichoderma sp.* in addressing competition cocoa seedlings were planted in the area around the plant roots productive yet available. This study aimed to determine the effect of *Trichoderma sp.* to the growth of cocoa seedlings under stands of old cocoa productive.

2. Materials and Methods

The experiment was conducted infarm field of Bunde village, Sampaga district, Mamuju regency, West Sulawesi. Six months old cocoa seedlings planted under the cocoa tree stand of around 20 years old, with a spacing of 3 x 3 m. Planting hole was made with size of 40 x 40 x 30 cm 3 hole, and in distance of 20 cm from old cocoa tree.

The materials used are the seeds of *Theobroma cacao* variety Masamba Cocoa Clone (MCC) 01, *Trichoderma asperellum* isolates ART-4 were obtained from Laboratory of Microbiology Faculty of Agriculture University of Hasanuddin, manure, NPK, meter, shove, and so on. The experiments used designed randomized block design (RBD) with frequency treatment applications *of T. asperellum.* The provision of *T. asperellum*: one time, two times, three times application of *T. asperellum* respectively of 4 gr.L^{-1} each plant and wihout application. The first application was given at the time of planting and subsequent intermittent applications a week later. Each treatment was repeated 3 times, so the total plants totaling 36 plants observed.

To assess the effect of treatment, it was carried out observations of parameters including average plant height (cm) measured from a height of 2 cm from ground level to the growing point of the top, the average number of leaves (leaf) formed , average trunk diameter (mm) 5 cm from ground level, and the average total leaf area (cm^2)was measured using graph paper (Nasaruddin, 2011) with the formula:

$$LD = n \ x \ lk \qquad (1)$$

LD is the leaf area (cm^2), n is the number of boxes, and lk is the area of each box (1 cm^2)

To determine the effect of treatment on the parameters observed, an analysis of variance and if there is a treatment effect were significantly different followed by Least Significant difference test (LSD) with significance level of 5%.

3. Results and Discussion

Observations were done to determine the physical and chemical properties of the soil. The results of the analysis of soil chemical properties in the study area is a total-N, C / N ratio, organic C, K and Na is low, pH, Ca and P_2O_5,is classified, and Mg and CEC is high and the type of clay clayey (Table 1).

Table 1. Chemical and physical properties of soil in the experiment

soil chemical properties	
pH H$_2$O	6,2
N total (%)	0,11
organic C (%)	1,08
C / N ratio	10
P$_2$O$_5$ (ppm)	10,9
Ca (cmol / kg)	6,84
Mg (cmol / kg)	3,52
Na (cmol / kg)	0,19
CEC (cmol / kg)	25,66

soil texture	
Sand (%)	32
dust (%)	30
Clay (%)	38

Note. Source: Lab. Chemistry and Soil Fertility, Soil Department Agriculture Fakulty, Hasanuddin University

The provision of *T. asperellum* was very influential on the vegetative growth of cocoa seedlings planted under old cocoa stand still in production (Table 2).

Table 2. Effect of Frequency Applications *T. asperellum* of the vegetative growth of cocoa seedlings age of 12 weeks after treatment applications in the field

Treatment	Height Plant (cm)	Number of leaves (leaf)	Stem Diameter (mm)	Total leaf area (cm^2)	Percentage Growth (%)
without application	109.33 a	24.56 a	8,55	999,72 a	52 a
one-time application	134 b	32.89 b	10,89	1357,22 b	83 b
two-times application	134.44 b	32.78 b	10,44	1302,84 b	94 bc
three-times application	144.45 c	37 c	12,22	1388,30 b	100 c
LSDα0.05	8.90	2.05	tn	130.79	13.21
CV (%)	5.91	5.59	12.35	8.98	15.27

Note. Description: Figures followed by the same letters in the same column are not significantly different according to LSD test level of 5%.

Growth of cocoa seedlings the highest and have the most was the number of leaves on the seedlings by *T. asperellum* for three times application and significantly different from other treatments. In total leaf area, giving *Trichoderma asperellum* once, two times and three times did not differ very significantly different result but with no provision of this fungus. Giving *T. asperellum* did not significantly affect seedling stem diameter, but the percentage of seedlings grown greatly affected by the fungus is mainly on the treatment two to three times as many applications. This indicates that the application of *T. asperellum* can increase vegetative growth is better than without the provision of *T. asperellum*.

The foregoing is highly correlated with the intensity of growth (elongation rate) shoots high. As we know that the growth of the plant involves a number of processes, such as multiplication and differentiation of cells (Basri, 2004). Cell multiplication caused more cell mass (as in the elongation and enlargement of the trunk diameter) while the cell differentiation leads to formation of tissues or organs (such as increasing the number of leaves). Thus, it is clear that with the increase of the length and diameter of the rod will be accompanied by the establishment organs, such as the size (length and width) as well as the number of leaves on shoots of cocoa. As we know that there are a number of factors that influence the growth of planting material, including external factors (environment such as climate, soil and applied technology) and internal factors (genetic including the quality and size of the mass meristem cells contained in a planting material) (Fosket, 1999; Hopkins, 1999).

The regression analysis in Figure 1 show that aplication of *T. asperellum* positively correlated linearly with the vegetative growth of cocoa seedlings age of 12 weeks after treatment. The more the frequency of application of *T. asperellum* increasingly better the vegetative growth of cocoa seedlings.
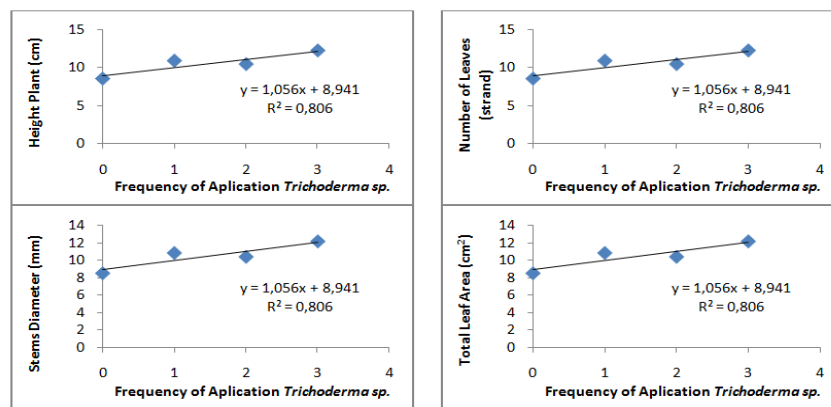
Figure 1. Graph of the regression equation vegetative growth of cocoa seedlings age of 12 weeks after treatment applications in the field

Based on the figure above shows that each increase of one unit of frequency applications *T. asperellum* with a dose of 4 gr.L^{-1} will increase by 7.07 cm plant height, leaf number 3.72 strands, stem diameter of 1.06 mm and leaf area of 111.1 cm^2. Giving *T. asperellum* able to increase vegetative growth of cocoa seedlings, because fixing *rhizosphere* plant roots and helps decompose soil organic matter into nutrients that plants need for growth (Adedeji, 2008). The existence of *T. asperellum* on the ground can improve the physical properties (porosity) and soil fertility. Conditions arable land with good soil aggregation can stimulate vegetative growth of plants.

Trichoderma asperellum can multiply rapidly in the *rhizosphere,* and a parasitic fungus that can attack and take nutrients from other fungi (antagonist). The role of *Trichoderma sp.* antagonistic and at the same rapid breeding in *the rhizosphere* make the existence of this fungus can act as a *biocontrol* against fungi that cause diseases (Harman, 2011) for example *Phytophtora palmivora* causes stem rot disease, the fruit and leaves of the cocoa that can improve plant growth

4. Conclusion

Granting *Trichoderma asperellum* on cocoa seedlings planted under old cocoa trees and is still productive, able to help overcome competition in the utilization of nutrients and water as well as other growth inhibiting factors, and the influential on the vegetative growth of cocoa seedlings.

Frequency of Trichoderma sp. the best is three times the application that provides the most effective results for growing cacao seeds, the seed growing percentage of 100% and an average plant height of 144.45 cm; number of leaves 37 strands; stem diameter 12.22 mm; and total leaf area 1388.30 cm^2.

Acknowledgments

References

Adebola, M. O., & Amadi, J. E. (2012). Studies on Penicillium digitatum, Botryodiploidia theobromae, Alternaria tenuis and Trichoderma harzianum for Bicontrol of Phytophthora palmivora. Cocoa Black Pod Disease Pathogen. *American-Eurasian Journal of Agronomy, 5*(2), 30-34. http://dx.doi.org/10.5829/idosi.aeja.2012.5.2.2046

Adedeji, A. R., Odebode, A. C., & Agbeniyi, S. O. (2008). Bioassay of Five Trichoderma Strains Againts Phytophtora megakarya (Cacao Pod-rot) in Nigeria. *Scientific Research and Essay, 3*(9), 390-394. Retrieved from http://www.academicjournals.org/SRE

Anaeani, F., & Frimpong, O. K. (2013). An Analysis of Yield Gap and Some Factors of Cocoa (Theobroma cacao) Yields in Ghana. *Sustainable Agriculture Research, 2*(4), 117-128. http://dx.doi.org/10.5539/sar.v2n4p117

Anonymous. (2014). *Badan Koordinasi Penanaman Modal, Potensi Kakao di Sulawesi Barat* (Diakses tanggal 3 Juni 2014, Indonesian). Retrieved from http://regionaliinvestment.bkpm.go.id/newsipid/id/index.php

Azis, A. I., Rosmana, A., & Vien, S. D. (2013). Pengendalian Penyakit Hawar Daun Phytophthora pada Bibit Kakao dengan Trichoderma asperellum. *Jurnal Fitopatologi Indonesia, 9*(1), 15–20. Indonesian.http://dx.doi.org/10.14692/jfi.10.5.139

Bae, H., Robert, D. P., Lim, H. S., Strem, M. D., Park, S. C., Ryu, C. M., … Bailey, B. A. (2011). Endophytic Trichoderma Isolates from Tropical Environments Delay Disease Onset and Induce Resistance against Phytophthora capsici in Hot Pepper Using Multiple Mechanisms. *Molecular Plant-Microbe Interactions, 24*(3), 336-351. http://dx.doi.org/10.1094/MPMI-09-10-0221

Fosket, D. E. (1999). *Plant Growth and Development: A Molecular Approach*. Academic Press, San Diego, New York, London.

Harman, G. E. (2011). Trichoderma -Not Just For BiocontrolAnymore. *Phytoparasitica, 39*, 103-108.

Hermosa, R., Viterbo, A., Chet, I., & Monte, E. (2012). Plant-Beneficial Effects of Trichoderma and of Its Genes. *Microbiology, 158*, 17-25. http://dx.doi.org/10.1099/mic.0.052274-0

Hopkins, W. G. (1999). *Introduction to Plant Physiology*.John Wiley and Sons, Inc., New York, Brisbane, Toronto.

Nasaruddin (2011). *Bahan Ajar Mata kuliah Analisis Pertumbuhan Tanaman*. Universitas Hasanuddin, Makassar, Indonesian.

Nurahmi, E., Susanna, & Sriwati, R. (2012). Pengaruh Trichoderma terhadap Perkecambahan dan Pertumbuhan Bibit Kakao, Tomat, dan Kedelai. *J. Floratek, 7*, 57-65. Indonesian.

Okoth, S. A., Otadoh, J. A., & Ochanda, J. O. (2011). Improved Seedling Emergence and Growth of Maize and Beans by Trichoderma harziunum. *Tropical and Subtropical Agroecosystem, 13*, 65-71. Retrieved from http://hdl.handle.net/10568/43096

Ololade, I. A., Ajayi, I. R., Gbadamosi, A. E., Mohammed, O. Z., & Minggu, A. G. (2010). A Study on Effects of Soil Physico-Chemical Properties on Cocoa Production in Ondo State. *Modern Applied Science, 4*(5), 35-43. http://dx.doi.org/10.5539/mas.v4n5p35

Saba, H., Vibhash, D., Manisha, M., Prashant, K. S., Farhan, H., & Tauseef, A. (2012). Trichoderma a Promising Plant Growth Stimulator and Biocontrol Agent. *Mycosphere, 3*(4), 524–531.

Worldatlas. (2015). *Top 10 Cocoa Producing Countries* (Published: April 22, 2015; Updated: July 14, 2016). Retrieved from http://www.worldatlas.com/articles/top-10-cocoa-producing-countries.html

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Energy Levels and Electromagnetic Transition of Some Even-Even Xe Isotopes

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Abstract

In this work, the energy levels electromagnetic transition B(E2) and B(M1), branching ratios, mixing ratios and electric quadrupole moment of even-even $^{120\text{-}126}$Xe isotopes have been investigated using Interacting Boson Model (IBM-1). The results were compared with some previous experimental and theoretical values, it was seen that the obtained theoretical results are in agreement with the experimental data.

Keywords: IBM-1, energy levels, electromagnetic transition, mixing ratio

1. Introduction

The interacting boson approximation represents a significant step towards our understanding of nuclear structure. It offers a simple Hamiltonian, capable of describing collective nuclear properties across a wide range of nuclei, and is founded on rather general algebraic group theoretical techniques which have also recently found application to problems in atomic, molecular, and high-energy physics (Firestone, 1996, Pan & Draayer, 1998). The IBM-1 is a valuable interactive model developed by Iachello and Arima (Iachello & Arima, 1974, Arima & Iachello, 1975). It has been successful in describing the collective nuclear structure by prediction of low lying states and description of electromagnetic transition rates in the medium mass nuclei. IBM-1 defines a six-dimensional space described in terms of the unitary group, U(6). Different reductions of U(6) give three dynamical symmetry limits known as harmonic Oscillator, deformed rotator and asymmetric deformed rotor which are labeled by U(5), SU(3) and O(6), respectively (Kumar *et al*., 2010, Cejnar *et al*., 2010).

Xenon isotopes belong to a very interesting but complex region of the periodic Table known as the transition region. The Xe isotopes can exhibit excitation spectra close to the O(6) symmetry. After some theoretical investigations it was concluded that the xenon isotopes should lie in a transitional region from U(5)- to an O(6)-like structure as the neutron number decreases from the closed shell N=82 (Casten & Von Brentano, 1985). The chain of $^{120\text{-}134}$Xe isotopes are interesting because of the existence of transitional nuclei where the nuclear structure changes from rotational to vibrational shapes. Many authors studied this area of isotopes experimentally and theoretically. IBM-1 model has been used in calculating the energy of the positive parity low-lying levels of Xe series of isotopes (Dilling *et al*., 2002). For the neutron number 66≤ N ≤72, the energy ratio E4$^+$/E2$^+$ is almost 2.5 already pointing to γ-soft shapes. In recent years many works have been done on the structure of Xenon isotopes; Kusakari and M. Sugawara (Kusakari & Sugawara, 1984) calculated the energy levels, the back-bending in the yrast bands , reduced transition probabilities for the positive-parity states of $^{122–130}$Xe within the framework of the interacting boson model. Xing-Wang Pan *et al* (Pan *et al*., 1996) and Al-Jubbori (Al-Jubbori *et al.,* 2016) described the low-lying energy levels for even-even and even-odd nuclei $^{126\text{-}132}$Xe and $^{131\text{-}137}$Ba by a unified analytical expression with two (three) adjustable parameters of the fermion model. Wang Bao-lin (Bao-lin, 1997) calculated the triaxial deformation parameters *β* and *γ* in the O(6)-like nuclei by comparing quadrupole moments between the interacting boson model IBM and the collective model studied. A.D. Efimov *et al* (Efimov *et al*., 2002) studied B(E2; $0_1^+ \rightarrow 2_1^+$) values in the intruder bands of ^{112,114,116,118}Sn within the framework of the interacting boson model (IBM1) and comparison with the ground state bands in the even-mass Xe isotopes to find a similarity not only for the energy spaces, but for the B (E2) values as well. B. Saha *et al* (Saha *et al*., 2004) calculated the B(E2) and B(M1) values for the isotope of ^{124}Xe within the framework of the interacting boson model (IBM1). Nureddin Turkan (Turkan, 2007) described the

quadrupole collective states of the medium-heavy nuclei within the framework of the interacting boson model (IBM) and calculated the energy levels and B(E2) values for the even-even [122-134]Xe isotopes. The results were compared with the previous experimental and theoretical data and it has been observed that they are in good agreement. Ismail Maras *et al* (Maras *et al*., 2010) studied the ground state, quasi beta and quasi gamma band energies for the[114,116,118,120]Xe isotopes using the interacting boson model (IBM) and calculated the energy levels using PHINT and NPBOS program codes. M. A. Jafarizadeh *et al* (Jafarizadeh *et al*., 2013) studied the properties of [114–134]Xe isotopes in the U(5)↔SO(6) transitional region of IBM and calculated the energy levels and B(E2) transition rates. Zhang Da-Li and Ding Bin-Gang (Da-Li & Bin-Gang, 2013) studied the structure evolution of the [124-134]Xe isotopic chain in the framework of the proton-neutron interacting model (IBM2), they have been calculated the B(E2) transition branching ratios, and the M1 excitations. L. Coquard *et al* (Coquard *et al*., 2011) described the low-lying collective states in [126]Xe and calculated the B(E2) values within the framework of the IBM which show a good agreement with the measured values. L Prochniak (Próchniak, 2015) studied the collective properties of the even-even [118–144]Xe isotopes within a model employing the general Bohr Hamiltonian, calculated the low energy spectra and B(E2) transition probabilities and compared the results with the experimental values.

The aim of the present work is study the energy levels, B(E2) and B(M1) values and explore the description of E2/M1 mixing ratios using IBM-1 for [120-128]Xe isotopes. Furthermore, calculate the value of electric quadrupole (Q_J) of these isotopes within the framework of the IBM-1 and comparing the results with the most recent experimental data and previous studies.

2. Method

The IBM-1 of Arima and Iachello (Arima & Iachello, 1976) has become widely accepted as a tractable theoretical scheme of correlating, describing and predicting low-energy collective properties of complex nuclei. In this model, it was assumed that low-lying collective states of even-even nuclei could be described as states of a given number N of bosons. Each boson could occupy two levels one with angular momentum (L = 0) (s-boson) and another, usually with higher energy, with (L = 2) (d-boson) (Sharrad *et al*., 2012). In the original form of the model known as IBM-1, proton- and neutron-boson degrees of freedom are not distinguished. The model has an inherent group structure, associated with it. The IBM-1 Hamiltonian can be expressed as (Casten & Cizewski, 1978, Abrahams *et al*., 1981, Iachello & Arima, 1987).

$$H = \varepsilon_s(s^\dagger.\tilde{s}) + \varepsilon_d(d^\dagger.\tilde{d}) + \sum_{L=0,2,4} \frac{1}{2}(2L+1)^{\frac{1}{2}} C_L \left[[d^\dagger \times d^\dagger]^{(L)} \times [\tilde{d} \times \tilde{d}]^{(L)}\right]^{(0)}$$

$$+ \frac{1}{\sqrt{2}} v_2 \left[[d^\dagger \times d^\dagger]^{(2)} \times [\tilde{d} \times \tilde{s}]^{(2)} + [d^\dagger \times s^\dagger]^{(2)} \times [\tilde{d} \times \tilde{d}]^{(2)}\right]^{(0)}$$

$$+ \frac{1}{2} v_0 \left[[d^\dagger \times d^\dagger]^{(0)} \times [\tilde{s} \times \tilde{s}]^{(0)} + [s^\dagger \times s^\dagger]^{(0)} \times [\tilde{d} \times \tilde{d}]^{(0)}\right]^{(0)}$$

$$+ \frac{1}{2} u_0 \left[[s^\dagger \times s^\dagger]^{(0)} \times [\tilde{s} \times \tilde{s}]^{(0)}\right]^{(0)} + u_2 \left[[d^\dagger \times s^\dagger]^{(2)} \times [\tilde{d} \times \tilde{s}]^{(2)}\right]^{(0)} \tag{1}$$

This Hamiltonian contains two terms of one body interactions, (ε_s and ε_d), and seven terms of two-body interactions [C_L (L =0 ,2,4), v_L (L =0 ,2), u_L (L =0 ,2)], where ε_s and ε_d are the single-boson energies, and C_L, v_L and u_L describe the two boson interactions. However, it turns out that for a fixed boson number N, only one of the one-body terms and five of the two body are terms independent, as it can be seen by noting N = n_s +n_d. Equation (1) can be rewritten in terms of the Casimir operators of U(6) group. In that case, one says that the Hamiltonian (H) has a dynamical symmetry. These symmetries are called U(5) vibrational, SU(3) rotational and O(6) γ-unstable (Casten & Warner, 1988, Kassim & Sharrad, 2014).

3. Results

The obtained results can be discussed separately for energy levels, transition probabilities B(E2) and quadrupole moment Q_J, B(M1) values and mixing ratio.

3.1 Energy levels

The γ-unstable limit of IBM-1 has been applied for [120–126]Xe nuclei due to the values of the experimental energy ratios (E2 :E4 :E6 :E8 =1:2 .5:4 .5:7). Therefore, these nuclei have γ-unstable dynamical symmetry O(6) with respect to IBM-1. The adopted Hamiltonian is expressing as (Casten & Warner, 1988, Iachello, 2001):

$$\hat{H} = a_0\hat{P}.\hat{P} + a_1\hat{L}.\hat{L} + a_3\hat{T}_3.\hat{T}_3 \tag{2}$$

The Xenon isotopes have a number of proton bosons 2, and number of neutron bosons varies from 7 to 10. The parameters value used in the present work are presented in Table 1.

Table 1. Adopted values for the parameters used for IBM-1 calculations. All parameters are given in MeV, except N.

Isotopes	N	a_0	a_1	a_3
^{120}Xe	10	0.082609	0.012133	0.178435
^{122}Xe	9	0.114918	0.015834	0.168768
^{124}Xe	8	0.14099	0.019322	0.170068
^{126}Xe	7	0.164235	0.022538	0.181002

The calculations of the g-bands, β-bands and γ-bands are compared with the experimental data (http://www.nndc.bnl.gov/chart/getENSDFDatasets.jsp, Kitao *et al.*, 2002, Tamura, 2007, Katakura & Wu, 2008, Katakura & Kitao, 2002) for all isotopes under study, and as it given in Table 2. In this Table, one can see a agreement between experimental data and the IBM-1 calculations. Levels with '*' correspond to cases for which the spin and/or parity of the corresponding states are not well established experimentally.

Table 2. The calculated excitation of the g-,β-,and γ-bands and comparison with the experimental data (http://www.nndc.bnl.gov/chart/getENSDFDatasets.jsp, Kitao *et al.*,2002, Tamura, 2007, Katakura & Wu, 2008, Katakura & Kitao, 2002).

^{120}Xe			^{122}Xe	
J^π	IBM	EXP	IBM	EXP
2_g^+	0.3226	0.3226	0.3317	0.33128
4_g^+	0.7780	0.79616	0.8240	0.82853
6_g^+	1.3664	1.39733	1.4769	1.46705
8_g^+	2.0876	2.09920	2.2904	2.21769
10_g^+	2.9417	2.87270	3.2645	3.03988
12_g^+	3.9286	3.67651	4.3992	4.1514*
14_g^+	5.0484	4.45892	5.6945	5.2361*
2_γ^+	0.8576	0.87610	0.8387	0.84313*
3_γ^+	1.5369	1.27170	1.5084	1.21434*
4_γ^+	1.4914	1.40134	1.5000	1.40271*
5_γ^+	2.3263	1.81698*	2.3345	1.77450*
6_γ^+	2.2581	1.98563	2.3219	2.05666*
7_γ^+	3.2486	2.46088	3.3212	2.8472*
8_γ^+	2.9962	2.65383*	3.3044	2.8472*
9_γ^+	4.3038	3.17411	4.4685	3.2161*
10_γ^+	3.8503	3.32643*	4.4145	3.6085*
0_β^+	0.9086	0.90870	1.1500	1.14918
2_β^+	1.2312	1.27443*	1.4817	1.49501
4_β^+	1.6867	1.71175*	1.9740	----
6_β^+	2.2750	2.72734*	2.6269	----
8_β^+	3.1577	----	3.4404	----

Continued

^{124}Xe			^{126}Xe	
J^π	IBM	EXP	IBM	EXP
2_g^+	0.3538	0.35403	0.3887	0.38863
4_g^+	0.8960	0.87892	0.9940	0.94200
6_g^+	1.6266	1.54846	1.8159	1.63498
8_g^+	2.5456	2.33104	2.8544	2.43571
10_g^+	3.6530	3.17144	4.1095	3.31414

12_a^+	4.9488	4.29914*	5.5812	3.88457
14_a^+	6.4330	5.5188*	7.2659	4.61945
2_γ^+	0.8638	0.84650	0.9317	0.87987
3_γ^+	1.5576	1.24763	1.6824	1.31768
4_γ^+	1.5760	1.43796	1.7180	1.48838
5_γ^+	2.4490	1.83692	2.6675	1.90349
6_γ^+	2.4766	2.14374	2.7209	2.21431
7_γ^+	3.5288	2.57461	3.8692	2.66142
8_γ^+	3.5656	2.91213	3.9404	3.11719*
9_γ^+	4.7970	3.34391*	5.2875	3.38378*
10_γ^+	4.8430	4.0190*	5.3765	3.35971
0_β^+	1.2690	1.26891	1.3136	1.31388
2_β^+	1.6228	1.62857	1.7023	1.678569
4_β^+	2.1650	2.01473*	2.3076	1.90313
6_β^+	2.8956	2.64765*	3.1295	2.9739*
8_β^+	3.8146	3.0132*	4.1680	----

3.2 Reduced transition probabilities B(E2) and quadrupole moment (Q_J)

The general form of the electromagnetic transitions operator in IBM-1 is (Iachello & Arima, 1987, Casten & Warner, 1988, Yazar & Erdem, 2008):

$$\hat{T}(\mathrm{L}) = \gamma_0[\hat{s}^\dagger \times \hat{s}^\sim]^{(0)} + \alpha_2[\hat{d}^\dagger \times \hat{s}^\sim + \hat{s}^\dagger \times \hat{d}^\sim]^{(2)} + \beta_\mathrm{L}[d^\dagger \times \tilde{d}]^{(\mathrm{L})}, \tag{3}$$

where γ_0, α_2 and β_L (L =0 ,1,2,3,4) are parameters specifying the various terms in the corresponding operators. Equation (3) yields transition operators for E2, and M1 transitions with appropriate values of the corresponding parameters. The E2 transition operator must be a Hermiston tensor of rank two and therefore the number of bosons must be conserved. Since, with these constraints, there are two operators possible in the lowest order, the general E2 operator can be written as (Abrahams et al., 1981, Casten & Warner, 1988):

$$\hat{T}(\mathrm{E2}) = \alpha_2[d^\dagger \tilde{s} + s^\dagger \tilde{d}]^{(2)} + \beta_2[d^\dagger \tilde{d}]^{(2)} = \alpha_2([d^\dagger \tilde{s} + s^\dagger \tilde{d}]^{(2)} + \chi[d^\dagger \tilde{d}]^{(2)}) = e_\mathrm{B}\hat{Q} \tag{4}$$

where ($s^\dagger, d^\dagger$) and ($\tilde{s}$, $\tilde{d}$) are creation and annihilation operators for s and d bosons, respectively (Casten & Warner, 1988), while α_2 and β_2 are two parameters, and ($\beta_2 = \chi\alpha_2$, $\alpha_2 = e_\mathrm{B}$ (e ective charge) and the quadrupole operator $\hat{Q} = ([d^\dagger \tilde{s} + s^\dagger \tilde{d}]^{(2)} + \chi[d^\dagger \tilde{d}]^{(2)})$. The electric transition probabilities B(E2) values are defined in terms of reduced matrix elements as (Casten & Warner, 1988, Yazar & Erdem, 2008):

$$B\big((E2), J_i \to J_f\big) = \frac{1}{2J_{i \to} + 1} \left| \langle J_f \| \hat{T}(E2) \| J_i \rangle \right|^2 \tag{5}$$

The parameter (e_B) used in present calculated the reduced probability for E2 transitions of the IBM-1 model are tabulated in Table 3. The values of e ective charge (e_B) were estimated to reproduce the experimental $B(E2; 2_1^+ \to 0_1^+)$.

Table 3. Effective charge (e_B) used in E2 transition calculations for $^{120\text{-}126}$Xe nuclei.

A	N	e_B (eb)
^{120}Xe	10	0.111162
^{122}Xe	9	0.109388
^{124}Xe	8	0.103000
^{126}Xe	7	0.100900

The calculated B(E2) values compared with the experimental data (Efimov *et al*., 2002, http://www.nndc.bnl.gov/chart/getENSDFDatasets.jsp, Kitao *et al*.,2002, Tamura, 2007, Katakura & Wu, 2008, Katakura & Kitao, 2002, Coquard, 2010) for all isotopes under study, and as given in Table 4. In this Table, the subscript 1, 2 and 3 numbers represented ground-, γ- and β- states, respectively. Table 4 shows that in general, most of the calculated results in IBM-1(p.w.) reasonably consistent with the available experimental data, except for few cases that deviate from the experimental data. Furthermore, our results have been compared with previous studies (Efimov *et al*., 2002, Coquard, 2010) and it better than those.

A measure of the deviation of a charge distribution from a spherical shape is the electric quadrupole moment of the distribution. Then the quadrupole moment (Q_J) is an important property for nuclei and can be determined if the nucleus spherical $(Q = 0)$, deformed oblate $(Q<0)$ or prolate $(Q>0)$ shapes. The electric quadrupole moments of the nuclei can be derived from the transition rate $B(E2, J_i \rightarrow J_f)$ values according to Eq. (5) (Iachello & Arima, 1987, Kassim & Sharrad, 2014):

$$QJ = (16\pi/5)^{1/2}[(2J-1)/(J+1)(2J+1)(2J+3)]^{1/2}[B(E2, J_i \rightarrow J_f)]^{1/2}, \qquad (6)$$

where: J is the total angular momentum. The calculations of the electric quadrupole moment Q_J within the framework of IBM-1 is shown in Table (5) for $^{120-126}$Xe nuclei. This Table shows that the $Q2_2^+$ has a negative value for all interested nuclei. The calculated $Q4_1^+$ has been positive value.

Table 4. The B(E2) values for $^{120-126}$Xe nuclei (in $e^2.b^2$).

$J_i \rightarrow J_f$	^{120}Xe			^{122}Xe		
	P.W.	EXP.(a, b)	Th.(c)	P.W.	EXP.(a, d)	Th.(c)
$2_1^+ \rightarrow 0_1^+$	0.3460	0.346(22)	0.2779	0.2800	0.280(12)	0.230
$2_2^+ \rightarrow 0_1^+$	0.0483	---	---	0.0392	---	---
$2_2^+ \rightarrow 2_1^+$	0.4766	---	---	0.3829	---	---
$4_1^+ \rightarrow 2_1^+$	0.4766	0.412(28)	0.4256	0.3829	0.409 (22)	0.3272
$4_2^+ \rightarrow 2_1^+$	0.0385	---	---	0.0307	---	---
$6_1^+ \rightarrow 4_1^+$	0.5272	0.415(63)	0.4819	0.4188	0.396(144)	0.3524
$6_2^+ \rightarrow 4_1^+$	0.0295	---	---	0.0228	---	---
$6_1^+ \rightarrow 4_2^+$	0.0245	---	---	0.0211	---	---
$8_1^+ \rightarrow 6_1^+$	0.5347	0.341 (59)	0.4925	0.4177	0.288(179)	0.3488
$8_1^+ \rightarrow 6_2^+$	0.0289	---	---	0.0255	---	---
$10_1^+ \rightarrow 8_1^+$	0.5133	0.324(53)	0.4714	0.3912	0.432(179)	0.320
$10_2^+ \rightarrow 10_1^+$	0.0046	---	---	0.0032	---	---
$12_1^+ \rightarrow 10_1^+$	0.4695	0.292(46)	0.4221	0.3446	---	0.2697
$12_2^+ \rightarrow 10_2^+$	0.3042	0.246 (246)	---	0.1532	---	---
$14_1^+ \rightarrow 12_1^+$	0.4070	0.282(42)	---	0.2809	---	---
$16_1^+ \rightarrow 14_1^+$	0.3278	0.42 (14)	---	0.2015	---	---
$18_1^+ \rightarrow 16_1^+$	0.2330	0.598(105)	---	0.1077	---	---
$6_2^+ \rightarrow 6_1^+$	0.1701	---	---	0.1329	---	---
$3_1^+ \rightarrow 4_1^+$	0.1507	---	---	0.1197	---	---
$3_1^+ \rightarrow 2_1^+$	0.0525	---	---	0.0419	---	---
$3_1^+ \rightarrow 2_2^+$	0.3766	---	---	0.2992	---	---

Continued

$J_i \rightarrow J_f$	^{124}Xe			^{126}Xe		
	P.W.	EXP. (a, e)	Th.(f)	P.W.	EXP.(a, g, f)	Th.(f)
$2_1^+ \rightarrow 0_1^+$	0.1920	0.192(12)	0.192	0.1540	0.154(5)	0.154
$2_2^+ \rightarrow 0_1^+$	0.0027	0.0026(5)	0.0054	0.00217	0.002 (7)	0.0024
$4_1^+ \rightarrow 2_1^+$	0.2600	0.2484(7)	0.3126	0.2057	0.267(3)	0.1569
$4_2^+ \rightarrow 2_1^+$	0.0206	0.00025	0.0012	0.0160	0.0015(3)	0.0005
$4_2^+ \rightarrow 2_2^+$	0.1467	0.254(92)	0.1782	0.1135	0.1355(16)	0.1246
$6_1^+ \rightarrow 4_1^+$	0.2800	0.323 (29)	0.3563	0.2167	0.315 (41)	0.2433
$6_2^+ \rightarrow 4_1^+$	0.0147	---	---	0.0108	---	---
$4_2^+ \rightarrow 6_1^+$	0.0228	---	---	0.0204	---	---
$8_1^+ \rightarrow 6_1^+$	0.2727	0.243(77)		0.2036	---	
$8_1^+ \rightarrow 6_2^+$	0.0195	---	---	0.0179	---	---
$10_1^+ \rightarrow 8_1^+$	0.2462	0.0772(1)	---	0.1731	---	---
$12_1^+ \rightarrow 10_1^+$	0.2040	0.202(44)	---	0.1280	---	---
$2_2^+ \rightarrow 2_1^+$	0.2600	0.118(22)	0.2250	0.2057	0.162 (1)	0.1836
$2_3^+ \rightarrow 2_1^+$	0.0031	0.0022(2)	0.0001	0.0026	0.0004	0.00001
$4_2^+ \rightarrow 4_1^+$	0.1333	0.125(47)	0.1232	0.1032	0.1062(14)	0.0968
$6_2^+ \rightarrow 6_1^+$	0.0868	---	---	0.0648	---	---
$10_2^+ \rightarrow 10_1^+$	0.0394	---	---	0.0247	---	---

$3_1^+ \to 4_1^+$	0.0799	0.096(44)	0.0761	0.0618	0.0829	0.0596
$3_1^+ \to 2_1^+$	0.0281	0.0029(6)	0.0081	0.0218	0.0034(2)	0.0034
$3_1^+ \to 2_2^+$	0.2000	0.3454	0.2414	0.1548	0.2091(24)	0.1689

a- http://www.nndc.bnl.gov/chart/getENSDFDatasets.jsp.

b- (Kitao *et al.*,2002)

c-(Efimov *et al.*, 2002)

d-(Tamura, 2007)

e-(Katakura & Wu, 2008)

f-(Coquard, 2010)

g-(Katakura & Kitao, 2002)

Table 5. The electric quadrupole moment Q_J in eb unit.

Q_J	^{120}Xe	^{122}Xe	^{124}Xe	^{26}Xe
2_1^+	0.4823	0.4415	0.3737	0.3443
2_2^+	-0.1672	-0.1542	-0.1317	-0.1228
4_1^+	0.7804	0.7194	0.6145	0.5730
6_1^+	1.0072	0.9364	0.8085	0.7643
8_1^+	1.2060	1.1319	0.9888	0.9485
10_1^+	1.3971	1.3244	1.1708	1.1397
12_1^+	1.5913	1.5234	1.3628	1.3452

3.3 Reduced transition probabilities B(M1) and E2/M1 mixing ratios

Similarly, from Eq. (3), the M1 operator would be just $\beta 1[d^\dagger \times \tilde{d}](1)$. For calculating M1 transitions, the IBM-1 rule must be extended to second-order in the U(6) generators (Abrahams et al.,1981, Casten & Warner, 1988). The most general second-order M1 generator can then be written as (Casten & Warner, 1988, Arima & Iachello, 1979):

$$\hat{T}(M1) = (g_B + A_1 \hat{N}) \hat{L} + B[\hat{T}(E2) \times \hat{L}] + C \hat{n}_d \hat{L} \tag{7}$$

where g_B is the effective boson g factor and can be written as (Arima & Iachello, 1979):

$$g_B = Z/A, \tag{8}$$

where Z and A are the atomic and mass numbers, respectively. Indeed from Eq. (7), N is the number of bosons, $\hat{L}$ is angular momentum, $\hat{T}(E2)$ is general matrix element of the E2 transition and $\hat{n}_d$ is d-boson number operators. The first term of Eq. (7) is diagonal and does not contribute to transitions. The last terms yield the M1 matrix element can be written as (Casten & Warner, 1988, Warner, 1981):

$$\langle \dot{\varphi} L_f \| T(M1) \| \varphi L_i \rangle = -B\mathfrak{f}(L_i L_f) \langle \dot{\varphi} L_f \| T(E2) \| \varphi L_i \rangle + C[L_i(L_i + 1)(2L_i + 1)]^{1/2} \times \langle \dot{\varphi} L_f | \hat{n}_d | \varphi L_i \rangle \delta_{L_i L_f} \tag{9}$$

where $\dot{\varphi}$ and φ denote additional quantum numbers. In the first term the spin factors given separately in Refs. (Abrahams *et al.*,1981, Casten & Warner, 1988) for the cases $L \to L\pm 1$ and $L \to L$, and it has been combined into the single factor $\mathfrak{f}(L_i L_f)$, given by:

$$\mathfrak{f}(L_i L_f) = \begin{bmatrix} \frac{1}{40}(L_i + L_f + 3)(L_f - L_i + 2) \\ \times (L_i - L_f + 2)(L_i + L_f - 1) \end{bmatrix}^{1/2} \tag{10}$$

The second term of Eq. (9) only contributes to transitions between states of the same spin, since the corresponding operator in Eq. (7) is diagonal in $\hat{L}$. In the O(6) symmetry of the IBM-1, the operator $\hat{n}_d \hat{L}$ contributes to both diagonal and off diagonal matrix elements. The matrix elements between the representations $\sigma = N$ and $\sigma = N - 2$ can be written as (Iachello & Arima, 1987,Casten & Warner, 1988):

$$\langle [N], \sigma = N, \tau, \nu_\Delta, L | \hat{n}_d | [N], \sigma = N - 2, \tau, \nu_\Delta, L \rangle = -\sqrt{N} \sqrt{\left[\frac{N(N+3)-\tau(\tau+3)}{2N(N+1)}\right]} \sqrt{\left[\frac{(N-1)(N-2)-\tau(\tau+3)}{2N(N+1)}\right]} \tag{11}$$

For $L\pm 1 \to L$ transitions, Eq. (9) leads to a particularly simple expression for the reduced $E2/M1$ mixing ratio,

namely

$$\Delta(E2/M1) = \langle \dot{\varphi} L_f \| T(E2) \| \varphi L_i \rangle / \langle \dot{\varphi} L_f \| T(M1) \| \varphi L_i \rangle = -1/Bf(L_i L_f) \tag{12}$$

The reduced mixing ratio is related to the quantity normally measured, $\delta(E2/M1)$ by (Casten & Warner, 1988):

$$\delta(E2/M1) = 0.835[E_\gamma/(1 Mev)]\, \Delta(E2/M1) \tag{13}$$

where E_γ is in MeV and $\Delta(E2/M1)$ is in eb/μN. The spin dependence of Eq. (10) has already been derived in the framework of the geometrical model by Grechukhin (Grechukhin, 1963) in an analogous way by expressing the relevant part of the M1 operator in terms of the quadrupole coordinates of the nuclear surface. In the IBM-1 model, the value of the constant B in Eq. (9) and the validity of the spin dependence can be investigated by looking at empirical values of $[\Delta(E2/M1)\, Bf(L_i L_f)^{-1}]$. To $L \rightarrow L$ transitions, the inclusion of both s and d bosons in the IBM-1 formalism gives rise to the additional contribution in Eq. (12) from the $\hat{n}_d$ operator, and the $L \rightarrow$ L, M1 matrix element thus, in principal, depends on the relative sizes and Signs of the two terms.

Table (6) shows that the parameters g_B, A_1, B and C were used in the present work for the T(M1) transitions. The calculated reduced probability for M1 transitions and the experimental data (http://www.nndc.bnl.gov/ chart/getENSDFDatasets.jsp, Kitao *et al*., 2002, Katakura & Wu, 2008, Coquard, 2010) are given in Table (7) for all isotopes under study.

Table 6. The parameters of T(M1) used in the present work. All parameters are given in (μ_N), except N.

A	N	g_B	A_1	B	C
^{120}Xe	10	0.45	- 0.0447	- 0.0571	0.0000
^{122}Xe	9	0.4426	- 0.0492	- 0.2379	0.0000
^{124}Xe	8	0.4355	- 0.0257	- 0.0353	- 0.0000065
^{126}Xe	7	0.4286	- 0.00835	- 0.0295	0.0000

Table 7. The B(M1) values for Xenon nuclei (in μ_N^2).

$J_i \rightarrow J_f$	^{120}Xe		^{122}Xe	
	IBM-1	EXP.(a, b)	IBM-1	EXP.
$2_2^+ \rightarrow 2_1^+$	0.0011	--	0.0292	--
$4_1^+ \rightarrow 4_1^+$	0.0003	--	0.0253	--
$4_2^+ \rightarrow 4_1^+$	0.0021	--	0.0557	--
$3_1^+ \rightarrow 4_1^+$	0.0008	--	0.0195	--
$2_4^+ \rightarrow 3_1^+$	0.0000	0.000007	0.0000	--
$6_1^+ \rightarrow 6_1^+$	0.0012	--	0.0758	--
$8_1^+ \rightarrow 8_1^+$	0.0030	--	0.1735	--
$10_1^+ \rightarrow 10_1^+$	0.0063	--	0.3435	--
$12_1^+ \rightarrow 12_1^+$	0.0120	--	0.6218	--
$3_1^+ \rightarrow 2_1^+$	0.0001	--	0.0036	--
$3_1^+ \rightarrow 2_2^+$	0.0010	--	0.0261	--
$J_i \rightarrow J_f$	^{124}Xe		^{26}Xe	
	IBM-1	EXP.(a, e, f)	IBM-1	EXP. (a, f)
$2_1^+ \rightarrow 2_1^+$	0.3014	---	0.8125	--
$2_2^+ \rightarrow 2_1^+$	0.0003	0.0003	0.0001	--
$2_3^+ \rightarrow 2_1^+$	0.0000	0.0025(3)	0.0000	0.000435 (90)
$2_3^+ \rightarrow 2_2^+$	0.0000	0.0055(11)	0.0000	--
$2_4^+ \rightarrow 2_1^+$	0.0000	0.0014(5)	0.0000	$\geq 0.025\ (^{+7}_{-4})$
$4_1^+ \rightarrow 4_1^+$	0.9970	--	2.6985	--
$4_2^+ \rightarrow 4_1^+$	0.0005	0.0052(36)	0.0003	--
$3_1^+ \rightarrow 4_1^+$	0.00013	--	0.00013	--
$6_1^+ \rightarrow 6_1^+$	2.0801	--	5.6480	--
$8_1^+ \rightarrow 8_1^+$	3.5428	--	9.6493	--
$10_1^+ \rightarrow 10_1^+$	5.3756	--	14.6878	--
$12_1^+ \rightarrow 12_1^+$	7.5669	--	20.7457	--
$3_1^+ \rightarrow 2_1^+$	0.0000	0.0030 (5)	0.0000	--

$5_1^+ \rightarrow 4_1^+$	0.0001	0.0011(7)	0.0000	--
$5_1^+ \rightarrow 4_2^+$	0.0002	0.00054(54)	0.0001	--

a- http://www.nndc.bnl.gov/chart/getENSDFDatasets.jsp.

b- (Kitao *et al*.,2002)

e-(Katakura & Wu, 2008)

f-(Coquard, 2010)

The IBM-1 has been rather successful at describing the collective properties of several medium and heavy nuclei. The δ (E2/M1) multipole mixing ratios of the electromagnetic transitions between the energy states of $^{120-126}$Xe nuclei were calculated using Eq. (13). The calculated values are given in Table 8. The IBM-1 model, particularly in its extended consistent-δ formalism, has been applied to the calculation of E2/M1 mixing ratios over a wide range of nuclei. In general, it can be seen from the Table that calculated results are not in good agreement with the available experimental data (http://www.nndc.bnl.gov/chart/getENSDFDatasets.jsp, Kitao *et al*.,2002, Katakura & Wu, 2008, Coquard, 2010) in Xe isotopes under study. The mixing ratio found for ^{122}Xe the 0.8829, 0.574 and 0.946 MeV transition are 3.353, 1.068 and 2.462 that value is in agreement with the experimental value of -3 (+1 or -3) , >1.9 and +0.9 (+20 or -4). For ^{124}Xe nucleus, the 0.4925 and 0.5591 MeV transitions are 15.355 and 10.365 that values are in agreement with the experimental values of +8 (+7 or -3) and +2.3 (+8 or -4). For ^{126}Xe nucleus, the 0.5464 MeV transition is 13.74 that value is in agreement with the experimental value of $+3.0 \left(+10 \text{ or } -9\right)$.

Table 8. The IBM-1 values and the experimental data of E2/M1 mixing ratios for $^{120-126}$Xe isotopes.

$J_i \rightarrow J_f$	E_γ(MeV).	δ(E2/M1)		E_γ(MeV)	δ(E2/M1)	
		IBM-1	EXP.(a, b)		IBM-1	EXP.(a, d)
		^{120}Xe			^{122}Xe	
$2_2^+ \rightarrow 2_1^+$	0.55345	9.298	---	0.512	3.2	---
$2_3^+ \rightarrow 2_1^+$	0.95193	Unknown	---	1.1636	6.15	---
$2_4^+ \rightarrow 3_1^+$	0.4535	0.0000	4.2 (**38**)	0.8511	Unknown	---
$3_1^+ \rightarrow 2_1^+$	0.949	23.24	---	0.8829	7.11	$-3 \left(^{+1}_{-3}\right)$
$3_1^+ \rightarrow 2_2^+$	0.395	11.08	---	0.3714	3.948	---
$3_1^+ \rightarrow 4_1^+$	0.4755	8.866	---	0.3857	2.947	---
$4_2^+ \rightarrow 4_1^+$	0.60527	6.514	---	0.574	2.228	>1 . 9
$5_1^+ \rightarrow 4_1^+$	1.02093	15.162	---	0.946	5.176	$+0 . 9 \left(^{+20}_{-4}\right)$
$J_i \rightarrow J_f$		^{124}Xe			^{126}Xe	
		(a, e, f)			(a, g, f)	
$2_2^+ \rightarrow 2_1^+$	0.49254	15.355	$+8 \left(^{+7}_{-3}\right)$	0.491243	10.28	$+9.1 \left(^{+43}_{-23}\right)$
$2_3^+ \rightarrow 2_1^+$	1.27438	Unknown	---	1.28987	Unknown	---
$3_1^+ \rightarrow 2_1^+$	0.89369	Unknown	+0.73 (**6**)	0.92908	Unknown	$+1.6 \left(^{+3}_{-7}\right)$
$3_1^+ \rightarrow 2_2^+$	0.40132	18.327	+0.32 (**5**)	0. 43785	14.24	$+8 \left(^{+3}_{-2}\right)$
$3_1^+ \rightarrow 4_1^+$	0.36809	13.809	$+3.85 \left(^{+0.57}_{-0.45}\right)$	0.37566	8.914	$+5.4 \left(^{+3}_{-2}\right)$
$4_2^+ \rightarrow 4_1^+$	0.5591	10.365	$+2.3 \left(^{+8}_{-4}\right)$	0.5464	13.74	$+3.0 \left(^{+10}_{-9}\right)$
$5_1^+ \rightarrow 4_1^+$	0.95825	18.615	$+1.0 \left(^{+5}_{-3}\right)$	0.9616	17.17	+0.8 (**3**)
$5_1^+ \rightarrow 4_2^+$	0.399	13.152	$+5.2 \left(^{+26}_{-13}\right)$	0.4151	10.09	$+9 \left(^{+50}_{-4}\right)$

a- http://www.nndc.bnl.gov/chart/getENSDFDatasets.jsp.

b- (Kitao *et al*.,2002)

c-(Efimov *et al*., 2002)

d-(Tamura, 2007)

e-(Katakura & Wu, 2008)

f-(Coquard, 2010)

g-(Katakura & Kitao, 2002)

3.4 Participant Flow

For experimental and quasi-experimental designs, there must be a description of the flow of participants (human, animal, or units such as classrooms or hospital wards) through the study. Present the total number of units recruited into the study and the number of participants assigned to each group. Provide the number of participants who did not complete the experiment or crossed over to other conditions and explain why. Note the number of participants used in the primary analyses. (This number might differ from the number who completed the study because participants might not show up for or complete the final measurement.)

4. Conclusion

The energy levels and electromagnetic transitions of moderately deformed even–even Xe nuclei have been studied in the present work. It can be described in terms of the O(6) limit in the framework of the IBM. The B(E2) , B(M1) transition probabilities, the E2/M1 mixing ratios, branching ratios, and electric quadrupole moment Q_J for the even– even $^{120-126}$Xe isotopes with neutron numbers between 66 and 72 are calculated using the IBM. The calculated B(E2) and B(M1) values all in good agreements with experimental data.

Acknowledgments

References

Abrahams, K., Allaartand, K., & Dieperink, A. E. L. (1981). Nuclear Structure (Plenum Press, New York London).

Al-Jubbori, M. A., Kassim, H. H., Sharrad. F. I., & Hossain, I. (2016). Nuclear structure of even 120–136Ba under the framework of IBM, IVBM and new method (SEF). *Nucl. Phys. A, 955*, 101-115. http://dx.doi.org/10.1016/j.nuclphysa.2016.06.005

Arima, A., & Iachello, F. (1975). Collective nuclear states as representations of a SU(6) group. *Phys. Rev .Lett., 35*(16), 1069-1072. http://dx.doi.org/10.1103/ PhysRevLett.35.1069

Arima, A., & Iachello, F. (1976). Interacting boson model of collective states I. The vibrational limit. *Ann. Phys., 99*(2), 253-317. http://dx.doi.org/10.1016/0003-4916(76)90097-X

Arima, A., & Iachello, F. (1979). Interacting boson model of collective nuclear states IV. The O (6) limit. *Ann. Phys., 123*(2), 468-492. http://dx.doi.org/10.1016/0003-4916(79)90347-6

Bao-lin, W. (1997). Systematics of β and γ Parameters of O (6)-Like Nuclei in the Interacting Boson Model. C*hin. Phys. Let., 14*(7), 503. http://dx.doi.org/10.1088/0256-307X/14/7/007

Casten, R. F., & Cizewski, J. A. (1978). The O (6)→ rotor transition in the Pt- Os nuclei. *Nucl. Phys A., 309*(3), 477-505. http://dx.doi.org/10.1016/0375-9474(78)90491-8

Casten, R. F., & Von Brentano, P. (1985). An extensive region of O (6)-like nuclei near A=130. *Phys. Lett B., 152*(1-2), 22-28. http://dx.doi.org/10.1016/0370-2693(85)91131-1

Casten, R. F., & Warner, D. D. (1988). The interacting boson approximation. *Rev. Mod. Phys., 60*(2), 389. http://dx.doi.org/10.1103/ RevModPhys.60.389

Cejnar, P., Jolie, J., & Casten, R. F. (2010). Quantum phase transitions in the shapes of atomic nuclei. *Rev. Mod. Phys., 82*(3), 2155. http://dx.doi.org/10.1103/RevModPhys.82.2155

Coquard, L. (2010). Evolution of the One-Quadrupole Phonon 2+$_{1,ms}$ Mixed-Symmetry State in ^{124,126,128,130,132}Xe. Ph.D. thesis, Technical University Darmstadt. Retrieved from http://tuprints.ulb.tu-darmstadt.de/2211/1/TUD_ Doktorarbeit_coquard-1.pdf

Coquard, L., Rainovski, G., Pietralla, N., Ahn, T., Bettermann, L., Carpenter, M. P., ... Zhu, S. (2011). O (6)-symmetry breaking in the γ-soft nucleus Xe 126 and its evolution in the light stable xenon isotopes. *Phys. Rev C., 83*(4), 044318. http://dx.doi.org/10.1103/ PhysRevC.83.044318

Da-Li, Z., & Bin-Gang, D. (2013). Structure Evolution in the Even-Even $^{124-134}$Xe with IBM2. *Commun. Theor. Phys., 60*(5), 581. http://dx.doi.org/10.1088/0253-6102/60/5/12

Dilling, J., Audi, G., Beck, D., Bollen, G., Henry, S., Herfurth, F., Kellerbauer, A., … Szerypo, J. (2002). Direct mass measurements of neutron-deficient xenon isotopes with the ISOLTRAP mass spectrometer. *Nucl. Phys A.*, *701*(1), 520-523. http://dx.doi.org/10.1016/S0375-9474(01)01638-4

Efimov, A. D., Lobach, Y. N., Pasternak, A. A., & Tryshyn, V. V. (2002). Transition probabilities in intruder bands of even-mass Sn isotopes. Ukr. J. Phys., *47*(2) 0503-1265. http://ujp.bitp.kiev.ua/files/journals/47/2/470202p.pdf

Firestone, R. B. (1996). CD: Table of Isotopes.

Grechukhin, D. P. (1963). Magnetic dipole transitions in even nuclei and purity of separation of collective quadrupole degrees of freedom. *Nucl. Phys.*, *40*, 422-437. http://dx.doi.org/10.1016/0029-5582(63)90285-2

Iachello, F. (2001). Analytic description of critical point nuclei in a spherical-axially deformed shape phase transition. *Phys. Rev. Lett.*, *87*(5), 052502. http://dx.doi.org/10.1103/PhysRevLett.87.052502

Iachello, F., & Arima, A. (1974). Boson symmetries in vibrational nuclei. *Phys. Lett B.*, *53*(4), 309-312. http://dx.doi.org/10.1016/0370-2693(74) 90389-X

Iachello, F., & Arima, A. (1987). *The interacting boson model*. Cambridge University Press.

Jafarizadeh, M. A., Fouladi, N., & Sabri, H. (2013). Description of Even–Even [114–134]Xe Isotopes in the Transitional Region of IBM. *Braz. J. Phys.*, *43*(1-2), 34-40. http://dx.doi.org/ 10.1007/s13538-013-0116-3

Kassim, H. H., & Sharrad, F. I. (2014). Energy levels and electromagnetic transition of [190–196]Pt nuclei. *Int. J. Mod. Phys E.*, *23*(11), 1450070. http://dx.doi.org/10.1142/S0218301314500700

Katakura, J., & Kitao, K. (2002). Nuclear data sheets for A= 126. *Nucl. Data Sheets*, *97*(3), 765-926. http://dx.doi.org/10.1006/ndsh.2002.0020

Katakura, J., & Wu, Z. D. (2008). Nuclear data sheets for A= 124. *Nucl. Data Sheets*, *109*(7), 1655-1877. http://dx.doi.org/10.1016/j.nds

Kitao, K., Tendow, Y., & Hashizume, A. (2002). Nuclear Data Sheets for A= 120. *Nucl. Data Sheets.*, *96*(2), 241-390. http://dx.doi.org/10.1006/ ndsh.2002.0012

Kumar, R., Sharma, S., & Gupta, J. B. (2010). Character of quasi-bands in [150]sm using IBM. *Arm. J. Phys.*, *3*(3), 150-154. http://ajp.asj-oa.am/279/1/01%2DSharma.pdf

Kusakari, H., & Sugawara, M. (1984). Study of [122–130]Xe with the extended interacting-boson approximation. *Z.Phys.*, *317*(3), 287-290. http://dx. doi.org/10.1007/BF01438360

Maras, I., Gümüs, R., & Türkan, N. (2010). The Investigation of Even-Even [114-120]xe Isotopes by the Framework of IBA. *Math. Comput. Appl.*, *15*(1), 79-88. http://dx.doi.org/10.3390/mca15010079

Pan, F., & Draayer, J. P. (1998). New algebraic solutions for SO(6) ↔ U (5) transitional nuclei in the interacting boson model. *Nucl. Phys A.*, *636*(2), 156-168. http://dx.doi.org/10.1016/S0375-9474(98)00207-3

Pan, X. W., Ping, J. L., Chen, J. Q., Wu, C. L., & Guidry, M. W. (1996). Fermion dynamical symmetry model for the even-even and even-odd nuclei in the Xe-Ba region. *Phys. Rev C.*, *53*(2), 715. http://dx.doi.org/10.1103/PhysRevC.53.715

Próchniak, L. (2015). Microscopic description of collective properties of even-even Xe isotopes. *Phys. Scr.*, *90*(11), 114005. http://dx.doi.org/10.1088/0031-8949/90/11/114005

Saha, B., Dewald, A., Möller, O., Peusquens, R., Jessen, K., Fitzler, A., Klug, T., Tonev, D., von Brentano, P. , Jolie, J., Gall, B. J. P., & Petkov, P. (2004). Probing nuclear structure of [124]Xe. *Phys. Rev C*, *70*(3), 034313. http://dx.doi.org/10.1103/PhysRevC.70.034313

Sharrad, F. I., Abdullah, H. Y., Al-Dahan, N., Mohammed-Ali, A. A., Okhunov, A. A., & Abu Kassim, H. (2012). Shape transition and collective excitations in neutron–rich 170-178Yb Nuclei. *Rom. J. Phys.*, *57*(9-10), 1346-1355. http://irep.iium.edu.my/32152/1/Rom_Journ_Phys_Vol57_ 2012.pdf

Tamura, T. (2007). Nuclear data sheets for A= 122. *Nucl. Data Sheets.*, *108*(3), 455-632. http://dx.doi.org/10.1016/j.nds.2007.02.001

Turkan, N. (2007). Search for E (5) behavior: IBM and Bohr–Mottelson model with Davidson potential calculations of some even–even Xe isotopes. *J. Phys. G: Nucl. Part. Phys., 34*(11), 2235. http://dx.doi.org/10.1088/0954-3899/34/11/001

Warner, D. D. (1981). Description of M 1 Transitions in Deformed Even-Even Nuclei with the Interacting Boson

Approximation. *Phys. Rev. Lett.*, *47*(25), 1819. http://dx.doi.org/10.1103/PhysRevLett. 47.1819

Yazar, H. R., & Erdem, Ü. (2008). Nature of Excited States of Gadolinium Isotopes. *Chin. J. Phys.*, *46*(3), 270-277. Retrieved from http://www.airitilibrary.com/Publication/ PublicationIndex/05779073

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Dipole Moment and Electronic Structure Calculations of the Electronic States of the Molecule SiC below 97000cm⁻¹

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Abstract

Beside its importance in the astrophysics, the silicon carbide has a great importance in the industry of semiconductors and ceramics. Because of the absence of theoretical data, extensive *ab initio* calculations of dipole moment and higher excited electronic state have been done for this molecule. These calculations have been performed by using the Complete Active Space Self Consistent Field (CASSCF) with Multireference Configuration Interaction MRCI+Q (singly and doubly excitation with Davidson corrections). The potential energy and the dipole moment curves for the 47 low-lying singlet, triplet and quintet electronic states in the representation $^{2s+1}\Lambda^{(+/-)}$ of the molecule SiC have been calculated. The harmonic frequency ω_e, the internuclear distance R_e, the electronic energy with respect to the ground state T_e, the rotational constants B_e and the permanent dipole moment have been obtained for these electronic states. The comparison between the values of the present work and those available in the literature, for several electronic states, shows a good agreement. In the present work thirteen new electronic states have been investigated here for the first time. These new results may leads to more investigation of new experimental works on this molecule.

Keywords: *ab initio* calculation, permanent dipole moments, electronic structure, spectroscopic constants, potential energy curves

1. Introduction

Since the SiC is an elusive molecule, its experimental detection is extremely difficult in a high temperature in thermodynamic equilibrium. But this problem can be solved by sputtering the SiC in a hollow discharge lamp. By using this technique Bernath et al. (Bernath et al., 1988) detected for the first time the $d^1\Sigma^+$ - $b^1\Pi$ electronic transition. By measuring the millimeter-wave spectrum Cernicharo et al. (Cernicharo et al., 1989) reported detailed study of the ground state $X^3\Pi$ of the molecule SiC. A rovibrational measurement of of the ground state has been done by Mollaaghababa et al. (Mollaaghababa et al., 1990). The $A^3\Sigma^-$-X^3P and $C^3\Pi$-$X^3\Pi$ electronic transition have been detected respectively by Brazier et al. (Brazier et al., 1989) and Ebben et al. (Ebben et al., 1991). From the electronic transition $C^3\Pi$-$X^3\Pi$, the spectroscopic constants of these electronic states have been measured by Butenhoff et al. (Butenhoff et al., 1991). Bauschliecher and Langhoff (Bauschlicher JR, & Langhoff (1987) have reported the spectroscopic parameters for the $^3\Pi$ ground state of SiC molecule along with the $A^3\Sigma^-$ states which is nearly 4000 cm⁻¹ above the $X^3\Pi$ ground state. Furthermore, the spectroscopic properties for the three lowest lying electronic states $X^3\Pi$, $A^3\Sigma^-$ and $a^1\Sigma^+$ of the diatomic SiC molecule have been computed based on an augmented coupled cluster and different basis sets methods by (Martin, Francois, & Gijbels, 1990).

The absence of theoretical dipole moment calculation and the electronic structure investigation for higher excited electronic states (up to 97000cm⁻¹) of the silicon carbide molecule SiC stimulates us to investigate, in the present work, more extensive *ab initio* calculation for this molecule. These theoretical calculations, in the present-days, are quite capable of producing, with high accuracy, the required data if they are judiciously applied. The potential energy curves and the spectroscopic constants of the low lying 47 singlet, triplet and quintet electronic states have been calculated where 13 electronic states have been investigated here for the first time. The transition energy with respect to the minimum energy for the ground state T_e, the equilibrium internuclear distance R_e, the harmonic frequency ω_e, and the rotational constant B_e have been calculated in order they can be assigned for experimental electronic transitions that have not been observed yet for the SiC molecule. Since the dipole moment curves are the important ingredients that may help to obtain accurate predictions of the transition

dipoles moments and hence the transition lines intensities the permanent dipole moment have been calculated for the considered electronic states of this molecule.

2. Method

In the present work we investigated the low-lying singlet, triplet and quintet electronic states of the molecule SiC using Complete Active Space Self Consistent Field (CASSCF) procedure followed by a multireference configuration interaction (MRCI+Q with Davidson correction) treatment for the electron correlation. The entire CASSCF configuration space was used as the reference in the MRCI calculations, which were done via the computational chemistry program MOLPRO (MOLPRO package) taking advantage of the graphical user interface GABEDIT (Allouche, 2011). The silicon species is treated as a system of 14 electrons by using the Ahlirchs-PVDZ; c basis set for s, p, and d functions. The 6 electrons of the carbon atom are considered using the aug-cc-pVTZ; c basis set for s, p and d functions. Among the 20 electrons explicitly considered for SiC molecule 7 valence electrons were explicitly treated, corresponding to 15 active orbitals. Being an heteronuclear diatomic molecule, SiC is of $C_{\infty v}$ point group symmetry; however, MOLPRO software can only make use of Abelian point groups which means that $C_{\infty v}$ will be treated using the C_{2v} point group placing the molecule along the $+ z$-axis and keeping Si at the origin.

3. Results

3.1 Potential Energy Curves and Spectroscopic Constants

The potential energy curves (PECs) for the 47 singlet, triplet and quintet electronic states, in the representation $^{2s+1}\Lambda^{(\pm)}$, of the molecule SiC were generated using the MRCI+Q for 96 internuclear distances calculations in the range $1.1\text{Å} \leq R_e \leq 4.1\text{Å}$ (Figure 1-6).
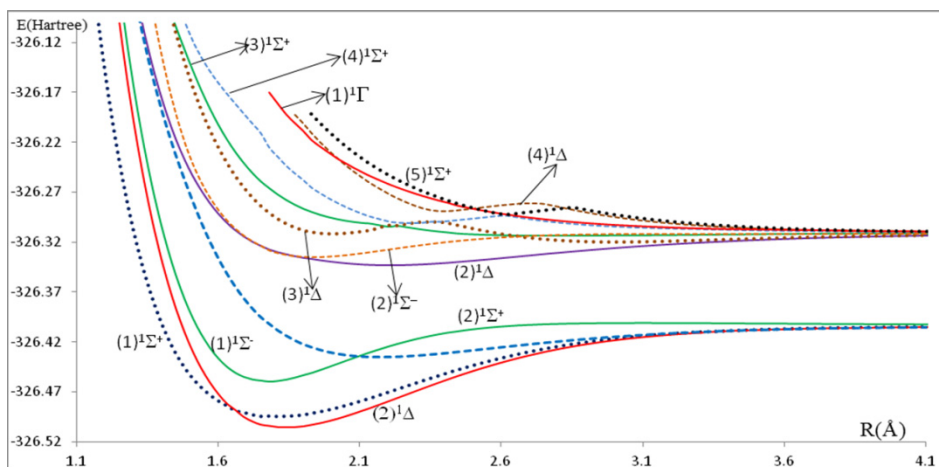
Figure 1. Potential energy curves of the $^1\Sigma^{\pm}$ an $^1\Delta$ states of the molecule SiC
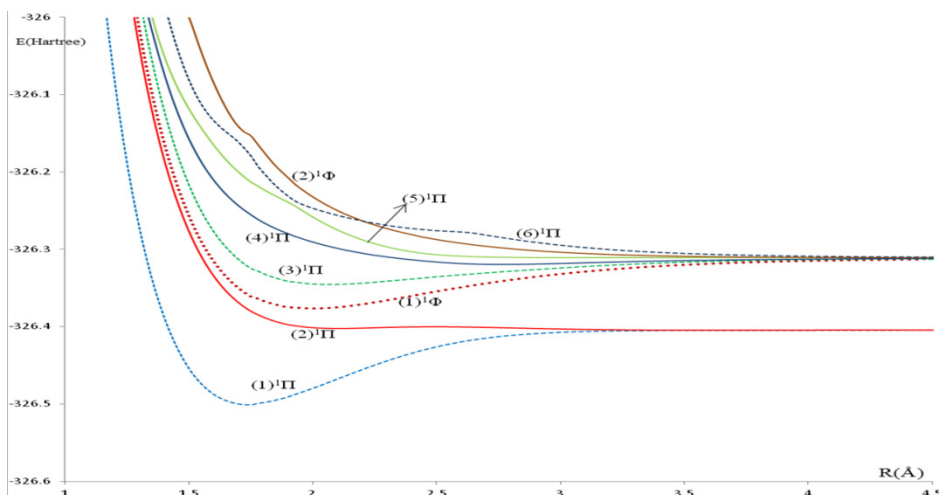
Figure 2. Potential energy curves of the $^1\Pi$ ανδ $^1\Phi$ states of the molecule SiC
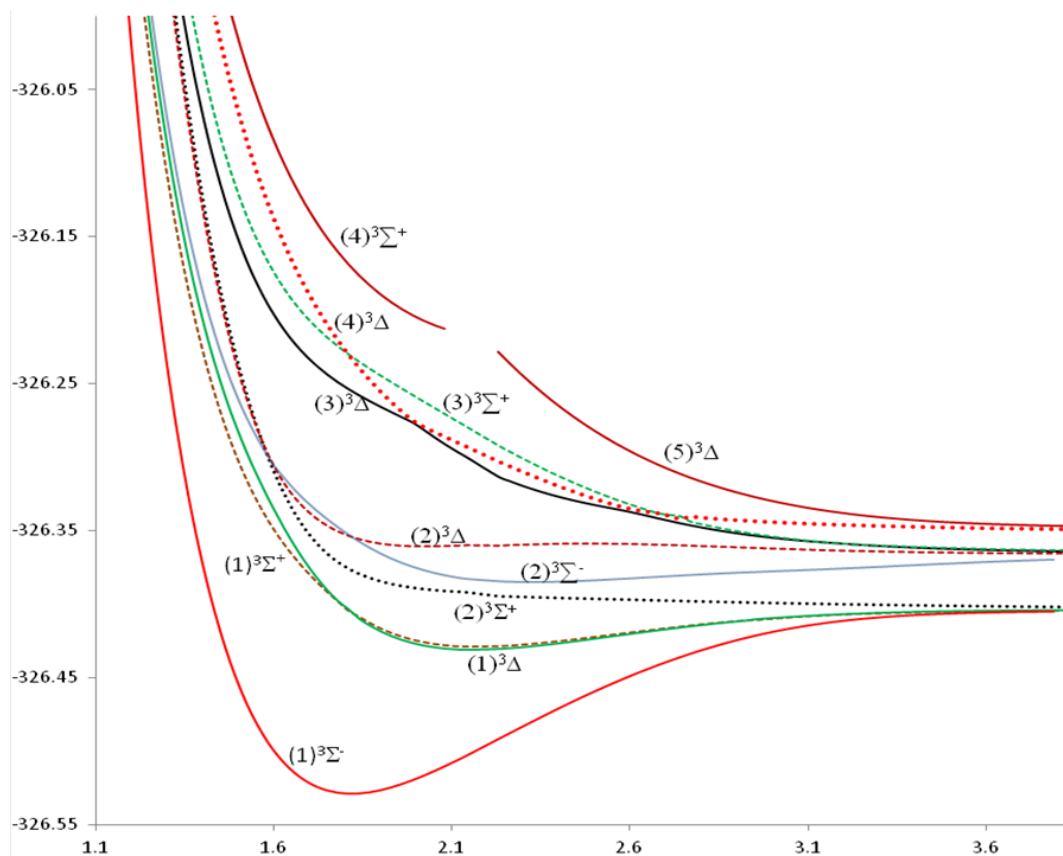
Figure 3. Potential energy curves of the $^3\Sigma^{\pm}$ an $^3\Delta$ states of the molecule SiC

Figure 4. Potential energy curves of the $^3\Pi$ and $^3\Phi$ states of the molecule SiC
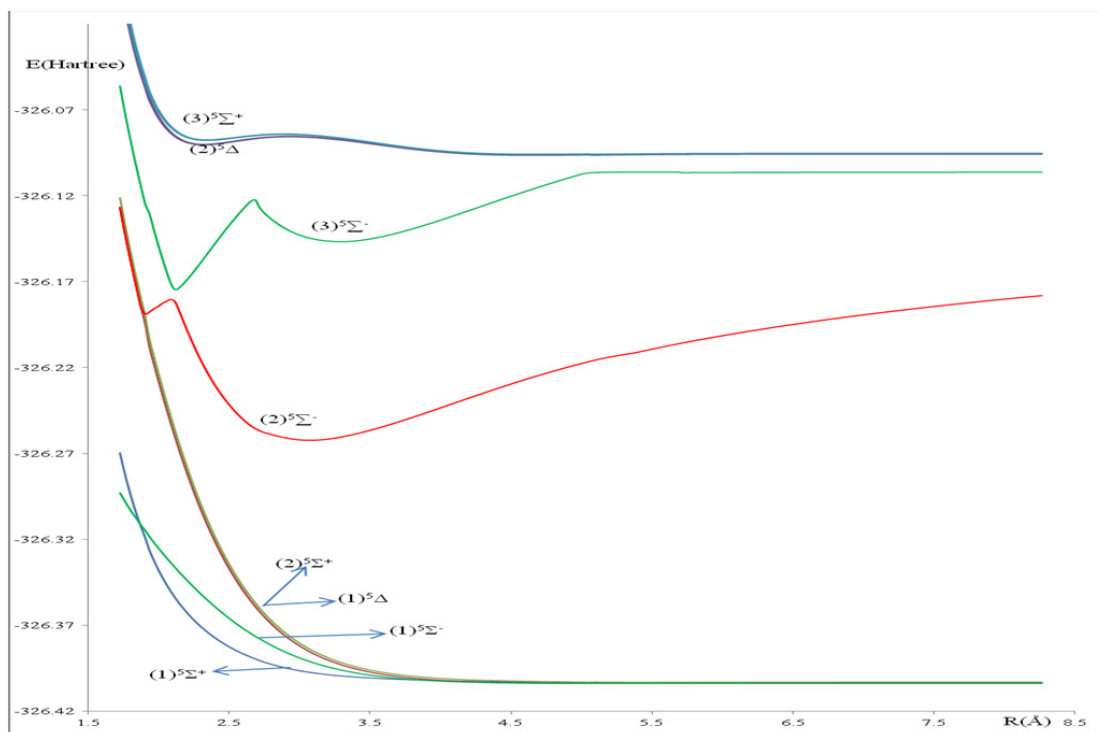
Figure 5. Potential energy curves of the $^5\Sigma^{\pm}$ an $^5\Delta$ states of the molecule SiC
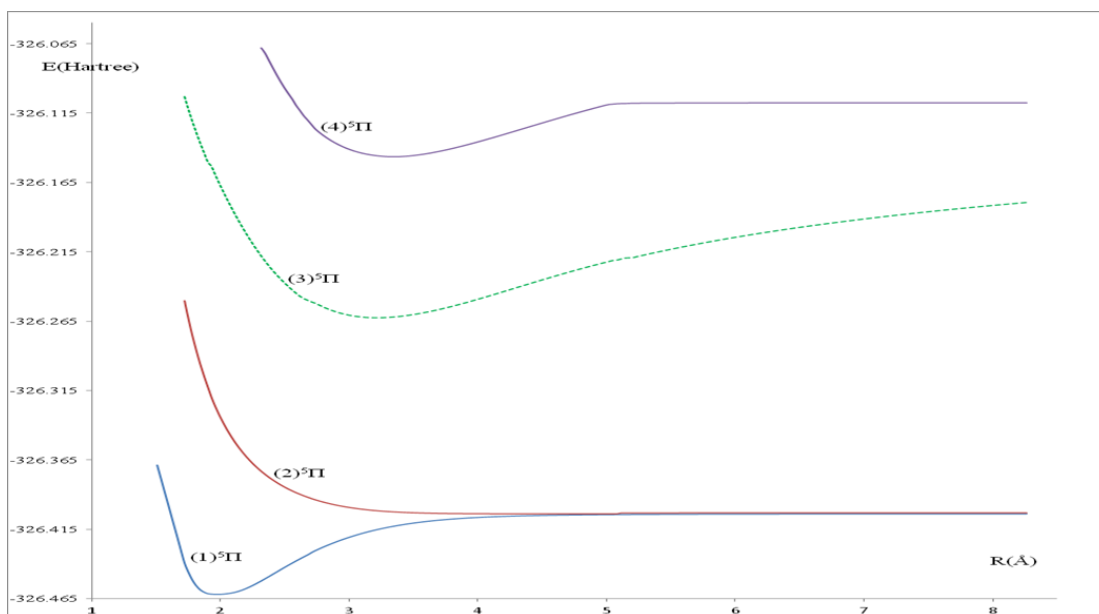
Figure 6. Potential energy curves of the $^5\Pi$ states of the molecule SiC

By fitting the calculated energy values of the different investigated electronic states, into a polynomial in R around the internuclear distance at equilibrium R_e, the harmonic vibrational frequencies ω_e, the relative energy separations T_e, and the rotational constants B_e have been calculated. These values with the available data in literature are given in Table 1.

Table 1. Spectroscopic constants of the silicon carbide molecule SciC

States	T_e (cm^{-1})	ω_e (cm^{-1})	B_e (cm^{-1})	$\alpha_e \times 10^3$	R_e (Å)
(X)$^3\Pi$	0	946.6	0.655	5.502	1.749
		927[a3]			1.722[a6]
		981[b1]	0.679[b1]	6.23[b1]	1.715[b1]
		984[b2]	0.681[b2]	6.24[b2]	1.713[b2]
		979[b3]	0.676[b3]	6.22[b3]	1.719[b3]
		976[b4]	0.676[b4]	6.22[b4]	1.720[b4]
		1033[c1]			1.709[c1]
		958[c2]			1.726[c2]
		947[c3]			1.732[c3]
		934[c4]			1.737[c4]
		923[c5]			1.741[c5]
		906[c6]			1.705[c6]
		917[c7]			1.701[c7]
		944[c8]			1.738[c8]
		1035[c9]			1.709[c9]
		963[c10]			1.726[c10]
		954[c11]			1.730[c11]
		937[c12]			1.737[c12]
		925[c13]			1.741[c13]
		979[d]	0.67502[d]	5.63[d]	
		914[e]			1.75[e]
		965.16[f1]	0.67976[f1]	5.38[f1]	1.7182[f1]
		964.6[f2]			
		954.2[f3]	0.6692[f3]	5.7[f3]	1.732[f3]
		930[g]			1.72[g]
		954[h]			1.726[h]
(1)^3	3380	857.1	0.605	5.358	1.820
	3619[a2]	835[a6]			1.802[a3]
	2076[c1]	904[c1]			1.796[c1]
	3191[c2]	875[2]			1.81^0[c2]
	3909[c3]	870[c3]			1.812[c3]
	2025[c9]	910[c9]			1.798[c9]
	3072[c10]	881[c10]			1.811[c10]
	3798[c11]	877[c11]			1.813[c11]
	3742[c12]	865[c12]			1.82[c12]
	3781[c13]	848[c13]			1.823[c13]
	3831[d]	855[d]	0.60968[d]	5.17[d]	
	5242.3[e]	960[e]			1.82[e]
	4597.5[g]	826[g]			1.82[g]
	3883[h]	860[h]			1.811[h]
(1)^1 $^+$	6740	1004.7	0.614		1.805
	5079[a2]	835[a3]			1.802[a3]
	4355[d2]	1053[d2]	0.72299[d2]	0.602[d2]	
	6855.845[b]	1202[e]	0.70977[d]		1.688[d]
	4968[h]	1023[h]			1.656[h]
(1)$^1\Pi$	7679	901.9	0.666	0.793	1.734
	7259[a7]	963[a5]			1.728[a5]
	7662.3[e]	950[e]			1.75[c]
	7661.715[e]	960[e]			1.82[b]
	7027[h]	942[h]			1.741[h]
(1)$^1\Delta$	9008	705.9	0.592	0.379	1.840

State					
	9094[a4]	821[a6]			1.821[a6]
	10889[e]	1202[e]			1.68[e]
	8397[h]	814[h]			1.834[h]
$(1)^3$	15000	450.7	0.424	1.460	2.128
$(2)^1{}^+$	13691	953.9	0.635	0.727	1.776
	12338[a1]				1.794[a5]
	12603[h]	979[h]			1.808[h]
$(1)^5$	16240	229.9	0.492		1.982
	16095[h]	659			1.942
$(2)^3\Pi$	21834	433.4	0.502	4.820	1.995
	22830.4[f]	615	0.5450[f]	0.12	1.919[f]
	22768[h]	594[h]			1.911[h]
$(1)^1{}^-$	22165	446.7	0.424	0.767	2.174
	24703[h]	503[h]			2.130[h]
$(1)^3\Delta$	22975	463.9	0.430	7.960	2.158
	25489[h]	459[h]			2.133[h]
$(1)^3{}^+$	23471	439.3	0.426	7.990	2.168
	19658[h]	1050[h]			1.652[h]
$(3)^3\Pi$	28387	537.7	0.488	9.330	2.025
	22830.4[f1]	615.72[f1]	0.5450[f1]	6.6[f1]	1.919[f1]
	22829.46[f2]	618.85[f2]	0.5474[f2]	1.98[f2]	1.908[f2]
	22768[f3]	615.8[f3]	0.5511[f3]	0.12[f3]	1.914[f3]
	27080[h]	553[h]			1.929[h]
$(2)^1\Pi$	29342	349.6	0.453	2.061	2.103
	28904[h]	540[h]			1.963[h]
$(2)^3{}^-$	33090	325.8	0.367	1.066	2.330
	35419[h]	385[h]			2.218[h]
$(1)^1$	35061	481.4	0.499	12.210	2.003
$(3)^1\Pi$	41852.0	464.3	0.468	0.580	2.069
$(2)^1\Delta$	42286.4	358.4	0.411	0.536	2.206
$(4)^1\Pi$	47535.7	249.3	0.263	0.645	2.763
	49197.7	621.3	0.496	0.189	2.008
$(5)^1\Pi$	49383.0	2552.9	0.291	0.369	3.075
	60020	248.0	0.194		3.216
	60068	280.0	0.213		3.068
	79329	1733.0	0.441		2.132
$(4)^5$	85471	275.0	0.178		3.352
$(2)^5$ (1st minimum)	97829	407.4	0.374		2.313
(2nd minimum)	96504	114.4	0.907		4.646
$(3)^5{}^+$ (1st minimum)	98364	331.0	0.365		2.341
(2nd minimum)	96533	13.4	0.091		4.713

(a) Bernath et al.: [a1]2MC-ScF+SD, [a2]MR-SOCI, [a3]Davidson correction- MR-SOCI, [a4]HF-SD

Transition $^1\Delta$-$^3\Sigma^-$, $^1\Pi$-$^3\Pi$, [a5]Davidson correction- 2MC-ScF+SD, [a6]Davidson correction-HF-SD,

(b) Midda et al.: [b1]basis set 6-311G (2df, 2pd), [b2] basis set 6-311G (3df, 3pd), [b3] basis set cc-pVTZ, [b4]basis set aug-cc-pVTZ

(c) Bauschlicher, Jr. & Langhoff: [c1]SDCI, [c2]SOCI+Q, [c3]CPF, [c4]MRCI, [c5]MRCI+Q, [c6]MP4 (SDQ)b, [c7]MP4 (SDTQ) b, [c8]CClb, [5s4p2d If /4s3p2d If] basis, [c9]SOCI , [c10]SDCI+Q1, [c11]CPF, [c12]MRCI, [C13]MRCI+Q

(d) Martin et al.: [d1]QCISD(T)IMC-31IG(2dj), [d2]QCISD(T)IMC-311G(d).

[e]Bruna et al.

[f1]Butenhoff & Rohlfing, [f2]Ebben et al., [f3]Larsson

[g]Andzeim et al.

[h]Borin et al.

The comparison of our calculated values of T_e with those obtained experimentally (Bernath et al. & Ebben et al.) for the electronic states $(1)^1\Delta$ and $(2)^3\Pi$ showed a very good agreement with the relative differences 0.95% and 4.56% respectively. While our calculated value of T_e for the electronic state $(3)^3\Pi$ is larger than those given by (Butenhoff & Rohlfing, Larsson, & Ebben et al.). The different theoretical techniques for the calculation of T_e have large influence on the investigated data for the different excited electronic states. For example, for the electronic state $(1)^3\Sigma^-$ one can find that the calculated values of T_e are 2076 cm^{-1} (Bauschlicher, Jr. and Langhoff/SDCI) and 5242 cm^{-1} (Bruna et al.). Similar results can be found for other excited electronic states. Concerning our calculated values of T_e, they are in good agreement with experimental values and with some theoretical data with the relative differences $\Delta T_e/T_e$= 1.07% ($(1)^3\Sigma^-$, Bauschlicher, Jr. and Langhoff/MRCI), $\Delta T_e/T_e$= 1.71% ($(1)^1\Sigma^+$, Bruna et al.), $\Delta T_e/T_e$= 0.22% ($(1)^1\Pi$, Bruna et al.), $\Delta T_e/T_e$= 0.95% ($(1)^1\Delta$, Bernath et al./Transition $^1\Delta$-$^3\Sigma^-$). By comparing our calculated values of T_e with those given by Borin et al., one can find the good agreement with the relative differences 1.4%, 1.49%, 7.04%, 4.6%, 10.9% for the electronic states $(1)^1\Sigma^-$, $(2)^1\Pi$, $(2)^3\Sigma^-$, $(2)^3\Pi$ and $(1)^3\Delta$ respectively. This relative difference becomes larger for the states $(2)^1\Sigma^+$, $(1)^5\Pi$, $(1)^3\Sigma^-$. There is no comparison for the other states since they are given here for the first time.

By comparing our investigated spectroscopic constants for the ground state with those obtained experimentally, one can find a very good agreement with the relative differences $\Delta\omega_e/\omega_e$= 1.6% (Ebben et al.), $\Delta\omega_e/\omega_e$=0.8% (Larsson), $\Delta B_e/B_e$= 3.1%, (Ebben et al.) $\Delta B_e/B_e$= 3.8% (Larsson), $\Delta\alpha_e/\alpha_e$= 1.8% (Ebben et al.), $\Delta\alpha_e/\alpha_e$=0.97% (Larsson) and $\Delta R_e/R_e$= 1.76%, (Ebben et al.), $\Delta R_e/R_e$= 0.97% (Larsson). Also good agreements are obtained by comparing our calculated values of these constants with the experimental data (Ebben et al. & Larsson) for the electronic state $(2)^3\Pi$. The agreement becomes less by comparing our investigated data for the electronic state $(3)^3\Pi$ with the experimental values (Ebben et al. & Larsson). In literature the spectroscopic constants for the molecule SiC have been calculated for different electronic states by different techniques. One can notice the good agreement between these different values for the ground and the first excited state. By comparing our calculated values of these constants for these electronic states with the theoretical data in literature we obtained the very good agreement with the relative differences 0.02%≤$\Delta\omega_e/\omega_e$≤12%, 0.77%≤$\Delta B_e/B_e$≤3.97%,

2.2%≤$\Delta\alpha_e/\alpha_e$≤13.23%, 0.0%≤$\Delta R_e/R_e$≤2.29%. While the theoretical investigated values for the spectroscopic constants ω_e depends in the different theoretical techniques of calculation in order one can find a large discrepancy between these values. Concerning our calculated values of this constants, they are in very good agreement with theoretical values with the relative differences 1.82%, 4.46%, 2.63%, 1.06%, 2.84% for the electronic states $(1)^1\Sigma^+$, $(1)^1\Pi$, $(2)^1\Sigma^+$, $(1)^3\Delta$, $(2)^3\Pi$ respectively given by Borin et al. The calculated values of B_e in the present work are in good agreement either with the theoretical values (Bruna et al.) for the electronic states $(1)^1\Sigma^+$ or experimental data (Butenhoff and Rohlfing) for the 2 electronic states $(2)^3\Pi$ and $(3)^3\Pi$. Our calculated values of the internuclear distance R_e are in very good agreement with those given in literature either theoretical or experimental except the investigated values for the electronic states $(1)^1\Sigma^-$, $(1)^3\Delta$, and $(1)^3\Sigma^+$.

3.2 Permanent Dipole Moment

The importance of the calculation of the permanent dipole moment (PMD), which is a fundamental electrostatic property of a neutral molecule, is lying in the description of numerous physical phenomena and in the accurate predictions of transition dipoles and hence intensities. The values of the expectation value of the dipole moment operator depend on the nature of the least energetic and most chemically relevant valence electrons. The calculation of the permanent dipole moment in term of the internuclear distance R have been done by taking the Sc atom at the origin and the carbon atom along the internuclear Z-axis (Figure 7-10).
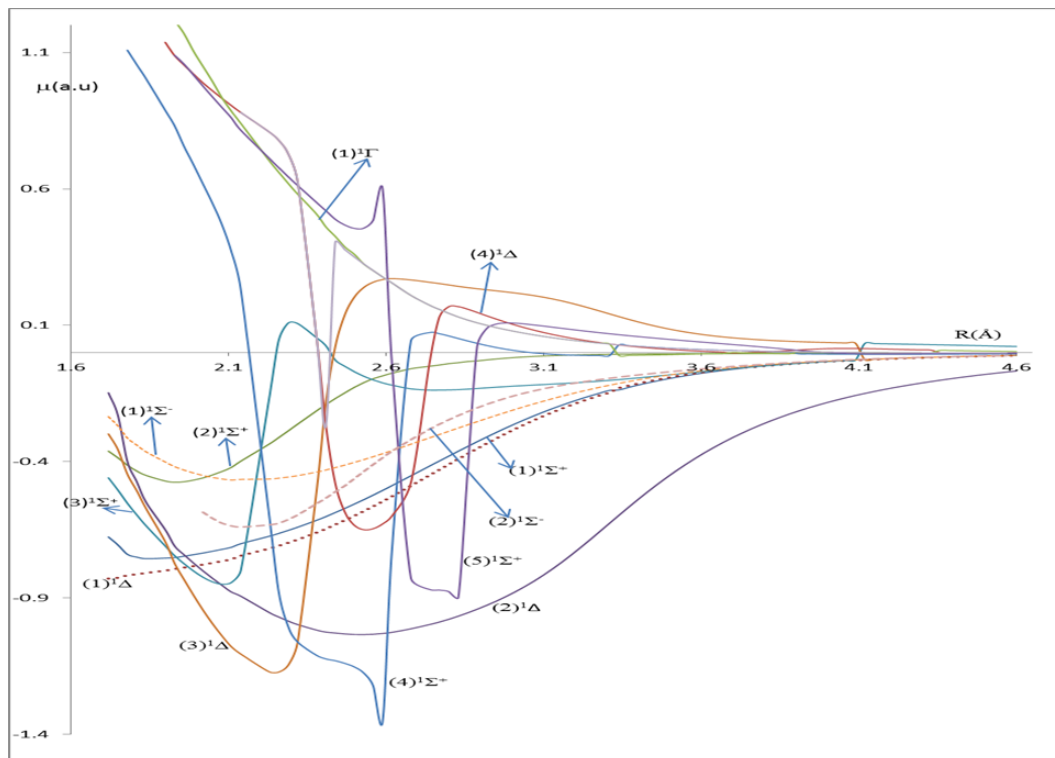
Figure 7. Permanent dipole cuves of the electronic states $^1\Sigma^{\pm}$, $^1\Delta$ and $^1\Gamma$ of the molecule SiC
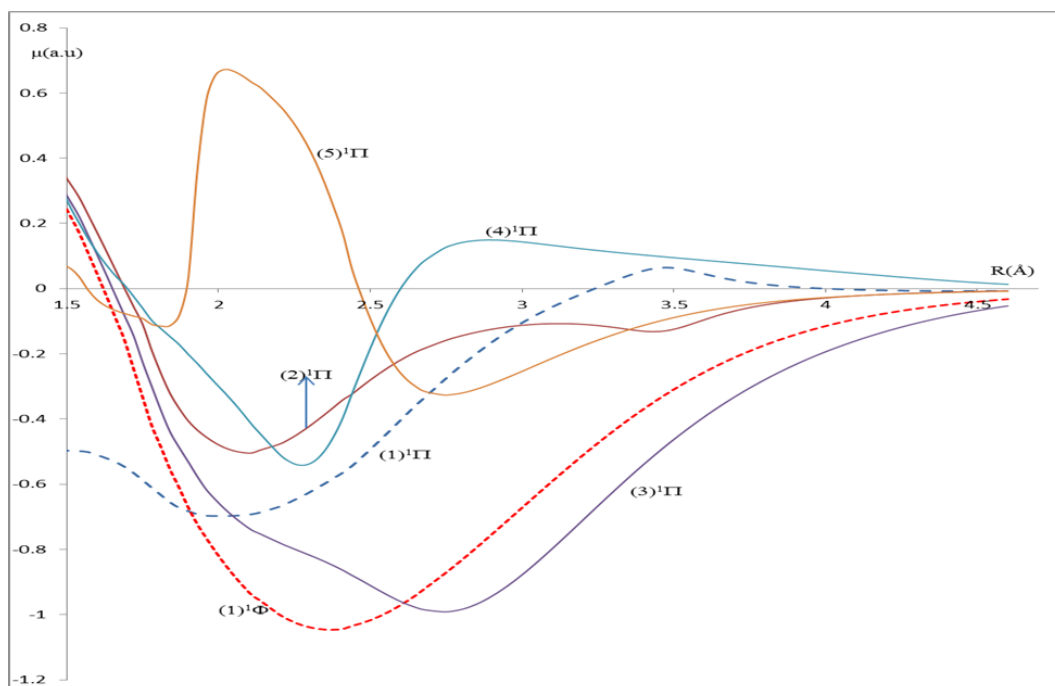
Figure 8. Permanent dipole cuves of the electronic states $^1\Pi$ and $^1\Phi$ and of the molecule SiC
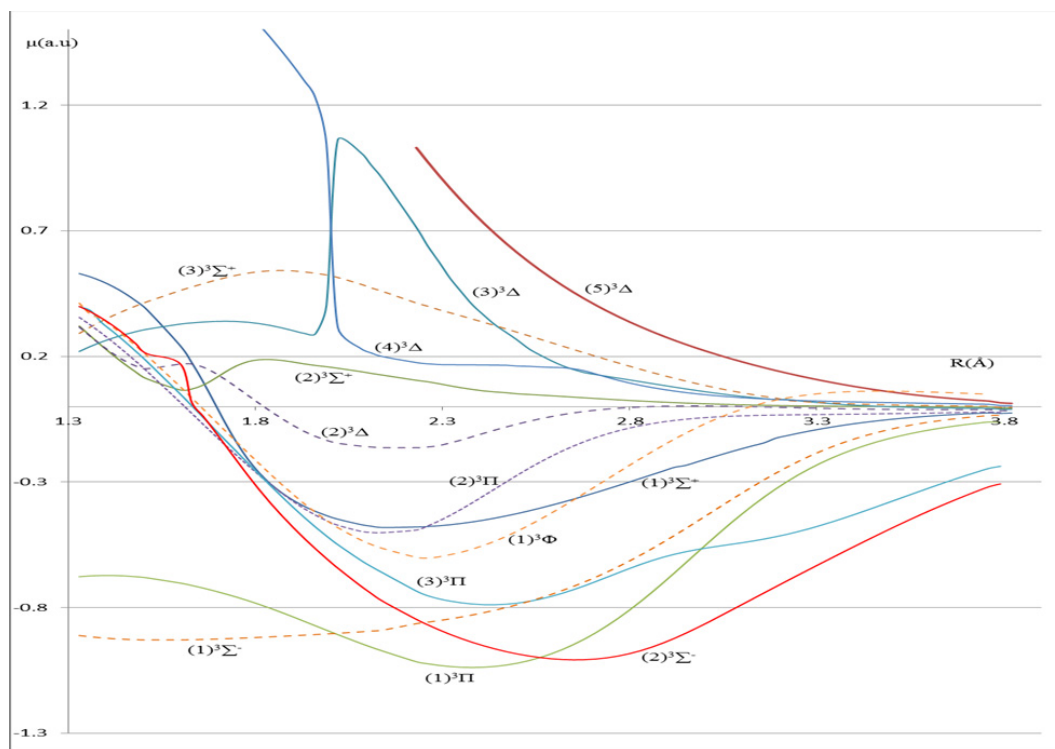
Figure 9. Permanent dipole cuves of the electronic states $^3\Sigma^\pm$, $^3\Delta$, $^3\Pi$ and $^3\Phi$ of the molecule SiC
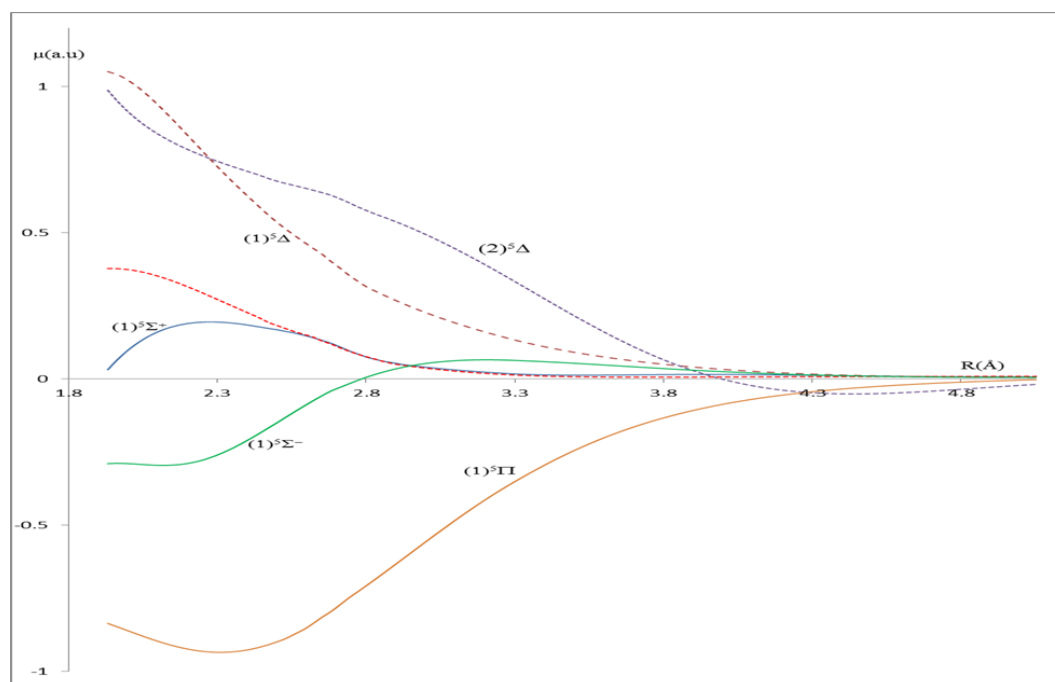
Figure 10. Permanent dipole cuves of the electronic states $^5\Sigma^\pm$, $^5\Delta$ and $^5\Phi$ of the molecule SiC

The investigation of these PDM curves is mainly used to discuss the bond nature, the polarity of the states and their interactions. As the internuclear distance increases one can notice three types of the DMC's for the singlet, triplet and quintet electronic states: *i)* curves in the positive region which are corresponding to an ionic structure of $Si^{\delta-}C^{\delta+}$ type *ii)* curves in the negative region which are corresponding to an ionic structure of $Si^{\delta+}C^{\delta-}$ type *iii)* curves passing from one region to another by changing the ionic structure. It is noticed that at large internuclear distances, the dipole moment curves of all the investigated electronic states tend smoothly to zero which is theoretically the correct behavior for a molecule that dissociates into natural fragments. The sharp change in the

directions of the PDM curves indicate an avoided crossing of the potential energy curves at the same position of the internuclear distance, e.g. $(3)^1\Sigma^+/(4)^1\Sigma^+$ at 2.22Å so that the polarity of the atoms is reversed. This agreement may confirm the validity and the accuracy of the calculation of the studied excited electronic states. No comparison of these values of the PDM with other results in literature since, to the best of our knowledge, they are given here for the first time.

4. Conclusion

From an *ab-initio* MRCI+Q calculation, the permanent dipole moment and the potential energy curves have been investigated for 47 singlets, triplet and quintet electronic states of the molecule SiC. The plots of these curves have been represented and the spectroscopic constants R_e, ω_e, T_e, α_e, and B_e are determined for the investigated electronic states. The spectroscopic constants for 13 states are given here for the first time. In literature there are fragmented experimental data for few electronic states of the molecule SiC. The confirmation of the theoretical investigated data can be done by a future experiment for these electronic states of the molecule SiC

References

Allouche, A. R. (2011). Gabedit-A graphical user interface for computational chemistry softwares. *Journal of Computational Chemistry, 32*, 174. http://dx.doi.org/10.1002/jcc.21600

Andzelm, J., Russo, N., & Salahub, R. D. (1987). Ground and excited states of group IVA diatomics from local-spin-density calculations: Model potentials for Si, Ge, and Sn. *Journal of Chemical Physics, 87*(11), 6562-6572. http://dx.doi.org/10.1063/1.453441

Bauschlicher, W. C. Jr., & Langhoff, R. S. (1987). Ab initio calculations on C_2, Si_2, and SiC. *Journal of Chemical Physics, 87*(5), 2919- 2924. http://dx.doi.org/10.1063/1.453080

Bernath, F. P., Rogers, A. S., O'Brien, C. L., Brazier, R. C., & McLean, D. A. (1988). Theoretical Prediction and Experimental Detection of the SiC molecule. *Physical Review Letters, 60*(3), 197-199. http://dx.doi.org/10.1103/PhysRevLett.60.197

Borin, C. A., Gobbo, P. J., Batista, de S. R., & de Macedo, M. G. L. (2005). The lowest singlet, triplet, and quintuplet electronic states of SiC. *Chemical Physics, 312*, 213–222. http://dx.doi.org/10.1016/j.chemphys.2004.11.042

Brazier, C. R., O'Brien, L. C., & Bernath, P. F. (1989). The $A^3\Sigma^--X^3\Pi$ transition of the SiC radical. *Journal of Chemical Physics, 91*, 7384. http://dx.doi.org/10.1063/1.457261

Butenhoff, J. T., & Rohlfing, A. E. (1991). The $C^3\Pi$-$X^3\Pi$ band system of the SiC radical. *Journal of Chemical Physics, 95*(6), 3939-3943. http://dx.doi.org/10.1063/1.460800

Bruna, J. P., Peyerimhoff, S., & Buenker, J. B. (1984). Theoretical prediction of the potential curves for the lowestlying states of the isovalent diatomics CN +, Si2, SiC, CP+, and SiN + using the ab initio MRD-CI method. *Journal of Chemical Physics, 72*(10), 5436-6445. http://dx.doi.org/10.1063/1.439012

Cernicharo, J., Gottlieb, C. A., Guelin, M., Thaddeus, P., & Vrtilek, J. M. (1989). Astronomical and laboratory detection of the SiC radical. *Astrophysical Journal, L25*, 341.

Ebben, M., Drabbels, M., & Ter Meulen, J. J. (1991). The $C^3\Pi$ (v'=0–6)–X 3Π (v'=0) transition in SiC. *Journal Chemical Physics, 95*, 2292. http://dx.doi.org/10.1063/1.460988

Ebben, M., Drabbels, M., & Ter Meulen, J. J. (1991). The first LIF spectrum of SiC. *Chem. Phys. Lett., 176*, 404. http://dx.doi.org/10.1016/0009-2614 (91)90052-B

Larsson, M. (1986). The $X^3\Pi$, $B^3\Sigma^+$ and C3Π states of SiC according to ab initio CASSCF-CCI calculations. *Journal of Physics B, 19,* L261. http://dx.doi.org/10.1088/0022-3700/19/8/001

Lutz, L., & Ryan, A. J. (1974). Silicon Carbide: SiC Its Ground State and Predicted Spectrum. *Astrophysical Journal, 194*(8), 753-756.

Martin, L. M. J., Francois, P. J., & Gijbels, R. (1990). Accurate ab initio spectroscopic and thermodynamic properties for the SiC molecule. *Journal of Chemical Physics, 92*(11), 6655-6667. http://dx.doi.org/10.1063/1.458595

Midda, S., & Das, K. A. (2003). Spectroscopic constants and molecular properties of AlC and SiC in their ground state. *Journal of Molecular Structure (Theochem), 633*, 67–71. http://dx.doi.org/10.1016/S0166-1280(03)00327-0

Mollaaghababa, R., Gottlieb, C. A., Vrtilek, J. M., & Thaddeus, P. (1990). *Astrophysical Journal, L21*, 352.

MOLPRO is a package of ab initio programs written by H. J.Werner and P. J. Knowles, with contributions from R. D. Amos, A. Bernhardsson, A. Berning, P. Celani, D. L. Cooper, M. J. O. Deegan, … T. Thorsteinsson. Retrieved from https://www.molpro.net/info/2015.1/doc/update/node1.html.

Rohling, M. C., & Martin, L. R. (1986). A theoretical study of the isovalent diatomics carbon dimer, silicon dimer, and silicon monocarbide. *Journal of Physical Chemistry, 90*(10), 2043-20146. http://dx.doi.org/10.1021/j100401a014

Sanders, J. H. (1984). High-tech ceramics. *Chemical Engineering News, 62*, 26. http://dx.doi.org/10.1021/cen-v062n028.p026

Suzuki, H. (1979). Molecular Evolution in Interstellar Clouds. I. *Progress of Theoretical Physics, 62*(4), 936. http://dx.doi.org/10.1143/PTP.62.936

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Numerical Simulations of V-Shaped Plates Subjected to Blast Loadings: A Validation Study

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Abstract

A series of numerical simulations utilizing LS-DYNA was performed to determine the mid-point deformations of V-shaped plates due to blast loading. The numerical simulation results were then compared with experimental results from published literature. The V-shaped plate is made of DOMEX 700 and is used underneath an armour personal carrier vehicle as an anti-tank mine to mitigate the effects of explosion from landmines in a battlefield. The performed numerical simulations of blast loading of V-shaped plates consisted of various angles i.e. 60°, 90°, 120°, 150° and 180°; variable mass of explosives located at the central mid-point of the V-shaped vertex with various stand-off distances. It could be seen that the numerical simulations produced good agreement with the experimental results where the average difference was about 26.6%.

Keywords: blast loading, numerical simulation, V-shaped plates, DOMEX 700, LS-DYNA

1. Introduction

Armour personal carriers (APC) were designed for protection against small arms bullets and shrapnel from hand grenades. The emergence of terrorist groups have brought in a new threat in the form of improvised explosive devices (IED) which are planted by the roadside or buried on dirt roads to obstruct the movement of law enforcement agencies. This put forward a demand for redesign of APC as well as some add-on gadgets for the already operational fleet of vehicles. An IED or landmine generate high speed fragments and a blast wave. The type of damage inflicted by the two is different and fall into different category of physical phenomena. The armour plate used to build vehicles is already good enough for protection against fragments, however, the blast wave may damage the plate and the impulse impacted to the vehicle may destabilise the vehicle while it is on the move. It is therefore important to study the blast wave interaction with different shapes of armour plates. In general, the blast wave amplitude attenuates rapidly and the pulse width depends upon the amount of high explosive involved. The shape of armour plate becomes important when a blast wave interacts with it. Therefore, any design study may consider at least the following parameters: (a) explosive mass, (b) stand-off distance and (c) plate geometry. By carefully varying these parameters, a fair assessment for redesigning can be made. The modelling and optimization need to be cost effective as well as having a better level of accuracy both in models and numerical computation.

The investigations into the responses of structures due to blast loading have attracted attentions from researchers from all around the world for the past decades (Chen, Louca, & Elghazouli, 2015; Fallah et al., 2014; Geretto, Chung, & Nurick, 2015; Li, Wang, Zhu, Wu, & Zhao, 2014; Ma, Xin, Hu, & Zheng, 2013; Micallef, Fallah, Curtis, & Louca, 2016; Othman et al., 2015; Shen, Lu, Wang, & Zhao, 2010; Spiller, Packer, Seica, & Yankelevsky, 2016; Wang & Xiong, 2015; Zhang, Hao, & Wang, 2015). An experimental and numerical simulation studies to mitigate the effects of mine explosion experienced by the underneath section of an armoured personal carrier by using 'V-shaped' plates of 60°, 90°, 120°, 150° and 180° angles, had been

successfully performed (Chung, Langdon, Nurick, Pickering, & Balden, 2012). They performed 35 small-scaled blast experimental tests on the V-shaped DOMEX 700 steel geometry plate and managed to obtain good agreements by using the numerical simulation i.e. AUTODYN to predict some of the experimental test results. It was observed that the V-shaped plate of 60° experienced the most reduced central deformation as compared to the other angles, which showed that it had managed to deflect the most amount of blast energy. Numerical simulation i.e. ABAQUS had been utilized to predict the effects of transient response and changing material properties of circular DOMEX 700 MC steel plates against multiple blast loading experimental tests and good predictions were achieved (Henchie, Chung, Nurick, Ranwaha, & Balden, 2014). Various masses of explosive were used with constant stand-off distance in the experimental blast tests and the circular plate was loaded with up to a maximum of 5 explosions per circular plate. It was found out that the strain hardening mechanical properties surged in the central area of the circular plate and around the perimeter of the circular plate where it was fully fixed during the experimental blast tests. A basic analytical method had been successfully proposed to predict the performance of water storage tank against blast loading (Wang & Xiong, 2015). They managed to prove that their newly proposed LANGRANGIAN equation, which incorporated multiple deflection shape function had managed to give good prediction of peak load with differences of around 5% when compared to results obtained from numerical simulation i.e. LS-DYNA.

The objective of this paper is to produce series of blast loading numerical simulations of specified amount of TNT equivalent explosive located at the mid-point of a V-shaped plate (see Figure 1 and Figure 2). The numerical simulations fully utilized the experimental tests' parameters performed by researchers at the University of Cape Town, South Africa (Chung et al., 2012) and the experimental tests' mid-point deflections produced by these researchers are used to validate the predictions obtained by the numerical simulations using LS-DYNA.
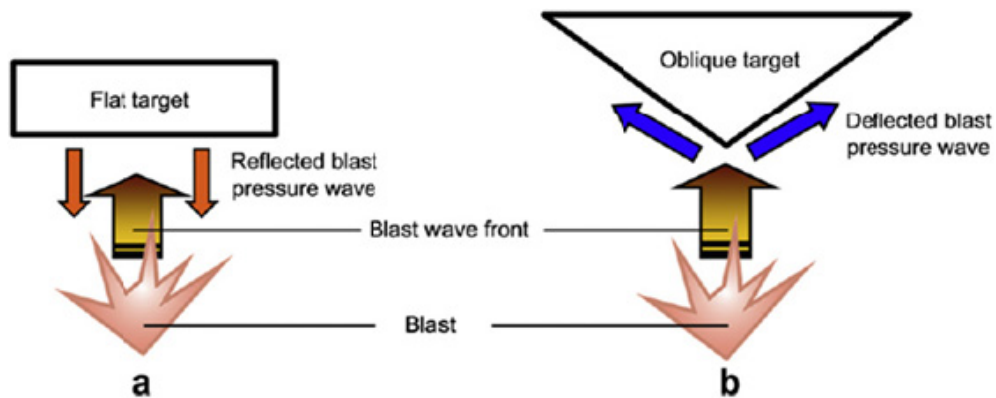
Figure 1. Flat target plate versus angled target plate for blast loading of structures (Chung et al., 2012)
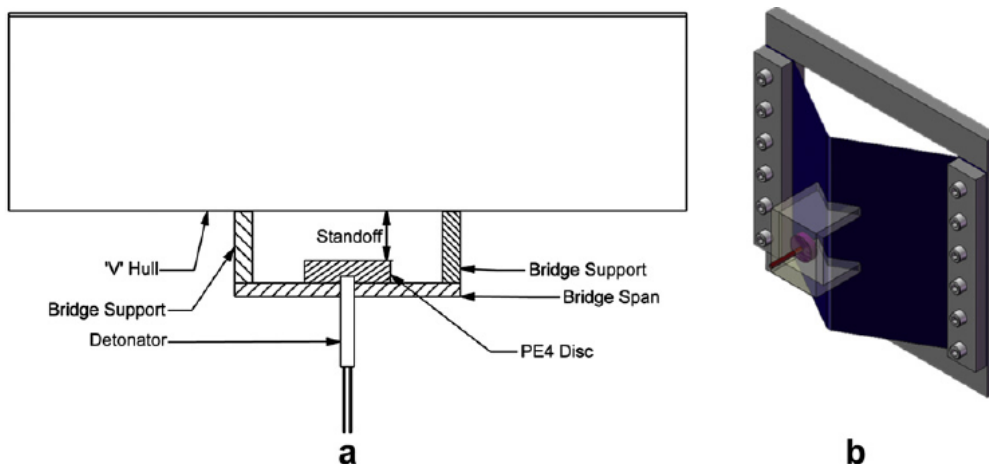
Figure 2. Experimental assembly of the blast loading of V-shaped plate (a) side view and (b) isometric view

(Chung et al., 2012)

2. Method

LS-DYNA, a leading general purpose multi-physics numerical simulation software developed distinctively for nonlinear transient dynamic finite element analysis using explicit time integration was used to simulate the blast loading of V-shaped plates in this study. Twenty-seven numerical simulations were performed to predict the mid-point deflections of previous experimental results for V-shaped plates consisted of 60°, 90°, 120°, 150° and 180° included angles (Chung et al., 2012). In their experimental tests, each of the included angles had variable mass of explosives and stand-off distances that produced different magnitudes of the mid-point deflections on the V-shaped plates. The numerical simulation started with modelling the three dimensional V-shaped plate by using the shell elements in x, y, z Cartesian coordinate system. An equivalent TNT mass was then derived from the PE4 mass used in the experimental test and positioned at the mid-point of the vertex of the V-shaped plate. Static and dynamic mechanical properties of DOMEX 700 were applied to the three dimensional V-shaped numerical simulation models. The boundary conditions for both of the lower edges of the V-shaped plate were fully constrained in all six degree of freedoms since both edges were bolted in the experimental tests. The numerical simulations' models were then processed by using the LS-DYNA solver and the twenty-seven numerical simulations' mid-point deflections were then compared against the experimental tests data; more detailed steps are as shown in the following paragraphs.

2.1 Geometry of the V-Shaped Plate

Figure 3 shows a full three-dimensional finite element analysis V-shaped model with a downward projecting area of 300 mm x 300 mm with included angles of 60°, 90°, 120°, 150° and 180° (Chung et al., 2012). Point A was the starting/reference point of the three dimensional model positioned at (x = 0, y = 0, z = 0) coordinate, point B was the far end of the V-shaped positioned at (x = -300 mm, y = 0, z = 0) coordinate, while point C was the suspended mid-point of the V-shaped length also known as the 'stand-off distance' upon which the explosive was located at (x= -150 mm, y = 0, z = 34 mm). The distance between point A and point B was 300 mm and the distance between edge E and edge D was 300 mm, which would enable the V-shaped plate to produce a 300 mm x 300 mm area in the x-y two-dimensional plane. Different masses of explosives and stand-off distances were applied to point C, according to the parameters as specified in the experimental test data. The model was meshed with 5 mm x 5 mm element size which produced 5,126 elements. This 5 mm x 5 mm element size was chosen after the mesh convergence analysis had been performed, which produced acceptable mid-point deformation and time duration.
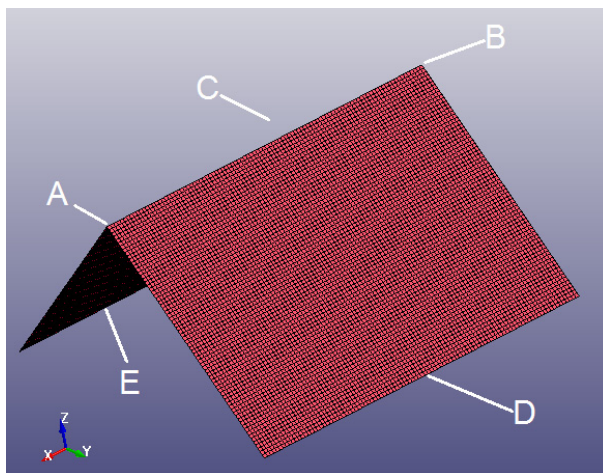
Figure 3. A three dimensional V-shaped finite element analysis model

2.2 Explosive Parameters

The experimental test utilized a cylindrical shape PE4 explosive to replicate the geometry of landmine, which had a 1.3 kg of TNT equivalent of explosive. *LOAD_BLAST_ENHANCED that used equivalent mass of TNT was utilized to model the blast loading effects in LS-DYNA. The equivalent mass of TNT (calculated from the respective amount of PE4 explosive used in the experimental test) that produced spherical air burst had to be positioned at a specific stand-off distance i.e. (x, y, z) coordinate on top of the central midpoint location or at

point C of the V-shaped specimen (see Figure 3). *LOAD_BLAST_SEGMENT_SET was then employed to represent both of the top surfaces of the V-shaped that were directly exposed to the blast loading of the idealised TNT explosive.

2.3 Material Properties and Boundary Conditions of the V-Shaped Plate

The V-shaped plate is made of DOMEX 700 steel (see Tab. 1) and to accommodate the large strain rate and large deformation of the specimen due to the blast loading effects, *MAT_SIMPLIFIED_JOHNSON_COOK (see Tab. 2) was used due to its advantage in reducing computational processing time. *SECTION_SHELL that utilized BELYTSCHKO-TSAY shell element formulation was used to model the V-shaped model with a 2 mm of shell thickness at the four corners of its nodes. Both edges of the model i.e. Edges 'E' and 'D' were fixed and constrained from moving in all directions i.e. in all of the x, y, z, translational and x, y, z, rotational directions to replicate the bolted edges of the specimen in the performed experimental tests.

Table 1. The mechanical properties for DOMEX 700 (Chung et al., 2012)

Density (kg/m^3)	Young's modulus (GPa)	Poisson's ratio
7850	200	0.285

Table 2. Johnson-Cook material properties for the V-shaped plate (Chung et al., 2012)

A (MPa)	B (MPa)	n	C(s^{-1})
818	1423	0.987	0.014

2.3 Processing the Numerical Simulation

*CONTROL_TERMINATION time of 30 milliseconds was chosen to fully capture the whole process of the blast loading for each of the numerical simulation test case. *BINARY_DBASE_D3PLOT with time interval between outputs of 5E-4 seconds was chosen to record the output data. The numerical simulation input file was then processed by using the LS-DYNA solver with hardware capabilities of Intel(R) Core(TM) i5-3210M CPU @ 2.5 GHz, 4.00 GB of RAM, which took around 5 minutes to complete. Upon the successful processing of the numerical simulation, the deflection of the V-shaped model due to the blast loading was obtained by selecting the 'Z-displacement' of the nodal mid-point displacement of the V-shaped model. All twenty-seven numerical simulation results of the mid-point deflections of the V-shaped models and compared against the experimental results are presented in the following section.

3. Results

Mesh convergence analysis had been performed to obtain the optimum element size that could give optimum results for the numerical simulations to predict all of the twenty-seven experimental blast load tests. Table 3 shows the mesh convergence analysis performed to predict the experimental test data of 90° of included angle, 19 g of PE4, and 34 mm of stand-off distance. Three element sizes were utilized in the numerical simulation i.e. 1 mm x 1 mm, 5 mm x 5 mm and 10 mm x 10 mm to predict the experimental mid-point deflection of the V-shaped due to blast loading. It was observed that element size of 5 mm x 5 mm gave the best result with reasonable CPU time duration of around 3 minutes, thus this element size was chosen to be used to produce numerical simulations to predict all twenty-seven experimental tests data.

Table 3. Mesh convergence analysis performed to predict the experimental test data of 90° of included angle, 19 g of PE4, and 34 mm of stand-off distance

Element size	Number of elements	Time duration	Experimental mid-point deflection (mm) (Chung et al., 2012)	Numerical simulation/LS-DYNA mid-point deflection (mm)	% Error
1 mm x 1 mm	127,628	6 hours 30 minutes	3.64	4.17	+14.56
5 mm x 5 mm	5,126	3 minutes	3.64	3.11	-15.0
10 mm x 10 mm	1,300	32 seconds	3.64	1.55	-57.0

Figure 4 shows some of the snapshots progressions of the deformation contours for the V-shaped plate upon blast

loading for one of the numerical simulations' cases i.e., Test number Z5, included angle of 90°, 19 g of PE4 and stand-off distance of 34 mm. It could be observed that the V-shaped plate was in its initial un-deformed geometrical shape at time, at t = 0 millisecond. Immediately after time, t = 0 millisecond until t = 30 milliseconds, the explosive had been detonated and it could be clearly seen that the mid-point area of the V-shaped located directly under the explosive had undergone visible deformations compared to other areas of the plate. The mid-point deformation of the V-shaped plate stabilized around and beyond time, t = 10 milliseconds and the overall registered deformation was recorded as 3.10 mm as shown in Figure 5.

Time = 0 millisecond

Time = 1 millisecond

Time = 5 milliseconds

Time = 10 milliseconds

Time = 20 milliseconds

Time = 30 milliseconds
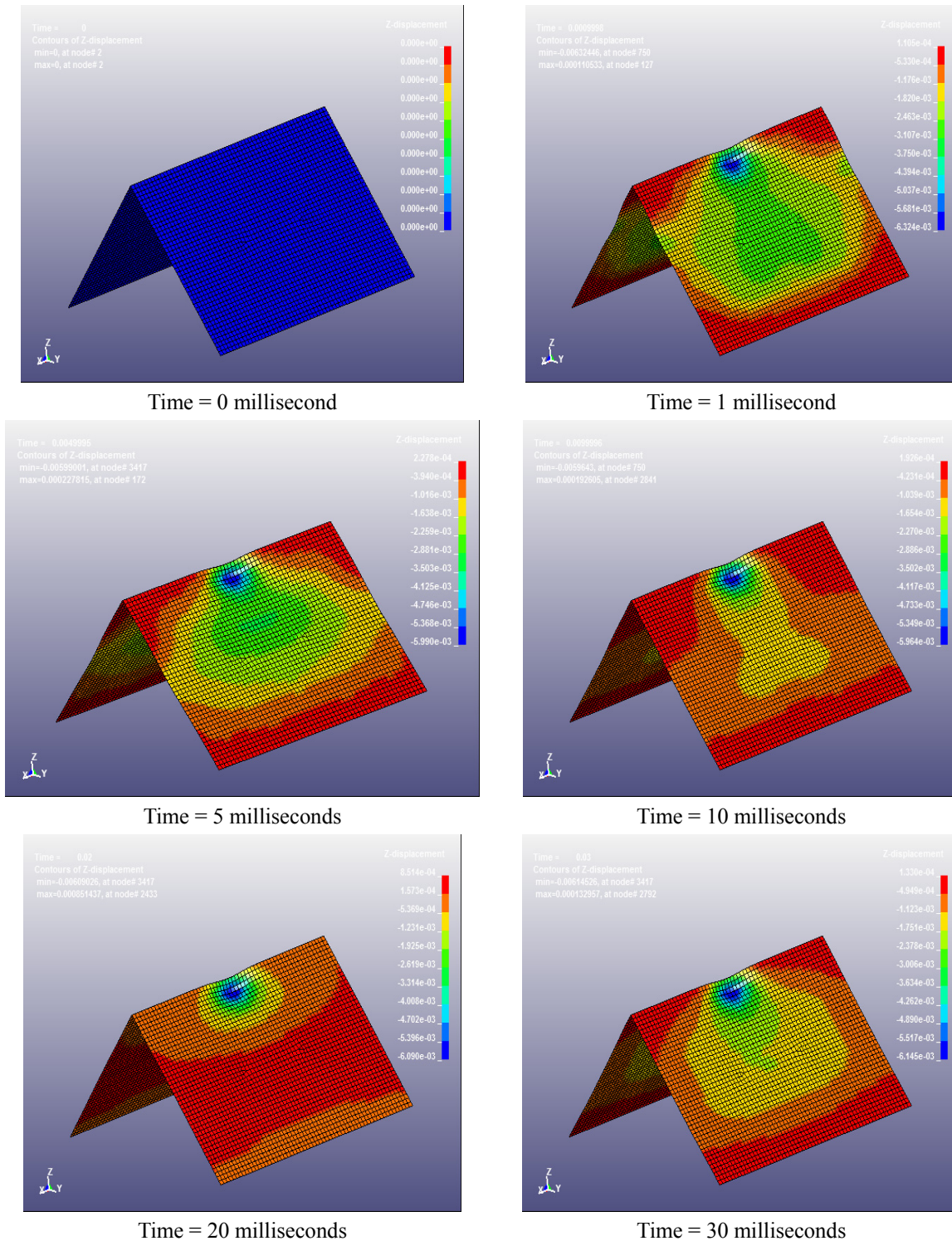
Figure 4. The mid-point deformation contours of the V-shaped plate from 0 millisecond to 30 milliseconds for

Test number Z5, included angle of 90°, 19 g of PE4 and stand-off distance of 34 mm
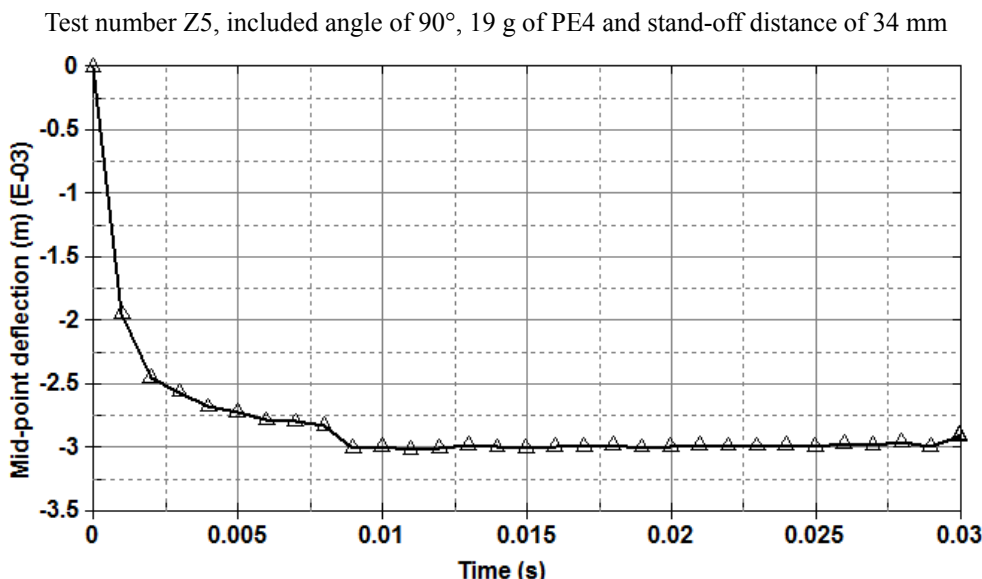
Figure 5. The mid-point deformation of the V-shaped plate plotted against time for time period of 30 milliseconds for Test number Z5, included angle of 90°, 19 g of PE4 and stand-off distance of 34 mm

Table 4 shows the numerical simulations' results that will be compared against the experimental tests data for twenty-seven mid-point deflections of V-shaped plates due to blast loadings as shown by the test number from Test Number Z1 to Test Number Z27. All twenty-seven numerical simulations comprised of different combinations of included angle, mass of explosive and stand-off distance based on the parameters in the experimental tests. It could be observed that the numerical simulations managed to produce relatively good agreement for V-shaped included angles of 60°, 90°, 120° but as the included angles increased i.e. as the V-shaped plate became flat plate for 150° and 180° the percentage errors also increased. Nevertheless, even though the percentage errors were quite large as could be seen in Test number Z1 that had +135% of errors, the real differences were quite 'small' as the dimensions involved were in 'mm' i.e. 0.73 mm as predicted by the numerical simulation as opposed to 0.31 mm obtained in the experimental test. Generally, it could be concluded that the numerical simulations had managed to produce good agreement with experimental results where the overall average percentage differences is 26.6 %.

Table 4. Scaled down experimental test blast loading results used to validate the numerical simulation predictions

Test number	Included angle	Mass of PE4 (g)	Stand-off distance (mm)	Experimental mid-point deflection (mm) (Chung et al., 2012)	LS-DYNA numerical simulation prediction for mid-point deflection (mm)	% Error
Z1	60°	19	34	0.31	0.73	+135.5
Z2	60°	29	34	1.50	1.36	-9.3
Z3	60°	40	34	2.23	2.90	+30.0
Z4	60°	45	34	2.02	3.90	+93.0
Z5	90°	19	34	3.64	3.10	-14.8
Z6	90°	14.5	50	0.71	0.47	-33.8
Z7	90°	29	34	9.03	8.10	-10.3
Z8	90°	29	50	2.56	2.92	+14.1
Z9	90°	40	34	11.65	15.70	+34.8
Z10	120°	19	34	17.74	18.10	+2.0
Z11	120°	29	26	38.33	46.30	+20.8
Z12	120°	29	34	31.01	38.90	+25.4
Z13	120°	29	42	24.76	32.00	+29.2
Z14	120°	29	50	14.29	16.80	+17.6
Z15	120°	35	34	42.66	50.70	+18.8

Z16	120°	40	34	51.09	62.20	+21.7
Z17	150°	5	34	6.28	2.98	-52.5
Z18	150°	10	34	17.51	23.50	+34.2
Z19	150°	12.5	34	28.47	32.50	+14.2
Z20	150°	14.5	34	28.81	38.60	+34.0
Z21	150°	17	34	30.97	46.90	+51.4
Z22	180°	5	34	8.42	6.78	-19.5
Z23	180°	10	34	16.12	27.5	+70.6
Z24	180°	14.5	34	24.26	40.7	+67.8
Z25	180°	19	34	38.72	51.4	+32.7
Z26	180°	21	34	37.38	55.5	+48.5
Z27	180°	23	34	37.88	59.4	+56.8

4. Discussion

4.1 Effect of Explosive Geometrical Shape

One of the possible source of errors is the geometrical shape of the explosive used in the numerical simulation. In their experimental blast tests, all of the explosives used were of cylindrical geometrical shape with varying masses of explosive with the detonator placed at the central location of the cylindrical explosive (see Figure 2) but they did not specify the exact height of the cylindrical parameter. In the numerical simulation, under the *LOAD_BLAST_ENHANCED keyword, only the mass of the explosive and the x, y, z coordinates of the explosive were utilized, i.e. the program modeled the explosive as a spherical geometrical shape, thus the inability to model the exact parameters of cylindrical geometrical shape of the explosive and the limited capability of *LOAD_BLAST_ENHANCED keyword in modeling the explosive as a spherical geometrical shaped played a factor in contributing to the errors produce by the numerical simulations' results.

4.2 Effect of Stand-Off Distance

Another possible source of errors is the inconsistent usage of universal definition of the stand-off distance utilized in the experimental tests and numerical simulations. Figure 2(a) shows the measurement of the stand-off distance used in the experimental test where the stand-off distance represents the measured distance from the outer surface/perimeter of the cylindrical explosive to the vertex of the V-shaped plate. On the other hand, in another reference, the stand-off distance is defined as the measured distance from the most outer surface of a structure to the center point of a spherical shape explosive (Hetherington & Smith, 1994). The non-standard measurement of the stand-off distance does play a significant effect on the outcome of the predicted deformation since a lower value of stand-off distance with constant mass of explosive will mean that the explosive is nearer to the structure thus the blast load will produce higher amount of deformation on the structure and a higher value of stand-off distance with constant mass of explosive will mean that the explosive is further away from the structure thus the blast load will result in lower value of deformation of the structure.

4.3 Percentage Error Reduction

Arbitrary Lagrangian Eulerian (ALE) method can be used in future work to further reduce the errors between the experimental and the numerical simulation data. The *LOAD_BLAST_ENHANCED keyword which was used in this paper utilized a spherical geometry shape of the explosive even though a cylindrical geometrical shape of explosive was used in the experimental test and this factor contributed to the large errors in some of the numerical simulation tests even though a large majority of the numerical simulations had managed to give good predictions with respect to the experimental test. Alternatively, by using the ALE method for future work, the exact dimensions of the three dimensional cylindrical geometrical shape of the explosive can be modeled together with air, explosive and the steel plate, thus will significantly reduce the differences between the numerical simulation predictions and the experimental tests data but the modeling of ALE is far more complex as compared to the *LOAD_BLAST_ENHANCED method.

5. Conclusions

A numerical simulation method with the utilization of LS-DYNA demonstrated case studies of V-shaped plate under blast loading. The numerical results are compared with experimental results from published literature showing close matching. The simulation method may be used for the parametric study of floor designing of personal armor vehicle. The mass of explosive mostly used in IEDs can be taken and simulations performed for different stand-off distance (floor-ground clearance), plate angle and plate thickness. A more thorough parametric

study shall give the optimal design for the V-shaped plate to mitigate blast loadings.

References

Chen, A., Louca, L. A., & Elghazouli, A. Y. (2015). Blast assessment of steel switch boxes under detonation loading scenarios. *International Journal of Impact Engineering, 78*, 51-63. http://dx.doi.org/10.1016/j.ijimpeng.2014.11.019

Chung, K. Y. S., Langdon, G. S., Nurick, G. N., Pickering, E. G., & Balden, V. H. (2012). Response of V-shape plates to localised blast load: Experiments and numerical simulation. *International Journal of Impact Engineering, 46*, 97-109. http://dx.doi.org/10.1016/j.ijimpeng.2012.02.007

Fallah, A. S., Micallef, K., Langdon, G. S., Lee, W. C., Curtis, P. T., & Louca, L. A. (2014). Dynamic response of Dyneema® HB26 plates to localised blast loading. *International Journal of Impact Engineering, 73*, 91-100. http://dx.doi.org/10.1016/j.ijimpeng.2014.06.014

Geretto, C., Chung Kim Yuen, S., & Nurick, G. N. (2015). An experimental study of the effects of degrees of confinement on the response of square mild steel plates subjected to blast loading. *International Journal of Impact Engineering, 79*, 32-44. http://dx.doi.org/10.1016/j.ijimpeng.2014.08.002

Henchie, T. F., Chung, K. Y. S., Nurick, G. N., Ranwaha, N., & Balden, V. H. (2014). The response of circular plates to repeated uniform blast loads: An experimental and numerical study. *International Journal of Impact Engineering, 74*, 36-45. http://dx.doi.org/10.1016/j.ijimpeng.2014.02.021

Li, X., Wang, Z., Zhu, F., Wu, G., & Zhao, L. (2014). Response of aluminium corrugated sandwich panels under air blast loadings: Experiment and numerical simulation. *International Journal of Impact Engineering, 65*, 79-88. http://dx.doi.org/10.1016/j.ijimpeng.2013.11.002

Ma, L., Xin, J., Hu, Y., & Zheng, J. (2013). Ductile and brittle failure assessment of containment vessels subjected to internal blast loading. *International Journal of Impact Engineering, 52*, 28-36. http://dx.doi.org/10.1016/j.ijimpeng.2012.09.004

Micallef, K., Fallah, A. S., Curtis, P. T., & Louca, L. A. (2016). On the dynamic plastic response of steel membranes subjected to localised blast loading. *International Journal of Impact Engineering, 89*, 25-37. http://dx.doi.org/10.1016/j.ijimpeng.2015.11.002

Othman, M. Z., Yuan, L. C., Yusoff, M. A. M., Ghani, A. R. A., Koslan, M. F. S., Jelani, J., & Zaidi, A. M. A. (2015). Numerical Simulations of Exposed Circular Surface of Rolled Homogeneous Armor Steel Plates Subjected to Blast Loadings by using AUTODYN 2D. *Modern Applied Science, 9*(3). http://dx.doi.org/10.5539/mas.v9n3p216

Shen, J., Lu, G., Wang, Z., & Zhao, L. (2010). Experiments on curved sandwich panels under blast loading. *International Journal of Impact Engineering, 37*(9), 960-970. http://dx.doi.org/10.1016/j.ijimpeng.2010.03.002

Spiller, K., Packer, J. A., Seica, M. V., & Yankelevsky, D. Z. (2016). Prediction of annealed glass window response to blast loading. *International Journal of Impact Engineering, 88*, 189-200. http://dx.doi.org/10.1016/j.ijimpeng.2015.10.010

Wang, Y., & Xiong, M. X. (2015). Analysis of axially restrained water storage tank under blast loading. *International Journal of Impact Engineering, 86*, 167-178. http://dx.doi.org/10.1016/j.ijimpeng.2015.07.012

Zhang, X., Hao, H., & Wang, Z. (2015). Experimental study of laminated glass window responses under impulsive and blast loading. *International Journal of Impact Engineering, 78*, 1-19. http://dx.doi.org/10.1016/j.ijimpeng.2014.11.020

Safety of Machinery and Special Scheme of Inspection's Requirement towards Industry Competitiveness in Malaysia

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Abstract

The amendment of the Factories and Machinery Act 1967 (FMA) in 2006, with the inclusion of the new provision on special scheme of inspection takes into account of the development and advancement of technology, particularly on the latest procedure of inspection of plant and machinery in the Malaysian industries. The FMA since 1967 is the safety at work legislation applicable in Malaysia that provides for the control of factories with respect to matters relating to safety, health and welfare of person therein, the registration and inspection of machinery and for matters connected therewith. Inclusion of such provision provides an option to the industry to conduct its special scheme of inspection that analyzes the likelihood of failure and the consequence of the same in its work. This is obviously important for the economic benefits as the implementation of the scheme safeguards the integrity of the plant that will eventually increase the industry productivity and competitiveness. This paper discusses the importance of the inclusion of the special scheme of inspection provision into the statute and how it regulates the implementation of the system in the light of the development of technology in the industry. Analysis was made based on the latest legal documentation enforced relating to special scheme of inspection and with the coming into force of the Factories and Machinery (Special Scheme of Inspection) (Risk-Based Inspection) Regulations on June 1, 2014, the provision under the Factories and Machinery (Amendment) Act 2006 on special scheme of inspection shall now be fully implemented to see the effectiveness of the inspection approach for plant equipment using 'risks analysis'.

Keywords: safety, machinery, special scheme of inspection

1. Introduction

Ensuring safety and health is practiced at the place of work fall under the duty of the employer or occupier of the workplace, and the occupational safety and health legislation have been enacted to provide for the specific provisions to govern safety and health of workers and other persons in the Malaysian industries. The provisions under the legislation encompass matters relating factory and machinery to inspection. In ensuring the safety or reliability of machinery, a mechanical inspection is usually carried out, particularly the testing during the use of such machinery to address the risk of breaking in service. Instances of solid object having the risk of damage or flaws from use are pressure vessels developing cracks in welds, corrosion and erosion in pipelines and pipes carrying products, and concrete structures weakened due to inner reinforcing steel corroded. Thus, inspection is essential as formal evaluation exercise to measure, test and gauge object or activity, using various technologies to analyze materials for either inherent flaws or damage from use.

2. Provisions for Inspection under the Factories and Machinery Act 1967

The important legislation which regulates matters relating to the operation of factory, the installation of machinery, certificate of fitness for certain machineries and the periodical inspections of all machineries is the Factories and Machinery Act 1967 (FMA). Before a person can occupy or use any premises as a factory and install any machinery in a factory, including machinery, which requires certificate of fitness, he must obtain a written permission or approval from the Inspector (s. 34(2) (a), s. 36(1)). In relation to machinery, which requires a certificate of fitness (certificated machinery), the occupier or owner of the factory must serve a written notice

to the Inspector or a licensed person who will make an inspection of the machinery (s. 36(3)). Upon inspection and satisfied with the finding, the Inspector shall issue a certificate of fitness specifying that the machinery has passed the inspection on the date of the inspection (s. 36(4)).

Under the FMA, the types of machinery that requires certificate of fitness are steam boilers, pressure vessels and hoisting machines. The certificate of fitness issued under the FMA 1967 shall be valid for fifteen (15) months from the date of inspection unless in cases where the certificated machinery is out of service for a long period immediately after the inspection by reason of dismantling or repair of any defect. In such case, the Inspector may issue a certificate of fitness effective from the date when the machinery is replaced in service (Regulation 10, Factories and Machinery (Notification, Certificate of Fitness and Inspection) Regulations, 1970). The FMA provides for periodical inspections of factory or machinery including all certificated machineries, which is the essential requirement where the Inspector or a licensed person shall inspect the factory, or machinery at the prescribed periods. There are initial inspection and regular inspection to be carried out by the authority. 'Initial inspection' is an inspection of any machinery or factory carried out by the Inspector subsequent to service of notices to the Inspector in respect of premises to be first used as a factory, or an inspection of any machinery for which a certificate of fitness is required (Regulation 2, Factories and Machinery (Notification, Certificate of Fitness and Inspection) Regulations, 1970).

After an initial inspection every factory and machinery shall be inspected at regular intervals by the Inspector so long as the factory remains in operation or the machinery remains in use. The 'regular inspection' shall be carried out during the fifteen (15) months following the month in which the last inspection was made, subject to an extension not exceeding thirty six (36) months, as may be authorized by the Chief Inspector. In cases of extension allowed by the Chief Inspector, the regular inspection shall be carried out during the month following the expiry of the extended interval (Regulation 14, Factories and Machinery (Notification, Certificate of Fitness and Inspection) Regulations, 1970). Postponement of regular inspection is allowed under Regulation 15 upon the owner's request, with good and sufficient reason. However, the postponement period allowed is not more than three (3) months after the date due or the date on which certificate of fitness expires. There are certain fees charged for these inspections.

Apart from the initial and regular inspection, there is also supplementary inspection and special inspection provided under the Factories and Machinery (Notification, Certificate of Fitness and Inspection) Regulations (1970). Supplementary inspection is in addition to the initial and regular inspections of a steam boiler and unfired pressure vessel, and shall be made by the Inspector within a period of three (3) months subsequent to the date of the initial and regular inspection (Regulation 19, Factories and Machinery (Notification, Certificate of Fitness and Inspection) Regulations, 1970). For special inspection, it is made by the Inspector upon written request of a prospective purchaser of any machinery (Regulation 20, Factories and Machinery (Notification, Certificate of Fitness and Inspection) Regulations 1970).

3. What Involve in the Preparation for Inspection?

As far as the preparation for inspection is concerned (under Regulation 17 of the Factories and Machinery (Notification, Certificate of Fitness and Inspection) Regulations, 1970), the owner of any machinery must ensure that the machinery is prepared for inspection in accordance with the regulations.

For steam boiler, it must be emptied, cooled and dried and has been thoroughly cleaned inside and outside; all firebars and firebridges have been removed; all smoke-tubes, exterior of water-tubes, furnaces, smoke-boxes and external flues have been thoroughly cleaned; all manhole, handhole and sighthole doors and cleaning plugs have been removed; all cocks and valves have been dismantled, cleaned and ground where necessary. The steam boiler must also has been effectively disconnected from any other steam boiler and source of steam or hot water; and other special requirements in respect of the drilling of any plates, the removal of any lagging, brick-work or masonry, the preparations for a hydrostatic test of the steam boiler, or its mountings and associated piping, the withdrawal of tubes, the verification of the pressure gauge, and the dismantling for inspection of any part of any associated steam engine (Regulation 17(a), Factories and Machinery (Notification, Certificate of Fitness and Inspection) Regulations, 1970).

For unfired pressure vessel, the preparations are almost the same like for the steam boiler (Regulation 17(b)). In respect of hoisting machine, the occupier or owner must make arrangements to enable the hoisting machine to be tested under conditions of maximum safe working load and so as to cause all safety devices to function (Regulation 17(c)). In respect of other machinery, the occupier or owner must make arrangements so far as practicable to operate any driven machinery under maximum load and to have all safety devices in proper working order (Regulation 17(d)).

Hence, where above inspection is concerned, if the machinery is not prepared for inspection on a visit by the Inspector, he may refuse to make or complete the inspection and shall inform the occupier or owner in writing of his reason for such refusal and appoint other date and time for inspection (Regulation 18(1)). This is very much related to the safety matter of the machinery or equipment involved, as well the safety of the Inspector having the duty to inspect them.

The above requirements show that the preparation for inspection involves shutdown of plant or machinery, stop of production or downtime and a break of continuity in business operation. In the practice of preparing the factory or machinery particularly the certificated machinery, for inspection, it does involve costs (tangible and intangible loss) during the period of shutdown of the factory or machinery. For example, the steam boiler needs to fulfill all the requirements under Regulation 17 and thus, the direct costs would include stop of work production, contracting out of works to contractors for shutdown purposes, inclusive of but not limited to cleaning, replacing parts of the machinery, repairing and maintaining the machinery. The direct costs for the shut down of plant or machinery may vary from RM5,000 to RM500,000 daily or RM20,000 to RM50,000,000 in total.

4. Why Special Scheme of Inspection?

Notwithstanding the importance of inspection for machinery used in the industry, the time-based inspection or conventional inspection (for minimum compliance of the rules and regulations for inspection) may involve business interruption inclusive of operational costs, unplanned shutdowns, equipment damage, and cause serious disruption in plant operations. For industry like oil and gas, nuclear power generation, and in refineries and petrochemical plant, the change from conventional or traditional inspection methods is a cost effective alternative that offers safer results and more reliable plant operations (SGS Group, 2008). Managing the integrity of plant and planning inspection from assessments of the risks of failure of the plant is the duty of owner and user of the plant. The responsibility is to implement the risk assessment and inspection planning processes effectively and in an appropriate manner (Wintle et al., 2001). An optimization formulation involves maximizing the expected service life and minimizing the expected total life-cycle cost consisting of inspection and maintenance costs; and the optimum inspection and maintenance types and times are gained through this formulation. This is crucial in inspection and maintenance planning of deteriorating structures (Kim et al., 2013).

This cost effective alternative refers to the 'special scheme of inspection' (SSI) provided under the Factories and Machinery (Amendment) Act 2006, whereby the provision for SSI takes into account the effective method of inspection for plant and machinery in the industry. This approval by the Chief Inspector for the use of SSI was made possible during the amendment to the FMA 1967, which was gazetted on 14 September 2006 and enforced on 1 January 2007. Under the FMA (Amendment) Act (2006), the additional provision Section 40(5) on SSI provides for the factory owner or occupier to make application to the Chief Inspector for an approval to conduct SSI. The approval of the application must be satisfied to have fulfilled the prescribed requirements relating to SSI, and upon approval, the inspection of the machinery shall be conducted according to the SSI (s. 40(7)).

By inserting the above provision, an option is thus provided to the industry to conduct its special scheme of inspection that analyzes the likelihood of failure and the consequence of the same in its work. This will provide the economic benefits and safeguard the integrity of the plant in the industry that will eventually increase the productivity and competitiveness of the industry. Malaysia, as a small and highly open economy is vulnerable to developments in the external environment. Real GDP is expected to register a growth of 4.5%-5.5% in 2015 supported by resilient domestic economic activity and by expansion in all economic sectors. Construction-related is expected to remain favorable and despite some investment cutback in upstream oil and gas activities, the mining sector is anticipated to expand, supported by higher crude oil output (Economic Report 2015/2016).

The purpose of the SSI is thus to provide economic benefits in terms of fewer inspections, minimum duration of shutdowns, longer run length and less frequent shutdowns, to safeguard integrity and improve reliability and availability of the plant equipment, and to move from a reactivate to proactive maintenance regime. This is opposed to the time-based or conventional inspection where the machinery has to be shut down every fifteen (15) months for regular inspection, which is not economical for the industries in terms of spending costs particularly for the oil and gas industry. One of the SSI approaches that are widely used by the oil and gas industries is known as the Risk-Based Inspection (RBI); an inspection approach for plant equipment using 'risks analysis'. Most often, RBI is used in engineering industries and predominant in oil and gas industry.

RBI is a technique used to reduce direct inspection costs for genuine cost saving. RBI is a combination of technologies, providing industries with a risk-based method towards evaluating and developing inspection plans (Kallen, 2002). The focus is on critical plant and it identifies priorities for inspection based on its failure risk.

RBI recognizes that there is little point to spending good money on very frequent inspection of something that is very unlikely to fail, or if it fails would have little financial or safety consequence (IET, 2007). RBI is thus a systematic and standard method for prioritizing inspection activities to focus first on 'high-risk' assets. Risk is the likelihood of occurrence and the consequence of failure. The likelihood and consequence will produce an estimate of risk and the risk factor can then be ranked and used to govern inspection schedules (Ramesh, 2005). It means the consequences and likelihood factor is used to identify which equipment poses the greater risk and therefore demands the most inspection attention in order to effectively manage the associated risk. The 'risk' in RBI refers to the need to prioritize the schedule of inspections that include various forms of non-destructive testing (Wiseman, 2008). In other words, RBI is a tool to firstly select which items require attention and next is to plan on inspecting the component or system, especially the high-risk components which had been identified (Kallen, 2002).

Thus, the various standard engineering calculations and models of corrosion rates would determine the decisions to be made. The calculations provide estimated time to reach an unsafe condition and a safe schedule for the next inspection (Wiseman, 2008), based on the consequences of possible failures and the likelihood of the failures as highlighted above (Kallen, 2002). There is RBI methodology commonly used within the chemical, petrochemical, and the oil and gas refinery that assesses risk to support the inspection planning. The risk-based inspection methodology shall provide recommendation on what, when, where and how to inspect, and also what should be documented based on the risk value calculated (Selvik et al., 2011). The international engineering standards and practices that relate to RBI include API RP 580 and 581, and ASME PCC-3. API RP 580 is the minimum guidelines in implementing effective and credible RBI program, and API RP 581 is the example of RBI methodology's technical basis.

The benefit of RBI is the minimization of potential losses in terms of safety, environmental impacts, equipment damage, and business interruption (Quest, 2008). Its utility is based on the rough premise that 10% of the equipment in a process contributes 90% of the risk. Consequently, if this 10% of the equipment can be identified, testing and inspection can be focused on it rather than low-risk items. This approach is clearly preferable to the usual method of treating all equipment equally, notwithstanding its risk contribution. Therefore, RBI permits companies to prioritize their equipment for inspection, optimize inspection methods and frequencies, and develop specific equipment inspection plans. As there are fewer forced shutdowns and reduction in operational costs, it hence resulted in improved safety (PrimaTech, 2008). Effective implementation of RBI program also extends the operating life of equipment and it is accepted as good engineering practice for the implementation of inspection and maintenance programs (Ramesh, 2005).

Since the probability that any component of the facility fails during operation is there, a risk-based inspection planning is crucial where RBI approach takes basis in a quantification of risk, thus different strategies, effort, quality of inspection and costs will give different impact on the risk (Faber, 2000). In the risk-based inspection planning for offshore production facilities for instance, engineering systems are designed to ensure an economical operation throughout the service life, to comply with the acceptance criteria, which are related to the safety of personnel and risk to the environment. In carrying out a piping inspection effectively, both a qualified Non-Destructive Examination (NDE) Inspector and right inspection procedures are essential requirements, and relies on highly skilled inspectors who are familiar with the environment in the workplace (Chang et al., 2005). Hence, RBI is carried out to ensure that the physical condition of the installation remains within design limits and continue in operation safely during its lifetime and risks to personnel and the environment are maintained as low as reasonably practicable (Goyet, 2000).

5. Application for Risk-Based Inspection Scheme under the Regulations

The new Factories and Machinery (Special Scheme of Inspection) (Risk-Based Inspection) Regulations 2014 made by the Minister had came into force on June 1, 2014 in furtherance to the new SSI provision being inserted in the Factories and Machinery (Amendment) Act 2006, to give heavy industry operators options for a risk-based inspection of their machineries under a special scheme of inspection. The implementation of this scheme meant that the statutory inspection interval of fifteen (15) months for certificated machineries would be extended and would bring cost saving in the long run, especially to the oil and gas and power sectors.

Under the Regulations, "risk-based inspection" is defined as means of inspection on the interior and exterior parts of a pressurized machinery the interval of which is determined based on the category of risk associated with the pressurized machinery, and "risk-based inspection scheme" means a special scheme of inspection which is based on a risk-based inspection. Pressurized machinery includes a steam boiler and an unfired pressure vessel used for processing or storage purposes, and this pressurized machinery comprises of "time-based pressurized

machinery" which holds a time-based certificate of fitness and "risk-based pressurized machinery" which holds a risk-based certificate of fitness (s.3).

The Regulations provide the requirement whereby the applicant will have to make a written application to the Chief Inspector for the approval of a risk-based inspection scheme in respect of the time-based pressurized machinery, with a processing fee of RM50, 000, at least six months before the expiry of the time-based certificate of fitness (s.4). Further upon receiving the application, there will be a risk-based audit conducted by an Inspector in the Department of Occupational Safety and Health (DOSH), to verify the requirements for the application (s.6). Once the audit completed, a risk-based inspection shall be conducted on the time-based pressurized machinery. Payment of the prescribed inspection fee shall be made upon completion of the risk-based inspection and upon the applicant being notified by the Inspector (s.7). In any case where the Inspector has refused to make or complete the risk-based inspection due to the reason that the time-based pressurized machinery is not prepared for the risk-based inspection, then the inspection fee shall be charged at the rate of twenty-five (25) per cent of the full amount.

The approval would be granted for the risk-based inspection scheme and the risk-based certificate of fitness would be issued by the Chief Inspector (s.8). The duration granted for the risk-based inspection scheme will last for one hundred and fifty (150) months unless revoked or terminated (s.9), and the risk-based certificate of fitness issued shall be valid for a period to be determined by the Chief Inspector (based on the calculation and evaluation of the risk-based data provided), but shall not exceed seventy-five (75) months (s.10).

6. Requirements for Application for Approval of Risk-Based Inspection Scheme

Among the important requirements to be provided for the application for approval are the establishment of the occupational safety and health (OSH) management system in place; the state of working condition of the time-based pressurized machinery must be satisfactory or fit for service; risk-based data is available in relation to the initial and regular inspection under the time-based inspection; the risk-based data collected is calculated and evaluated to determine the remnant life, category of risk, proposed inspection interval, and proposed inspection plan; the methodology for calculation and evaluation of risk-based data is maintained and applied; the establishment of a risk-based inspection team that consists of a team leader (qualified person who has adequate knowledge and experience to execute all tasks relating to the risk-based inspection scheme), an engineer with corrosion engineering knowledge and expertise, a representative from the process or production department, a representative from the inspection or engineering department, and a safety and health officer or a person in charge of occupational safety and health at the workplace (ss.12-17).

The Regulations also provide provisions for the renewal of the certificate, whereby the scheme user must submit the application three months before the expiry of the risk-based certificate of fitness (s.23). The validity period of the risk-based certificate of fitness shall be determined by the Chief Inspector bur shall not exceed seventy-five (75) months or the remaining duration of a risk-based inspection scheme, whichever is the shorter (s.28).

An application can also be made for new duration of risk-based inspection scheme, to be submitted at least six months before the expiry of the existing duration of the risk-based inspection scheme (s.35). There will also be a risk-based audit to be conducted by the Inspector and if the approval is granted, the new duration of a risk-based inspection scheme shall be for another one hundred fifty (150) months unless the scheme is revoked, deemed to have been revoked or terminated under the Regulations (s.40). During the duration of a risk-based inspection scheme, the Inspector of DOSH may conduct a risk-based audit at any time to verify all the requirements specified have been fulfilled (s.43). The Inspector may also conduct a risk-based inspection at any time during the duration of a risk-based inspection scheme, to ensure the integrity and strength of the risk-based pressurized machinery (s.44).

7. Conclusion

The change from conventional or traditional inspection method to the risk-based inspection scheme is certainly a cost effective alternative for reliable plant operations and minimization of potential losses in terms of safety, environmental impacts, equipment damage and business interruption. In order for the Malaysian industries to remain competitive, in particular oil and gas and power sectors, the development of the legal framework of the Malaysian law relating to safety at work including machinery safety, has provided for the option to the heavy industry operators to implement the special scheme of inspection for their plants. Positively, the economic benefits in terms of fewer inspections, minimum duration of shutdowns, longer run length and less frequent shutdowns should safeguard the integrity and improve reliability and availability of the plant, as the implementation of the special scheme of inspection had made a move from a reactive to proactive maintenance regime. Thus, with the coming into force of the Factories and Machinery (Special Scheme of Inspection)

(Risk-Based Inspection) Regulations on June 1, 2014, the provision under the Factories and Machinery (Amendment) Act 2006 on special scheme of inspection shall now be fully implemented to see the effectiveness of the inspection approach for plant equipment using 'risks analysis'.

References

Chang, M. K., Chang, R. R., Shu, C. M., & Lin, K. N. (2005). Application of risk based inspection in refinery and processing piping. *Journal of Loss Prevention in the Process Industries, 18*(4-6), 397-402, July-November, 2005.

Economic Report. (2015/2016). Retrieved from http://www.treasury.gov.my/pdf/ekonomi/er/1516/chapter3.pdf

Faber, M. H. (2001). Risk Based Inspection and Maintenance Planning. *Proceedings to International Workshop* (14-15, Dec, 2000). Zurich.

Factories and Machinery (Notification, Certificate of Fitness and Inspection) Regulations. (1970). Retrieved from http://www.dosh.gov.my/index.php/en/legislation/regulations-1/regulations-under-factories-and-machinery-act-1967-act-139

Factories and Machinery (Special Scheme of Inspection) (Risk-Based Inspection) Regulations. (2014). Retrieved from http://www.dosh.gov.my/index.php/en/legislation/regulations-1/regulations-under-factories-and-machinery-act-1967-act-139

Factories and Machinery Act. (2015). Retrieved from http://www.dosh.gov.my/index.php/en/legislation/acts/26-03-factories-and-machinery-1967-revised-1974-acts-139/file

Goyet, J. (2001). Integrated Approach for RBI of Offshore Installations. *Proceedings to International Workshop* (14-15, Dec., 2000). Zurich.

IET (The Institution of Engineering and Technology). (2007). Risk Based Inspection. *Health and Safety Briefing, 27*. Retrieved from http://www.theiet.org/factfiles/health/hsb01.cfm?type=pdf

Kallen, M. J. (2002). *Risk based inspection in the process and refining industry* (Master's thesis). Technical University of Delft, Delft, the Netherlands. Retrieved from http://www.ewi.tudelft.nl/fileadmin/Faculteit/EWI/Over_de_faculteit/Afdelingen/Applied_Mathematics/Risico_en_Beslissings_Analyse/Theses/MJK_thesis.pdf

Kim, S., Frangopol, D., & Soliman, M. (2013). Generalised Probabilistic Framework for Optimum Inspection and Maintenance Planning. *J. Struct. Eng., 139*(3), 435-447, March, 2013.

Patel, R. J. (2005). *Risk Based Inspection*. 3rd MENDT-Middle East Nondestructive Testing Conference & Exhibition, 27-30, Nov., 2005. Manama, Bahrain.

PrimaTech (Primatech Training Institute). (2008). *Risk-Based Inspection*. Retrieved from http://www.primatech.com/images/docs/brochure_training.pdf

Quest Reliability. (2008). *Risk-Based Inspection*. Retrieved from http://www.questintegrity.com/services/engineering-and-consulting/risk-based-inspection

Selvik, J. T., Scarf, P., & Aven, T. (2011). *An Extended Methodology for Risk Based Inspection Planning*. RT&A #01(20) (Vol. 2), 2011

SGS Group. (2008). *Risk-Based Inspection*. Retrieved from http://www.sgs.com/en/oil-gas/asset-integrity-management-services/risk-based-inspections

Wintle, J. B., Kenzie, B. W., Amphlett, G. J., & Smalley, S. (2001). *Best practice for risk based inspection as part of plant integrity management.* Retrieved from http://www.hse.gov.uk/research/crr_pdf/2001/crr01363.pdf

Wiseman, M. (2008). *Risk Based Inspection*. Retrieved from http:// www.omdec.com/wiki/tiki-view_forum_thread.php?comments_parentld=349&topics_offset=49&forumld=2&

The Participants' Perspective on a Cognitive Rehabilitation Program Following Traumatic Brain Injury

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Abstract

Given the recommendations for evidence-based treatment practice, rehabilitation programs are typically evaluated using standardized objective measures of pre- and post-treatment performance. However, the potentially informative opinions and perspectives of the participants themselves are not reported. This paper sought to redress this imbalance by using a semi-structured telephone interview to gather feedback from 19 participants who had undergone a group-based eight-week cognitive rehabilitation program to improve attentional impairment following traumatic brain injury (TBI). The program incorporated cognitive training using an action video game and psycho-education, including a workbook for developing compensatory skills. Findings indicated that the majority of participants found the program to be a positive experience, resulting in self-perceived skill development that generalized beyond the training context. Participants particularly valued the social aspects of the rehabilitation program and reported benefiting from their interactions with the other group members. Most enjoyed the action video game playing, although for some, the opportunity to select between a set of different games rather than playing the single game that featured in the program would have been more appropriate. The majority of participants also found the workbook helpful. Other useful suggestions included extending the program to 10-12 weeks, increasing group size, developing more of a 'take away' aspect of the program to be administered at home, and formalizing the 'mentoring' roles that emerged in the group.

Keywords: cognitive rehabilitation, cognitive remediation, traumatic brain injury, attention, patient perspective

1. Introduction

Traumatic Brain Injury (TBI) is a major cause of impairment and disability and research into rehabilitating these deficits is an area of increasing interest. Research to date has focused primarily on systematically reviewing and empirically evaluating cognitive rehabilitation (CR) programs (Carney et al., 1999; Chesnut et al., 1999; Cicerone et al., 2000; Cicerone et al., 2005). However, while evaluating the effectiveness of a program through measuring objective changes in test performance and other interviewer-based measures is crucial, some potentially valuable information can be lost, especially with regard to the subjective experiences of the persons undergoing rehabilitation. This information is highly valuable to researchers and clinicians alike when developing rehabilitation programs. Given the often ignored value of the perspectives of participants in a rehabilitation program, this paper represents a shift of focus to highlight the subjective opinions of the participants.

During the process of empirical research, clinicians and researchers often become aware of the perspectives of the participants and these may be reported anecdotally, but they are rarely systematically recorded so that quantitative data can be reported. While anecdotal reports can be valuable, the inclusion of such quantifiable data, even if in the form of simple frequencies, is important to advance the scientific evaluation of programs and also to allow the replication of methodology, as well as to extend evaluation of the generalization of post-treatment improvements. However, such data is also very important for a number of other reasons. First, the participants' opinions of the strengths and weaknesses of a particular program, plus their ideas to improve on the existing program, may guide further modifications to improve future application of CR programs in the brain injury units. Second, it is important to know how participants perceive the impact of the program on their daily functioning so as to better understand generalization. For example, some behavioural changes post-treatment might be

automatic while others will require intentional effort to bring about the changes, for example, in new activities being attempted or in old activities being resumed. It is unlikely that the patients will intentionally try to change such behaviours post-treatment if they do not believe that the program has had an effect on their functional abilities. Additionally, clinical experience has been that participants in rehabilitation programs can experience negative emotions at the cessation of programs due to the withdrawal of treatment and contact with others. It is important to identify such cases so as to intervene.

For the aforementioned reasons, the current study used a brief semi-structured telephone survey to evaluate the participants' thoughts on their participation in a CR program to rehabilitate attentional deficits following TBI using action video-game playing and a psycho-education component, including a workbook for developing compensatory skills (see Valkili & Langdon, submitted, for full details). In brief, participants had attended a two-hour group rehabilitation session at their Brain Injury Unit (BIU) once a week for eight weeks. Groups consisted of four to five participants. In each session participants played "Medal of Honor: Rising Sun" (MoHRS; Electronic Arts, 2003) for approximately three-quarters of the session, and the remainder of the time was dedicated to a psycho-education program addressing some of the common consequences of brain injury and introducing compensatory strategies. The survey being reported here was administered over the phone following completion of this program and the pre/post treatment assessments.

2. Method

In the treatment study under specific investigation, 31 participants were recruited from two brain injury rehabilitation units in Sydney, Australia. Eleven participants dropped out of the treatment study before completion (five in the original treatment group and six in the waitlist group who were later offered treatment after completion of the formal post-treatment assessment phase), leaving 20 participants to complete the survey. Nineteen out of the 20 participants agreed to complete the survey, and one participant could not be contacted. All 19 had thus undergone the treatment program, were male, aged between 18 and 65 years old, and had sustained a TBI at least one year prior to the program.

A brief phone survey was administered within 30 days of completing the eight-week CR program. The survey was administered by a third party researcher (not the researcher who ran the groups) to allow the participants to express their views openly. The survey was structured to allow closed- and open-ended responses. The following questions were asked of each participant:

- What did you like best about the video game research?
- What did you like about the video game "Medal of Honor"?
- What did you like about being part of a group each week?
- Did you find the workbook helpful?
- Do you think it improved any of your skills/helped you learn other things?
- Do you think those skills will be useful in other things you do?
- What did you like least about the video game research?
- How did you find the group of people you were with?
- How did you manage travelling in to the BIU each week?
- Was eight weeks long enough, or too long?
- Any suggestions for improvements to the video game group that you would like to make?
- Location
- Duration (number of weeks, and two-hour sessions)
- Number in group
- Any other comments that you would like to make? Prompt- how did you feel when the group ended?
- Would you like to keep being part of a video game group?
- If yes, would you want to do this yourself at home, or as part of a group?
- Where do you think is a good place for a group to meet to play video games? (prompts: local library, Brain Injury Unit, Brain Injury Association)
- Would you like to take part in a research project like this in the future?

- Can you please tell me the reason/s you would/wouldn't like to take part?

Responses were coded, as appropriate, and simple frequencies and percentages are reported.

3. Results

- What did you like best about the video game research?

A total of 26.3% of participants referred to the social or entertainment aspects of the CR program, indicating that they enjoyed meeting new people, getting out of the house and having fun. Another 21.1% reported enjoying the content of the video game most. Another 15.8% referred to the cognitive benefits of training, and 15.8% gave very general positive responses such as "everything". Only 10.5% gave a negative response, such as "nothing" or indicating that it was a waste of time. One participant indicated monetary gain as the best thing about the program and one did not respond. Table 1 below summarises some of the responses for each categorisation.

Table 1. Responses to the question "What did you like best about the video game research?"

	Frequency	Sample Responses
Social or entertainment value	5	"Meeting new people" "Enjoyable" "Got me out of the house" "It was different, relaxing" "I got to have fun"
Reference to the Video Game	4	"It was a medium I was familiar with. I spend a lot of time playing computers" "Playing the shooting games" "It was challenging to get over the bridge and to the other side" "Didn't die (in the video game), could keep coming back to life"
Cognitive Training	3	"Taught me different mental skills, anger management, better thinking skills" "Helpful to get on everyday and teach strategies. Exercise brain" "Things were actually explained to me. It provided education about my injury"
General Positive Response	3	"Everything" "Alex was good at explaining things" "It was a bit hard and a bit easy (it was a challenge but also got some things right)"
Negative Response	2	"Was a waste of time" "Nothing- I had a breakdown halfway through. Couldn't handle things"
Monetary Gain	1	"Got paid to do it"
No response	1	

- What did you like about the video game "Medal of Honor"?

When asked about the video game in particular, 36.8% of participants said they liked the game content, such as the shooting action and the challenge of trying to get to the next level. Another 21.1% reported liking the game for the rehabilitation outcomes, for example, commenting on the challenges and the cognitive exercise it provided. And 10.5% liked the game but provided general reasons, such as it being a different thing to do and the competitive nature of it. Only 21.1% reported not liking the game, for example, finding it too hard or not liking the action content. Table 2 below summarises some of the responses for each categorisation.

Table 2. Responses to the question "What did you like about the video game Medal of Honour?"

	Frequency	Sample Responses
Positive Response: Game Related	7	"Didn't die (in the video game), could keep coming back to life" "Trying to get to the next level" "It was a first person shooter, I have played these games my entire life" "It was good I like shooting games"

		"I got to shoot people"
		"It had strategy and had to figure out who to shoot"
		"The game in general and playing it with others"
Positive Response: Rehabilitation Related	*4*	*"Good - could practice what I learnt each week"*
		"Challenged me"
		"Enjoyed- good works the brain. But too difficult, get frustrated"
		"A good thinking game"
Negative response	*4*	*"Didn't like the second part of the game as it was too hard but other part was good"*
		"Not into video games"
		"Didn't like it, difficult to figure out"
		"Hated it- Worst game to play given my situation, i.e.,thoughts of violence"
Positive Response: General	*2*	*"Different thing to do"*
		"Very competitive"
No response	*2*	

- What did you like about being part of a group each week?

When asked specifically about the group, 57.9% responded positively to the social aspect of the group, identifying relating to others, learning about others, helping others and making friends as their favourite part of being in the group; 21.1% responded positively to the personal benefit that came from working in a group, such as realising they were not alone and striving to reach the level others were at; 5.3% responded positively but very generally ("It was good"). Only 10.5% responded negatively about the group, saying that they didn't care or didn't like anything about the group. Table 3 below summarises some of the responses for each categorisation.

Table 3. Responses to the question "What did you like about being part of a group each week?"

	Frequency	*Sample Answers*
Social	11	*"Relating to other people in the group. Thinking better as a result of the program - thinking before speaking, answering questions better"*
		"Finding out different things about others"
		"Talking to new people"
		"Loved it- loved helping each other out"
		"Like working with family - talking to others, social"
		"Got to meet other people with a brain injury"
		"Made friends"
		"Socialising"
		"Enjoy the game together"
		"It helps you more and makes the experience entertaining"
		"Good to relax with other people and help others"
Positive Response: Benefit to self	4	*"Help clarify things and explain why I snap at people"*
		"Realised I'm not alone"
		"Didn't mind. There were some nice people there, better than doing it alone"
		"Good. I was the worst one there. I did my best. I strived to get to their level"
Positive Response: General	1	*"It was good"*
Negative Response	2	*"Nothing"*
		"I didn't care about the group thing. I just went every week. It came down to how you played by yourself"
No response	1	

- Did you find the workbook helpful?

Fifteen of nineteen, or 78.9% of participants reported finding the workbook helpful. Another 10.5% (2/19) reported that it was not helpful, and 10.5% (2/19) were neutral in their response.

- *Do you think it improved any of your skills/helped you learn other things?*

When asked about any improvement in skills gained from training, 78.9% (15/19) identified benefits such as concentration, organisation and managing tiredness, while 10.5% (2/19) of participants did not see any benefits from the training. One participant identified worsening skills (5.3%) and another one (5.3%) was uncertain. Table 4 provides some examples of the positive responses.

Table 4. Responses to the question "Do you think it improved any of your skills/helped you learn other things?"

	Frequency	Sample Responses
Positive Response:	15	*"Little bit - concentration, ability to get up and get organised"*
		"Helped with attitude and getting less upset"
		"I think so- help understand and manage my tiredness"
		"Yes helped exercise my brain"
		"Yes I realised I'm not alone and I'm one of the lucky ones"
		"Definitely - benefit wasn't just from the game itself"
		"Helped because it was stimulating and challenging"

- *Do you think those skills will be useful in other things you do?*

With regard to the generalisation of skills, 73.5% (14/19) identified cognitive and emotional benefits from training, while 21.1% (4/19) did not think they would derive any benefit from the treatment. One participant (5.3%) identified bowling as a specific improved skill. Table 5 below provides examples of the positive responses.

Table 5. Responses to the question "Do you think those skills will be useful in other things you do?"

	Frequency	Sample Response
Positive Response: Cognitive and Emotional	14	*"Yes - can plan things better"*
		"Yes - problem-solving"
		"Memory and got my brain going"
		"When driving and helped with strategies and patience"
		"Yes, improved the way I approach situations and behave in them"
		"Anger management, dealing with things, stopping to think before I do or say things"
		"Makes things easier and teach to become more patient in everyday life. Help me socialise more after head injury"
		"It helped me to catch dropped objects. Faster reaction times"
		"Due to the group environment, I knew I could catch up. It helped me with perseverance"
		"Yes helped me understand things so I can change before I react"

- What did you like least about the video game research?

When asked about what they least liked, 52.6% (10/19) could not identify anything they did not like; and 21.1% (4/19) identified the particular video game as their least favourite. One participant (5.3%) 'hated' the pre- and post-assessments, while one participant (5.3%) did not like the travel involved to attend and one participant (5.3%) found the furniture in the testing room used for the assessments uncomfortable. Two (10.6%) responded 'don't know'. Table 6 below provides examples of the negative game comments.

Table 6. Responses to the question "What did you like least about the video game research?"

	Frequency	Sample Responses
The Video	4	*"Sometimes the game went too fast"*
		"When I got shot I didn't like to go back to the beginning. It was frustrating to go

Game	*back and start from the beginning"*
	"The video game"
	"Can't remember. Maybe a variety of games would have been good, not just one game. Maybe a puzzle game would be helpful"

- How did you find the group of people you were with?

When asked about the other people who were in the group, 78.9% (15/19) of people responded positively, indicating that they enjoyed and benefited from the group component of the program. Another 15.8% (3/19) responded negatively to the group component; two of these responses regarded being bothered by a single other participant. One person (5.6%) failed to respond.

- How did you manage travelling in to the BIU each week?

Regarding travel, 78.9% (15/19) did not report any problem in travelling to their BIU to take part. The remaining 21.1% (4/19) reported a negative reaction to the travel; for two of these participants parking was the main problem.

- Was 8 weeks long enough, or too long?

Eight weeks was seen as an appropriate amount of time by 63.2% (12/19) of participants. Another 31.5% (6/19) of participants saw eight weeks as not long enough, and one participant (5.3%) did not know.

- Any suggestions for improvements to the video game group that you would like to make?

Of the participants, 68.4% (15/19) had no suggestions. Another 10.5% (2/19) suggested using some other game and 10.5% (2/19) suggested more sessions.

- Location

One participant would have preferred the location of the program closer to home and one failed to respond. The remaining participants (17/19: 89%) were happy with the program being held at their BIU.

- Duration

Five of nineteen, or 26.3%, of participants believed the duration of the program was too short. Two responded 'don't know'. The majority (12/19: 63%) were happy with two-hour sessions for eight weeks.

- Number in group

A total of 36.8% of the participants felt the group could have been larger. One responded 'don't know' and the majority (11/19: 58%) were happy with four to five people per group.

- Any other comments that you would like to make? Prompt- how did you feel when the group ended?

Five of nineteen, or 26.3%, of participants reported positive feelings at the cessation of the program; these people generally felt they had benefited from the program and expressed no loss or sadness at not attending group after its completion. Another 21.1% (4/19) expressed that they felt sadness at cessation of the program. Other comments included requests to keep the program going, developing a take-home version, and to make the workbook more relevant to the patients' lives. The remaining 36.8% (7/19) of participants had no comment.

- Would you like to keep being part of a video game group?

A majority of 84.2% (16/19) of participants would have liked to continue being a part of the group and 15.8% (3/19) did not.

- If yes, would you want to do this yourself at home, or as part of a group?

Of those who wished to continue, 57.9% (11/19) wished to participate as part of the group. Another 15.5% (3/19) were happy with either option, and 10.5% (2/19) of participants preferred to continue at home.

- Where do you think is a good place for a group to meet to play video games? (prompts: local library, BIU, Brain Injury Association: BIA)

A total of 84.2% (16/19) of participants identified the hospital's BIU as a preferable place to hold the rehabilitation program. One participant preferred to do it at home and two responded 'don't know'.

- Would you like to take part in a research project like this in the future?

A majority of 89.5% (17/19) of participants affirmed wanting to take part in another research project such as this one. One participant did not wish to participate and one was neutral.

- Can you please tell me the reason/s you would/wouldn't like to take part?

A total of 47.4% (9/19) referred to helping themselves or helping others in their reason for wanting to take part again. Another 31.6% (6/19) indicated general positivity such as having fun or keeping occupied. Of the three who reported not wanting to continue, one reported disliking the action video game used in the program, one felt uncomfortable about not knowing the others in the group, and one didn't like the necessary time investment. Table 7 below provides examples of the positive responses.

Table 7. Responses to the question "Can you please tell me the reason/s you would/wouldn't like to take part?"

	Frequency	Sample Response
Positive Response : Helping Self/Others	9	*"Good research because it helps others"* *"Can benefit me and help others with their cognitive thinking"* *"Because I can help people"* *"Try and help myself get better"* *"Helps understand… my understanding of things and how to improve or make things better (re: injury)"* *"Helped me in small ways, sees improvements as valuable"* *"Help self and help others"* *"It was fun to be with other people and learn stuff"*
Positive Response : General	6	*"Keeps you occupied"* *"Because I've finished school and want to do more stuff"* *"Fun and meet new people"*

4. Discussion

This study aimed to collect and report in quantifiable form the valuable opinions of participants who took part in an eight-week CR program. It must be acknowledged that the uncontrolled and qualitative nature of this research leaves it vulnerable to error and bias. For example, it may be the case that following an investment of time in the program, participants felt obliged to provide positive responses. This research implemented some techniques to minimise the impact of bias, such as utilising independent interviewers, unknown to the participants, to administer the questionnaires. However, the interpretation of the findings should remain tentative and sceptical. There is much to be gained from the experiences and opinions of our research participants and these inherent limitations do not justify the lack of investigation and publication of these perspectives.

In summary, most participants expressed positive feelings overall, identified improvement in their skills following training, identified gains outside the training context, and said they would like to participate in a similar program again. We have collated two lists guided by the feedback from the participants: 1) the elements we would recommend implementing in any future CR program and 2) the elements to reconsider in any new program design.

4.1 Recommendations for Future Programs

The group format: Participants reported that the social aspects of the program were a very important part of the experience. Not only was the group reported to provide enjoyment and entertainment; it also assisted participants to deal with the emotional consequences of the brain injury, i.e., participants reported feeling less isolated and realizing that they were not alone. Of the participants who would like to continue with CR, the vast majority wished to continue as part of a group.

The workbook: The majority of participants found the workbook helpful. One participant suggested making the workbook more relevant to the participants' lives. The current literature affirms that the more closely the activities used in rehabilitation programs resemble everyday activities, the more likely training is to generalise. Therefore, future programs based on action video-gaming and incorporating psycho-education may be more flexible in including tasks that more closely resemble the participants' functional requirements.

Located in the hospital BIU: The majority of participants were happy with the program being run at their local brain injury unit.

4.2 Redesigning Future Programs

The video game (*Medal of Honor: Rising Sun*): One-fifth of the participants identified the particular video game used as their least liked part of the program. It was possibly too difficult, too fast, and frustrating in that the

nature of this game is such that participants had to return to the beginning of a level every time their character died. While games in the 'action' genre are recommended to remediate attention deficits, a variety of such games might be offered in future programs of this type, as suggested by one participant.

The duration could potentially be extended from eight weeks to 10 or 12 weeks. A number of participants felt the program was too short and suggested more sessions, although programs that become too lengthy increase risk of drop-outs.

Larger groups: A proportion of respondents suggested larger group numbers. If manageable, a larger group could be considered, with an additional group leader.

A 'take away' program to be administered at home. One participant reported that they would have preferred to do the program at home alone. Others suggested continuing the program at home after it ended at the brain injury unit.

Enhancing the 'mentoring' aspects of the program: Many participants enjoyed assisting other participants with game play and also enjoyed sharing experiences and providing moral support. These co-mentoring aspects of the program could be formalized and encouraged.

There was one participant who had a fairly negative experience. He reported increased thoughts of violence following the action video game and did not report any benefit from the program. More extensive psychological and clinical screening should be considered to exclude participants who have violent or aggressive tendencies and/or possible paranoia associated with exposure to violent action, albeit in the context of a video game

In sum, from the participants' perspective, the program was a positive experience, resulted in skill development, and generalized benefits beyond the training context. Participants reported enjoying and benefiting from the social nature of the group setting and finding the workbook helpful. Most also reported enjoying the video game activity, although for some a selection of different action games would have been more appropriate and additional screening to match participant to game or to exclude may be worthwhile. Most rewarding was that the vast majority would like to participate in a similar group rehabilitation program again.

References

Carney, N., Chesnut, R. M., Maynard, H., Mann, N. C., Patterson, P., & Helfand, M. (1999). Effect of cognitive rehabilitation on outcomes for persons with traumatic brain injury: A systematic review. *J. Head Trauma Rehabil, 14*(3), 277-307. http://dx.doi.org.acs.hcn.com.au/10.1097/00001199-199906000-00008

Chesnut, R. M., Carney, N., Maynard, H., Mann, N. C., Patterson, P., & Helfand, M. (1999). Summary report: evidence for the effectiveness of rehabilitation for persons with traumatic brain injury. *J. Head Trauma Rehabil, 14*(2), 176-188. http://dx.doi.org.acs.hcn.com.au/10.1097/00001199-199904000-00007

Cicerone, K. D., Dahlberg, C., Kalmar, K., Langenbahn, D. M., Malec, J. F., … Bergquist, T. F. (2000). Evidence-based cognitive rehabilitation: Recommendations for clinical practice. *Arch Phys Med Rehabil, 81*(12), 1596-1615. http://dx.doi.org/10.1053/apmr.2000.19240

Cicerone, K. D., Dahlberg, C., Malec, J. F., Langenbahn, D. M., Felicetti, T., … Kneipp, S. (2005). Evidence-based cognitive rehabilitation: updated review of the literature from 1998 through 2002. *Arch Phys Med Rehabil, 86*(8), 1681-1692. http://dx.doi.org/10.1016/j.apmr.2005.03.024

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Bending Response and Energy Absorption of Closed-Hat-Section Beams

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Abstract

Many articles on bending collapse but not limited to closed-hat-section beams have been reported mainly from experimental point of view but less in simulation-based approach. Detailed investigation on critical parameters of closed-hat-section beams to examine their energy absorption capability is also less found in the literature. This paper presents the procedure for development and validation of a finite element (FE) model of a closed-hat-section beam under quasi static three-point bending using an explicit nonlinear FE technique. Developed FE models were validated through comparison with existing and present experiment results. Firstly, the existing models were rebulit via present modeling technique using informations provided in the relevant research report. Simulation results of rebuilt model were compared with existing results for verification and validation. Next, to further validate the present model, actual physical experiment replicating the FE model was set up for comparison of results. Validated models were then used in parametric studies in order to investigate the effect of some critical parameters such as plate thickness, flange and web width, and foam filler. Results show that the wall thickness, web width, and filler have direct effect on bending stiffness. Foam filling indicated significant enhancement on the crush and energy absorption of closed-hat-section beams. This study provides detail procedures and research information which will facilitate improvisation of current design as well as the design of foam filled closed-hat-section beams as energy absorbers in impact applications.

Keywords: bending, hat-section, quasi-static, finite element

1. Introduction

In order to remain competitive with new alternative materials, a good understanding of the collapse behavior of closed-hat-section beams is essential particularly for automotive structural applications. This would allow enhancement of the development mathematical models to be made, which would take into account the effect of extended flange and closed-plate. Physical experiment provides information and knowledge of collapse behavior with actual condition and truly reliable. However, for optimization of one design, repetitive experiments are considered non-economical for it may requires the use of quite number of test specimens. Here, the role of FEA becomes a tremendous productivity tool, resulting in overall cost and time reduction.

Among famous articles reported about theoretical bending collapse of rectangular tubes with analytical approach were made by Kecman (1983), Wierzbicki et al. (1994), and Kim & Reid (2001). Here, only Wierzbicki et al. used FE simulation to validate the analytical model. Thereafter, analytical model developed by Wierzbicki et al. was criticized by Kim & Reid (2001) since it was irreproducible. Cimpoeru & Murray (1993) experimentally studied the moment-rotation properties of square tubes under large deflection pure bending and the results acquainted with Kecman (1983). Even though Kecman's theory (Kecman, 1983) is not kinematically admissible as one proposed by Kim & Reid (2001), it suits well with most of the experiment and simulation works done later. Chen (2001) studied experimentally the crushing behavior of empty and foam-filled aluminum closed-hat-section and double hat-section under three-point and deep bending. FE models replicate actual experiment were developed and validated well. Chen's article (Chen, 2001) provides information in quite detail and has been used by author to compare the FE results through model replication. A similar study was reported

by Santosa et al. (2001) in their work to investigate the bending response of fully and partially filled beams experimentally and numerically. Closed cell aluminium foam was used as a filler and it presence has increased the bending resistance significantly as expected. Same results were reported for partially filled beam which indicate potentiality of lighter foam filled energy absorber. Later work by Chen et al. (2002) which could be considered a continuity from Santosa et al. had focused on comparing the strengthening effect of foam and honeycomb filler on the plastic resistance during bending collapse. The moment resistance from honeycomb filling is larger than that of foam, however, honeycomb material is very orthogonal that depends too much on the loading direction, not like the foam which is more isotropic.

A companion study on closed-hat-section was reported by Bambach et al. (2009) who experimentally studied the influence of perforations at the compression flange on moment-rotation relation when subject to large pure bending. An empirical procedure was developed to determine the large deformation bending but no numerical approach was reported. Another study on the bending crush performance of closed-hat-section was reported by Belingardi & Scattina (2013). The aim was to evaluate the adhesion strength of closed-hat-section jointed by structural adhesive and spot weld. Hybrid composite-metal specimens which were jointed using adhesive absorbed highest energy, followed by full metal spot-welded and lastly the fully composite hat-section. Results demonstrate the advantages of utilizing adhesive for structural joining to reduce weight. This study however was purely experimental.

A review of literature showed that many articles on bending collapse but not limited to closed-hat-section have been published mainly from experimental point of view but less in simulation approach. Most of the tubes and beams involved in the existing literature are of aluminium extrusion type closed section. This paper presents FE model development using ABAQUS with validation procedures for closed-hat-section beams subject to three-point bending. The developed explicit non-linear FE model went through two types of validation procedures which are from existing results and present physical experiments. Simulation results are compared with existing and present testing results showing good agreement. Validated models were then used in parametric studies to investigate the effect of some critical parameters such as plate thickness, flange and web width, and foam filler. Foam filling indicated the most significant enhancement on the crush and energy absorption of closed-hat-section beams compared to wall thickness, web, and flange width. This study provides detail procedures and research information which will facilitate improvisation of current design of closed-hat-section beams as well as the design of foam filled closed-hat-section beams as energy absorbers in impact applications.

2. Energy Absorption Performance Indices

Crashworthiness of a structure is defined as the ability to absorb the impact energy and thereby bringing the vehicle to rest without the occupant being subjected to high or sudden deceleration. It is expressed in term of specific energy absorption (SEA), E_s which is the ratio of energy absorbed to the unit mass of the material;

$$E_s = W/V\rho \quad (1)$$

where W = total energy absorbed

V = volume of material

ρ = density of material.

3. Computer Modeling and Development of FE Model

3.1 Specimen / Model Geometry and Finite Element Mesh

A closed-hat-section beam is a combination of a hat-section and a closed-plate. For present experiment, both parts were drilled and bolted together to form a closed-hat-section. This type of connection becomes useful when the overall thickness increase. Beam was modeled using robust conventional shell elements, S4R, which is a four-noded quadrilateral element with six degrees of freedom per node while the indenter and rigid support were modeled using R3D4 rigid elements. S4R is suitable for large strain analyses with ability to enhance hourglass
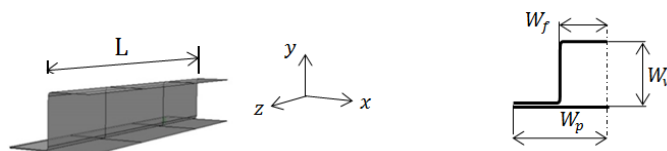
Figure 1. Half model geometry of the closed-hat-section beam

Table 1. Design dimensions of the closed-hat-section beam (Half model, Unit: mm)

Specimens	Section	L	Web, W_w	Flange, W_f	Plate, W_p	Span	t
1) QS_H0_1	Hat	300	15	30	-	250	1
2) QS_H0_2	Closed plate	300	-	-	60	250	1
3) QS_H0_3							
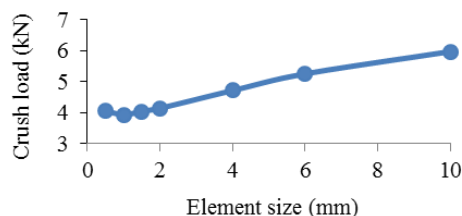
Figure 2. Mesh convergence of S4R element for closed-hat-section beam

control. To allow nonlinear material behavior, five integration points was employed through the shell thickness. From detail observation of the preliminary simulation, the deformation mode of full and half model can be treated symmetrically. Therefore half models were used to reduce the number of degrees of freedom (DOFs) and computational time as shown in Figure 1. Table 1 tabulates design dimensions of the beam.

3.2 Mesh Convergence Study

The most fundamental in constructing an accurate FE model are the correct element type and its required smallness. This can be achieved through mesh discretization method where number of elements are recorded and compared as implemented by Koslan et al. (2013) and Amir et al. (2013). Figure 2 shows maximum indentation force versus element size in the refined mesh of hinge region. The crush load converged as the mesh density increased. Therefore the element size of 2.0 x 2.0 mm is chosen to model the hinge region, while the rest of parts with a size of 5.0 x 2.0 mm (Chen, 2001). To avoid an infinite stress, a radius of 2 mm at each flange's corner was introduced and based on the convergence study the radius size is reasonable as well as number of elements spaced around the corner area.

3.3 Loading, Interaction, and Boundary Condition

The indenter is described as a rigid surface translates only along the y axis as shown in Figure 3. The beam specimen is supported by a simple supporting system which is fully constrained (i.e., U1=U2=U3=UR1=UR2=UR3=0) to avoid relevant geometric or dimensional change. Here, U1, U2, and U3 are linear displacement while UR1, UR2, and UR3 are rotation about *x*, *y*, and *z* axis respectively. Indenter and rigid supports are tagged by a reference node each to ease control on the motion of the body as a whole. Due to mirror symmetry, boundary conditions along free edges of beam are applied symmetrically constraining U1, UR2, and UR3. Other important aspect in modeling would be the size of the step time. This parameter is essential for the convergence of the values as well as the total time of the simulation. For quasi-static nonlinear crushing analysis, the step time is determined from a FREQUENCY linear perturbation analysis step which is provided in ABAQUS/Standard (ABAQUS 6.13 User's Manual, 2013). In this study, the step time was determined at 0.03 s. In an explicit impact analysis, the step time represents the actual impact duration. For a smooth indentation, the motion of the indenter was simulated using the SMOOTH STEP sub-option of the AMPLITUDE option.
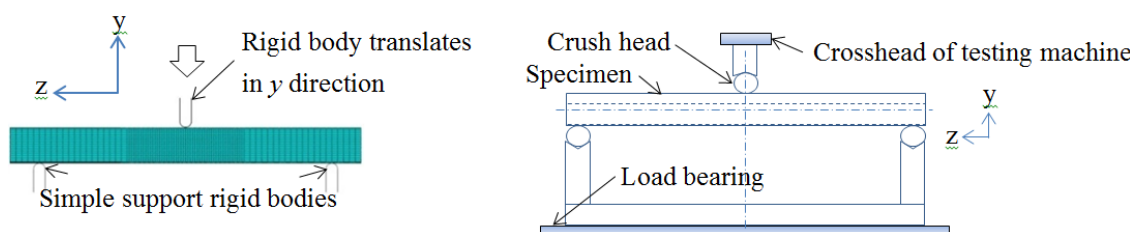
Figure 3. A FE mesh of the full model subject to three-point bending
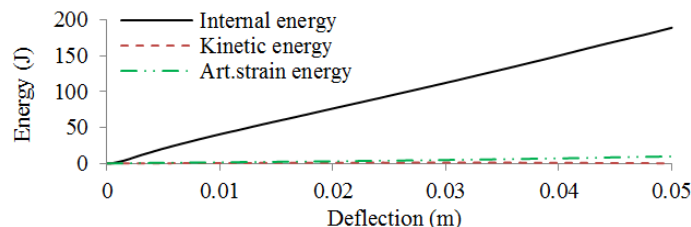
Figure 4. A FE mesh of the full model subject to three-point bending

This option can avoid inaccurate results caused by system noise and at the same time enable user to control the motion of the indenter so it can travels over required time duration as prescribed in the total step time (ABAQUS 6.13 User's Manual, 2013). In modeling contact, the highly automated contact algorithm which includes all surface definition was used for the whole system. The finite sliding "penalty" based contact algorithm with contact pairs and "hard" contact were used to define the self-contact between the beam walls during collapse, and surface-to-surface contact between each rigid surface and the beam. All surface contact in the present finite element models was treated with 0.25 friction coefficient except those contacted with rigid surfaces which was treated as frictionless.

For an acceptable quasi static result, the kinetic energy of the deforming part should not exceed a small fraction of its internal energy throughout the majority of the analysis, typically 1-5% (ABAQUS 6.13 User's Manual, 2013). This is because the indenter is massless and so the only kinetic energy is carried by the beam. Figure 4 shows the energy plot of quasi-static simulation of the beam. It clearly shows that the maximum kinetic energy is sufficiently small compared with the internal energy. It also shows both the kinetic and internal energy-time profiles are smooth which indicates that no significant plasticity behavior which could affect the solution. To ensure hourglass is minimized, the ratio of artificial strain energy to internal energy was investigated and found to be less than 5%.

3.4 Mesh Independent Spot Weld

In this study, mesh-independent spot weld was used to model rigid spot weld which do not fail under any circumstances. The principal advantage of using mesh-independent spot welds instead other connections methods is that the parts that are to be connected can be meshed independently of their assembly, later the spot welds can be located by specifying a single coordinate point near to the surfaces of the parts, thus the locations of the spot welds can be independent of the locations of the nodes on both sides of the connection. The size of the region of influence can be modified by changing the radius of influence. In this work, the radius of influence was chosen to be equal to the physical hole radius which is 3 mm.

3.5 Material Model

The beam was modeled with a piecewise linear elastic-plastic material model with strain hardening. Material coupon tensile test was conducted using the Instron model 3382 Universal Testing Machine (UTM). The material properties for the mild steel are as follows: initial yields stress; $\sigma_y = 340$ MPa, Young's modulus; E=200 GPa, Poisson ratio; $v = 0.3$, Ultimate Tensile Strength (UTS); $\sigma_u = 391$ MPa, and density; $\rho = 7809$ kg/m^3. The engineering stress-strain curve of the material was obtained using a standard tensile test in accordance with AS1391-1991(1991). Figure 5 shows the true stress-strain curve from coupon tensile test. From this curve, the approximated data points which are used in the FE models are tabulated in Table 2. The ancillary strain data was converted into true strain by using;
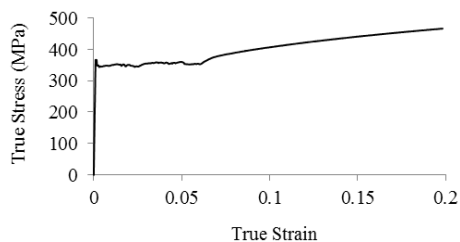
Figure 5. A FE mesh of the full model subject to three-point bending

Table 2. Approximated true stress-plastic strain data points for the FE model

σ_t (N/mm^2)	340.40	354.21	398.41	425.02	446.21	462.10
ε_p	0	0.0613	0.0900	0.1251	0.1600	0.1900

$$\varepsilon_{true} = \ln(1 + \varepsilon) \tag{2}$$

where, ε = experimental strain. The true stress data was converted using;

$$\sigma_{true} = \sigma \cdot (1 + \varepsilon) \tag{3}$$

where, σ = experimental stress.

4. FE Validation against Existing and Present Results

4.1 Rebuilding of Existing Model for Validation of the Present Modeling Technique

The International Journal of Solids and Structures is one of the strong sources of relevant literature in the field of structural mechanics. A published article by Chen (2001) contains many relevant works to the present study like the similar cross section and boundary condition which provide worthwhile reading and reference. In the previous study, Chen (2001) used a high strength aluminium alloy of variant AA5754 to produce the closed-hat-section specimens. The true stress-strain curve of the alloy is shown in Figure 6. In the present work, author managed to remodel the specimen and the experimental setup using present FE modeling approach. This is to verify whether the FE remodel capable to replicate and predict the experimental behavior of Chen (2001) and thus validate the FE remodel. In addition, the FE remodel was also compared with Chen (2001) FE model that was developed parallel to his experiment work. Figure 7 shows half cross section geometries of conventional and double-hat-section beams used by Chen (2001). The double-hat-section had also been considered for remodeling to be more convincing of the present modeling technique. Details about section dimensions are listed in Table 3. The mesh, loading, and boundary conditions are all follow Chen (2001) model. Type and element designation were the same used in the present FE model as well as the 25 mm pitch spot welds. For information, Chen (2001) utilized a non-linear explicit code PAM-CRASH throughout his simulation.
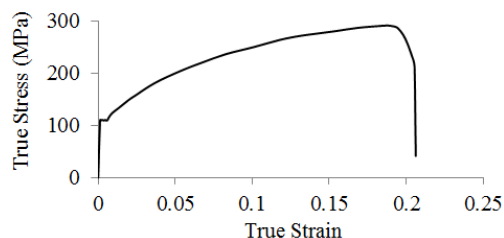
Figure 6. Stress-strain curves of aluminum alloy HS5754 (Chen, 2001)
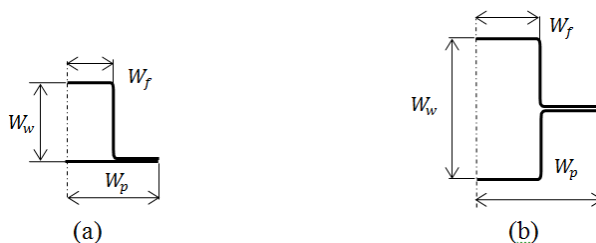
Figure 7. Half geometry of (a) closed and (b) double hat-section (Chen, 2001)

Table 3. Measured half geometry of section dimensions (Unit: mm) (Chen, 2001)

Specimens	L	Web, W_w	Flange, W_f	Plate, W_p	Span	t
Closed-hat-section	675	25	12.50	23	550	2
Double-hat-section	675	52	12.75	23	550	2
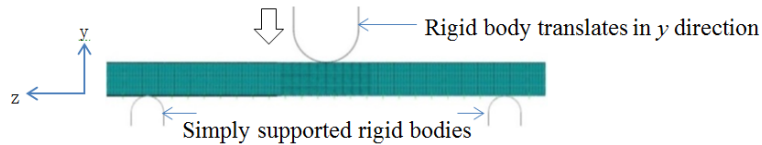
Figure 8. A FE mesh of Chen's remodel under three-point bending (Chen, 2001)

4.2 Quasi static Experimental Testing for Validation of the Closed-hat-section Beam Model

Three-point bending experiment was carried out to validate the present FE model. Beam geometry and dimensions are shown in Figure 1 and Table 1 respectively. Three specimens were fabricated to ensure repeatability and reducing the number of experiments. Quasi static tests were performed using Instron 3382 Universal Tensile Machine (UTM). Specimen is positioned between the indenter and two simple round supports as shown in Figure 3(b).

5. Validation Results

5.1 Remodelling Results of Closed-hat-section Beams under Quasi Static Three-point Bending

Figure 9 shows comparison of quasi static load and mean load-deflection curves between present remodel and Chen (2001). Figure 9(a) is referred, after the indenter crushing the beam center, there were forces that abruptly increased to a peak of just fewer than 8 and 7 kN for both experiment and simulation. Just after the peak, both forces were slowly decreased to almost half of their peak load. As shown in Figure 9(b), both mean loads increased to a peak point before they were leveled off throughout the indentation process. The mean load was calculated by dividing the energy absorbed by the crush distance. The energy absorbed was obtained by integrating the crush load with respect to crush distance using functions in MATLAB. On average the difference is within ±6.5 %.

Figure 10 shows the comparison result of present FE remodel and Chen's simulation. Both are generally similar in the initial prediction but slightly deviated towards the end. This is possibly due to the effect of curve fitting technique employed on both graphs. The deformation mode predicted by the present FE remodel compared well with experimental results as depicted in Figure 11. Figure 12 shows comparison result of quasi static load and
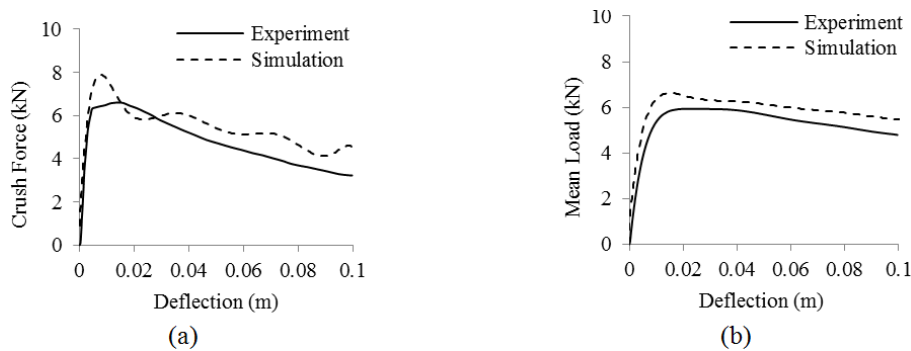
Figure 9. Comparison of quasi static (a) load and (b) mean-load deflection curves between present FE remodel and Chen (2001)
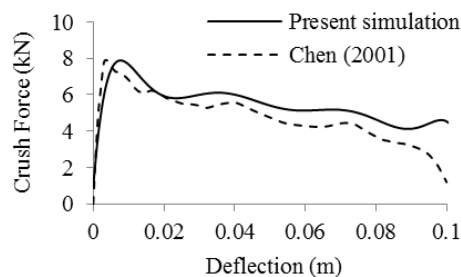
Figure 10. Comparison of present remodel and existing simulation results (Chen, 2001)

(a)   (b)

Figure 11. Comparison of collapse modes of a closed-hat-section beam from (a) existing experiment and (b) present remodel

(a)   (b)
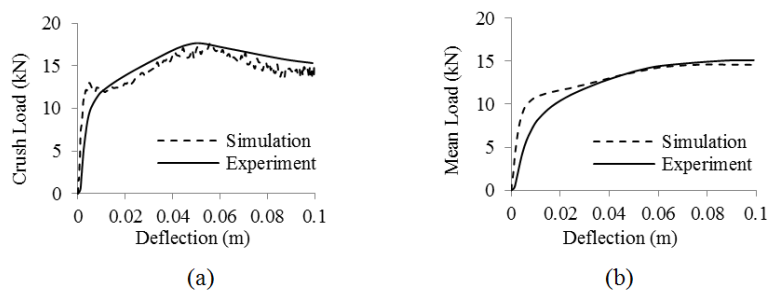
Figure 12. Comparison of quasi static (a) load and (b) mean load-deflection curves between present FE remodel and existing experimental results for double hat-section (Chen, 2001)

(a)   (b)
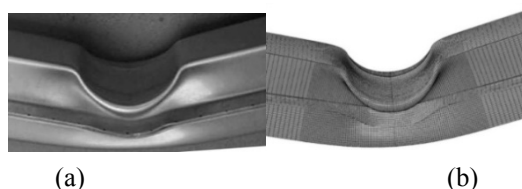
Figure 13. Comparison of collapse mode of a double hat-section from present FE remodel and existing experimental results (Chen, 2001)

mean-load deflection curves between present FE remodel and existing experimental results for double hat-section. Good agreement is seen between FE remodel and experimental results for both curves as well as the collapse mode as shown in Figure 13. As a whole, results from FE remodel demonstrate a reasonable agreement with Chen experimental data (Chen, 2001).

5.2 Validation Results of Present FE Model against Three-point Bending Experiment

Again, the quasi static three-point bending results demonstrate a reasonable agreement, this time between present FE model and experimental data. Figure 14 shows comparison of load-deflection curves between present model and experiment. During inital crush, there were forces that abruptly increased to a peak of approximately 5 kN for FEA and 4 kN for the experiment result. Just after the peak, both forces were gradually decreased before leveling off with little fluctuation throughout the indentation. Figure 15(a) shows comparison of mean load-deflection curves between present FE model and experiment. FE model output and measured output are broadly similar with average difference within 5 %. The deformation mode predicted by the FE model also compared well with present experiment result as depicted in Figure 16.
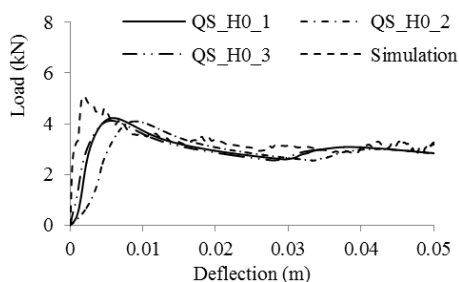
Figure 14. Quasi static load-deflection for closed-hat-section beams (FEA vs. Experiment)

(a)   (b)
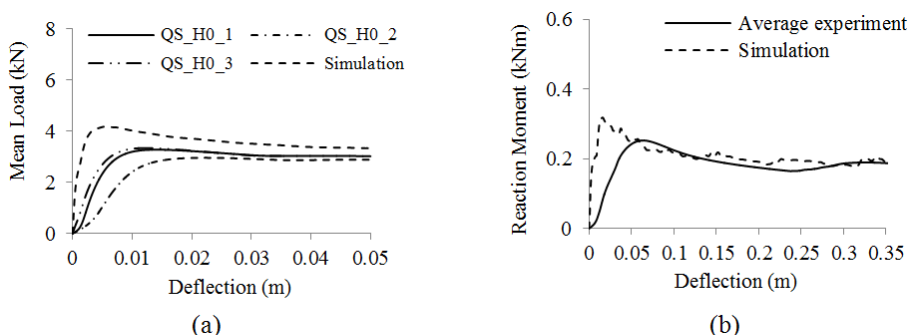
Figure 15. (a) Mean load-deflection and (b) Moment-rotation curves for closed-hat-section beams (FEA vs Experiment)

(a)   (b)

Figure 16. Comparison of collapse mode of closed-hat-section beam between (a) experiment and (b) present simulation

5.3 Effect of Thickness

Comparison of quasi static load and mean load-deflection responses as the wall thickness increases for conventional closed-hat-section (H0) beam when subjected to three-point bending are shown in Figure 17. Mean load is the average load indicates measured load at any particular deflection by dividing the energy absorbed over deflection. In this figure, a mean load curve is plotted by using several values of the mean or average load calculated from a set of load deflection data. Thicker plate thickness contributes to a significant increase in the mean load up to a given deflection. It is worth noting that at 1.5 and 2 mm thickness, the mean load of the H0 increases dramatically up to double and over triple till the end of bending deflection of the crush distance. This could possibly due to the compaction of the folds and the densification of the hinge region under compression loading. In similar fashion, as the plate thickness increases, the energy absorbed as well as the SEA increase up to a given deflection as plotted in Figure 18 and 19. Thicker plate provides more material for plastic deformation, subsequently increase the energy absorption capacity with increasing deflection. Figure 20 shows deformed shape of H0 at various wall thicknesses. Stress area increases by the increase of wall thickness. Obviously, the energy dissipation of H0 beams is significantly affected by increasing the wall thickness.
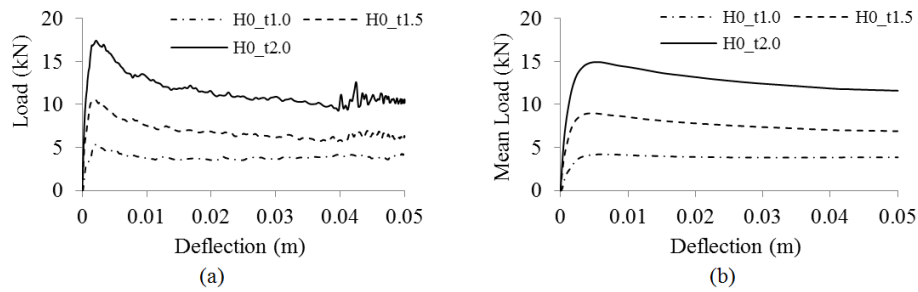
Figure 17. Effect of wall thickness on (a) load and (b) mean load-deflection curves
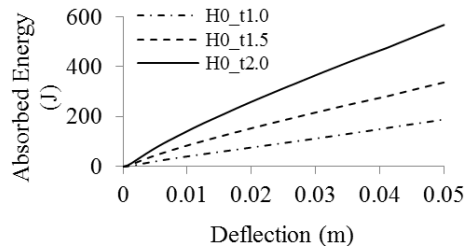
Figure 18. Effect of wall thickness on energy absorption
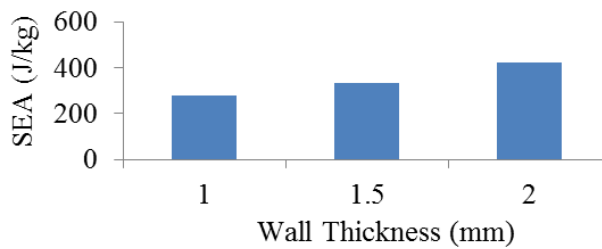
Figure 19. Specific energy absorption (SEA) at various wall thicknesses

H0 (t = 1.0 mm)

H0 (t = 1.5 mm)

H0 (t = 2.0 mm)
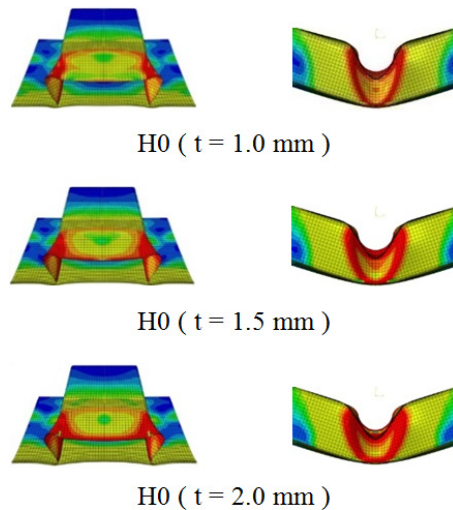
Figure 20. Deformed shape of closed-hat-section at various wall thicknesses

5.4 Effect of Web and Flange Width

Under three-point bending, the web section will be the first to buckle before hinge line is created. Since the energy absorption response could be influenced by the size of the web section, the effects of varying the web width at 20 mm, 30 mm, and 40 mm were studied with constant 1 mm plate thickness and 60 mm flange width. Figure 21 shows the load and mean load-deflection responses from different web width. For H0 type beam, it

can be seen that the web width affects significantly the mean load-deflection response at the width of 30 mm. However, increasing the web width to 40 mm has only increased the mean load by 0.5 kN which is less significant compared to the previous increase of 30 mm. The findings are similar as what were presented by Amir et al. (2013) during the investigation of the effect of groove depth on square beams with U-shape grooves. On the other hand, increasing the flange width surprisingly does not increase the load as the deflection increases as shown in Figure 22.
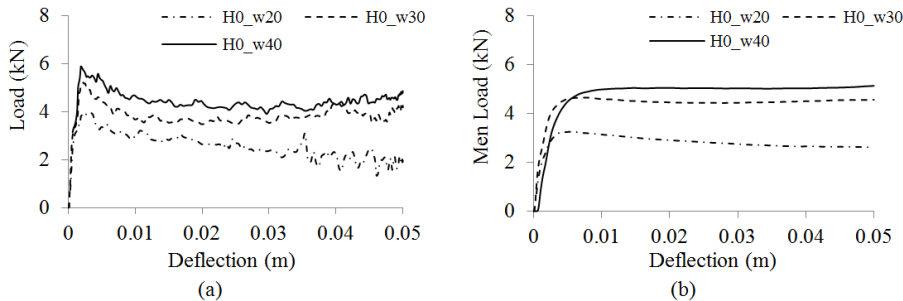
Figure 21. Effect of web width on (a) load and (b) mean load-deflection curves
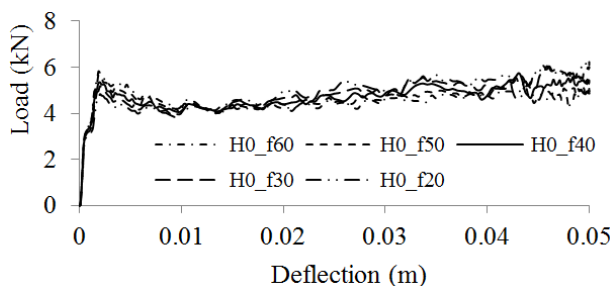
Figure 22. Effect of flange width load-deflection curves
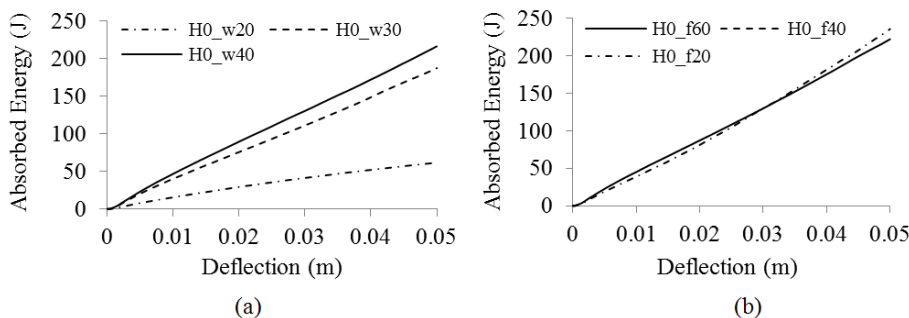
Figure 23. Effect of (a) web and (b) flange width on energy absorption
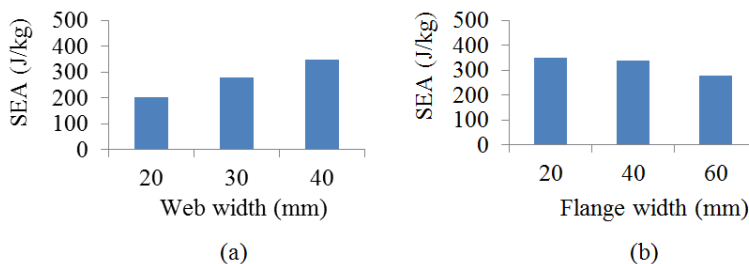
Figure 24. Specific energy absorption (SEA) at various (a) web and (b) flange width

In terms of energy absorption response, the effect of web width is quite similar to the aforementioned response of the mean load, as the mean load is always related to the energy absorbed. Figure 23 shows the effect of the web and flange width on the absorbed energy of the H0 beams under quasi static three-point bending. In general, the energy absorbed is slightly increases when introducing a wider web width. It is contradict with varying the flange width where amount of energy absorbed is almost unchanged. For the SEA, similar response can be seen as shown in Figure 24. It can be concluded that, varying the web width has more significant effect on energy absorption and SEA than the flange width, however due to the balance response with minimal fluctuations, wider flange width can offer higher cushioning effect which is more forgiving for low to medium velocity and small inertia impact for instance in motorcycle crash barrier application. Figure 25 and 26 show the deformed shape of H0 at various web and flange width.

H0 (W_w = 20 mm)

H0 (W_w = 30 mm)

H0 (W_w = 40 mm)
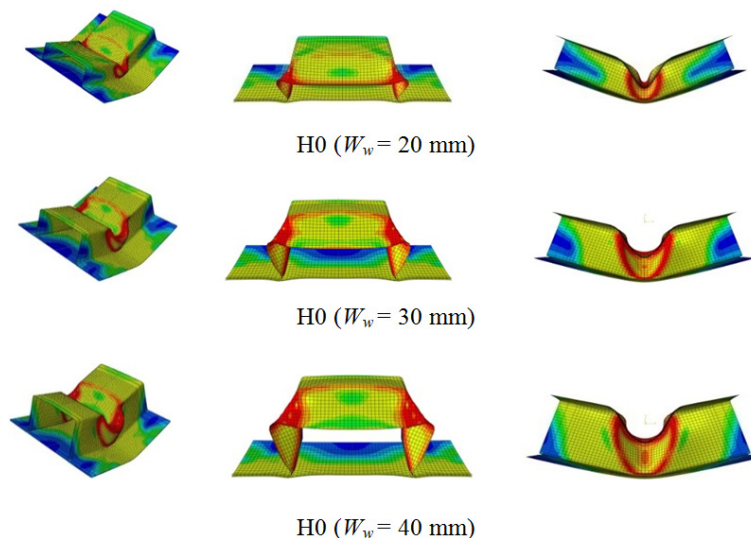
Figure 25. Deformed shape of closed-hat-section at various web width (constant t, W_f)

H0 (W_f = 60 mm)

H0 (W_f = 40 mm)

H0 (W_f = 20 mm)
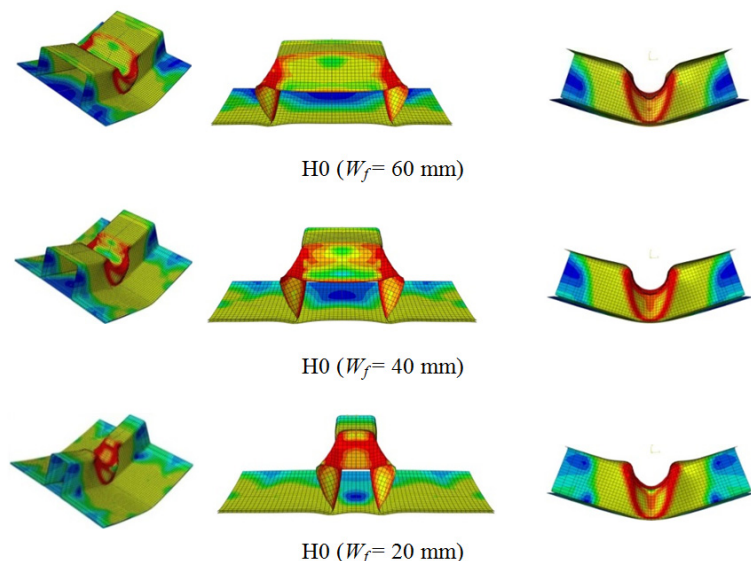
Figure 26. Deformed shape of closed-hat-section at various flange width (constant t, W_w)

5.5 Effect of Foam Filled

The aluminium foam used in this study was adopted from Chen (2001) and the stress-strain relationship for the foam was derived from compression test as shown in Figure 27. Graphs show typical stress-strain plot for a closed-cell aluminium. The first is a roughly linear elastic regime. This is followed by a long stress-plateau

where the stress remains nearly constant and then truncated by a densification response, where the stress again increase steeply. The mechanical properties of foam are highly dependent on the relative density of the foam material. For this study, the beams were fully filled and partially filled in the center by one third of its total length. The same approach was implemented by Santosa et al. (2001) in the previous work.
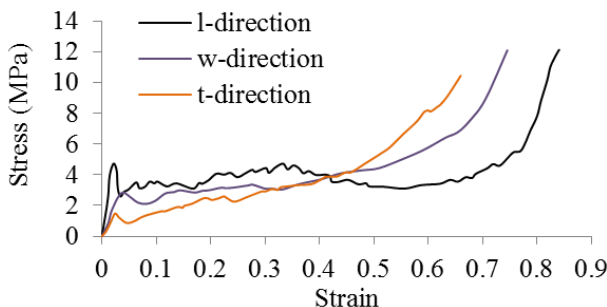
Figure 27. Stress-strain curves of aluminium foam (0.27 g/cm^3)

Figure 28 shows load and mean load–deflection responses for empty and foam filled H0 under quasi static three-point bending. A previous study by Santosa et al. (2001) indicated that friction between the side wall and foam material had little effect on the deformation pattern or mean-load. For the present simulation, contact between foam and beam's wall was defined as frictionless. Results reveal that the presence of foam filler has significant effect on the load and mean load-deflection responses by approximately half of the empty beam. The load and mean load were slightly increased towards the end of indentation due to the densification effect of the filler. Figure 29 shows that the filled beam improved the performance indicator, SEA for about 58% compared to empty beam. The SEA can be furher improved by optimizing the length of filled filler in order to minimize the weight.

(a)

(b)
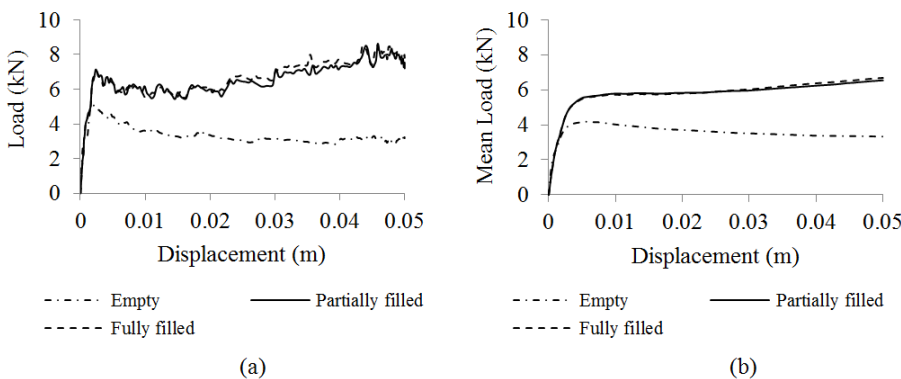
Figure 28. Effect of foam filled on (a) load and (b) mean load-deflection
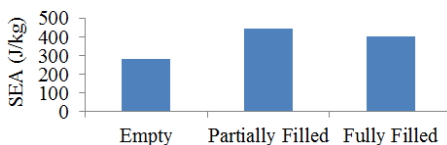
Figure 29. Comparison of SEA for empty, partially filled, and fully filled H0 beams

(a) Empty H0 beam

(b) Partially foam filled H0 beam

(c) Fully foam filled H0 beam
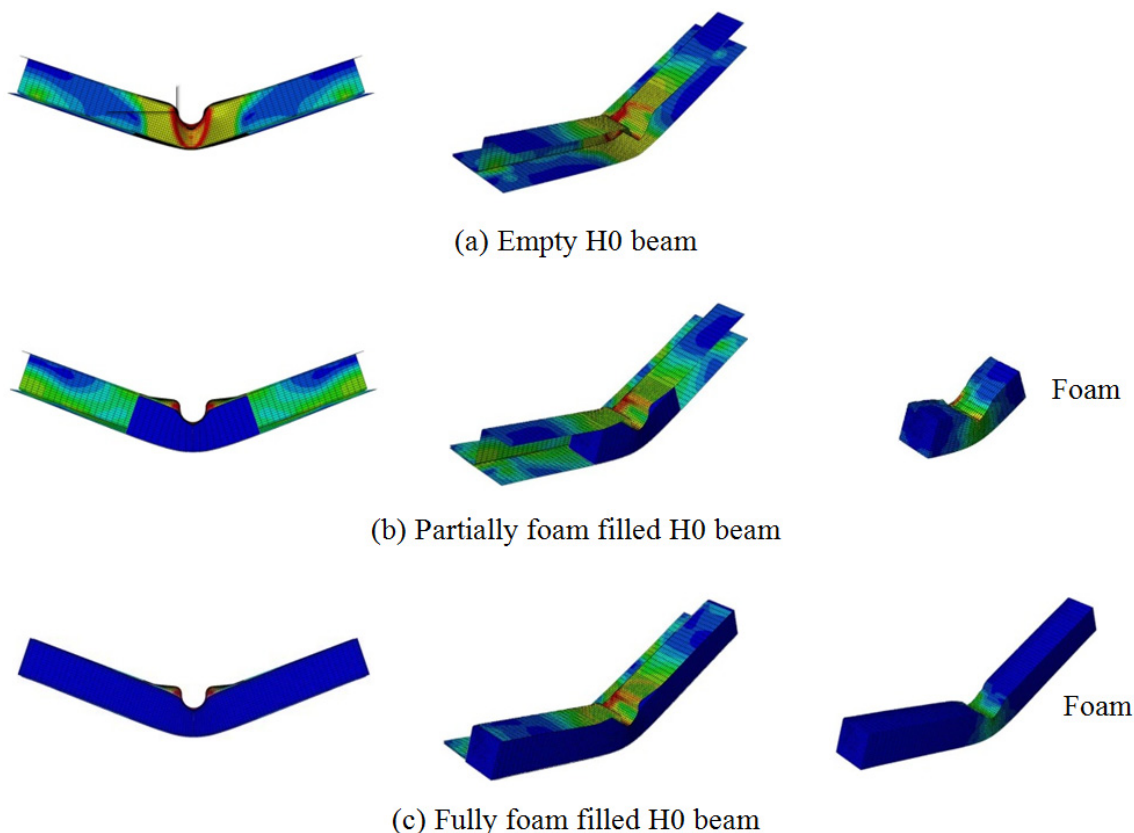
Figure 30. Deformed shape of (a) empty, (b) partially foam filled and (b) fully foam filled closed-hat-section beam

Figure 30 shows the deformed shape of empry and foam filed H0 beam. The presence of foam filler has slightly shortens the fold length, resulting in folds of larger curvature. Based on the present observation, the numbers of folds are expected to increase if the filled beams went under deep bending which exceed present indentation depth. More fold means more plastic deformation can occur thus acquire more loads and subsequently improve the SEA.

6. Conclusion

Quasi-static experimental three-point bending tests and model replication and rebuilding on conventional closed-hat-section beams have been conducted. Present FE model was successfully validated using existing model replication and physical experiment. To further details on the bending behavior, parametric studies on some critical parameters via simulation were performed using explicit FE code ABAQUS. Parameters in FE simulation include wall thickness, flange and web width, and foam filler. The results reveal the following:

1) Increasing wall thickness has significant effect on the load-deflection response. Thicker wall means more material for plastic work, indirectly means higher bending stiffness thus require higher force for bending. Thicker wall however, affects mass and volume of the beam which is undesirable and it does not reflect directly to the amount of energy absorbed.

2) For H0 beam with equivalent cross sectional area, increasing the web width gives more loading effect than the flange width. However for greater cushioning effect, wider flange width is desirable since wider flange does not affect the load characteristic significantly thus suitable for containing small inertia effect.

3) The presence of foam filler improved the SEA significantly by shortening the fold length for larger folding curvature allowing more plastic deformation to occur. Without sacrificing the mass and volume, filled beam is considered the best among other H0 beams.

4) Partially filled beam can be considered working effectively as well as fully filled beam. Partially filled beam is lighter than the fully filled beam but may require optimization on the filled length in order to improve the

cost and efficiency.

References

ABAQUS 6.13 User's Manual. (2013). Retrieved from https://www.sharcnet.ca/Software/Abaqus/6.13.3/books/gsk/default.htm

Amir Radzi, B. A. G., Kee, C. S., Othman, M. Z., Bin Koslan, M. F. S., & Zaidi, A. M. A. (2013). Impact response of multi-grooved square column. *Modern Applied Science, 7*(11), 12. http://dx.doi.org/10.5539/mas.v7n11p12

Bambach, M. R., Tan, G., & Grzebieta, R. H. (2009). Steel spot-welded hat sections with perforations subjected to large deformation pure bending. *Thin-Walled Structures, 47*(11), 1305-1315. http://dx.doi.org/10.1016/j.tws.2009.03.010

Belingardi, G., & Scattina, A. (2013). Experimental investigation on the bending behaviour of hybrid and steel thin walled box beams—The role of adhesive joints. *International Journal of Adhesion and Adhesives, 40*, 31-37. http://dx.doi.org/10.1016/j.ijadhadh.2012.08.002

Chen, W. (2001). Experimental and numerical study on bending collapse of aluminum foam-filled hat profiles. *International Journal of Solids and Structures, 38*(44), 7919-7944. http://dx.doi.org/10.1016/S0020-7683(01)00094-4

Chen, W., Wierzbicki, T., & Santosa, S. (2002). Bending collapse of thin-walled beams with ultralight filler: numerical simulation and weight optimization. *Acta Mechanica, 153*(3-4), 183-206. http://dx.doi.org/10.1007/BF01177451

Cimpoeru, S. J., & Murray, N. W. (1993). The large-deflection pure bending properties of a square thin-walled tube. *International Journal of Mechanical Sciences, 35*(3), 247-256. http://dx.doi.org/10.1016/0020-7403(93)90079-A

Kecman, D. (1983). Bending collapse of rectangular and square section tubes. *International Journal of Mechanical Sciences, 25*(9), 623-636. http://dx.doi.org/10.1016/0020-7403(83)90072-3

Kim, T. H., & Reid, S. R. (2001). Bending collapse of thin-walled rectangular section columns. *Computers & structures, 79*(20), 1897-1911. http://dx.doi.org/10.1016/S0045-7949(01)00089-X

Koslan, M. F. S., Zaidi, A. M. A., Othman, M. Z., Abdullah, S., & Thanakodi, S. (2013). The effect of mesh sizing toward deformation result in computational dynamic simulation for blast loading application. *Modern Applied Science, 7*(7), 23. http://dx.doi.org/10.5539/mas.v7n7p23

Santosa, S., Banhart, J., & Wierzbicki, T. (2001). Experimental and numerical analyses of bending of foam-filled sections. *Acta Mechanica, 148*(1-4), 199-213. http://dx.doi.org/10.1007/BF01183678

Wierzbicki, T., Recke, L., Abramowicz, W., Gholami, T., & Huang, J. (1994). Stress profiles in thin-walled prismatic columns subjected to crush loading-II. Bending. *Computers & structures, 51*(6), 625-641. http://dx.doi.org/10.1016/S0045-7949(05)80002-1

Effect of Fertilizer Management in Combination with Soil Conditioner on Yield of Cassava Cultivated on Coarse-Textured Soil in Thailand

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Abstract

This study was conducted to determine the effect of fertilizer management in combination with soil conditioner (zeolite, pumice and organic fertilizer) on yield of cassava *var*. Huay Bong 60 cultivated on coarse-textured soil in Thailand. The experiment was arranged in a randomized complete block design. The results revealed that addition of chemical fertilizer combined with organic fertilizer rate 1,018.75 kg ha^{-1} gave the highest plant height, above ground biomass, fresh tuber yield, starch content, starch yield and concentration of primary nutrient in fresh tuber yield and were not difference from addition of 100% chemical fertilizer combined with zeolite rate 312.5 kg ha^{-1} (P≤0.01). After experiment, it was found that all treatments comprising sole chemical fertilizer at various rates or combined with soil conditioners were found to influence soil properties; soil pH was moderately to slightly acid, electrical conductivity (EC$_e$) was non-saline soil, low to moderately low organic matter in soil, moderately low to moderate cation exchange capacity (CEC), low to moderate available P in soil; very low exchangeable K in soil.

Keywords: fertilizer, soil conditioner, cassava, coarse textured soil, zeolite, pumice, organic fertilizer

1. Introduction

Cassava is one of the very importance economic crops in Thailand because Thailand is the leading cassava exporter in the world. The situation of cassava demand in the world will increase in the future as animal feed and energy crops for bioethanol production. In 2013, Office of Agricultural Economics of Thailand reported 1.45 million ha planting area of cassava in Thailand, mostly located in northeast region of Thailand (0.75 million ha) where the soils were coarse-textured in this region (Kaewkamthong et al., 2014; Office of Agricultural Economics [OAE], 2014). Naturally, coarse-textured soils were characterized in weak structure, soil texture range from sand or loamy sand, low water holding capacity, soil pH range between 5-6, organic matter lower than 1%, low fertility and low cation exchange capacity. All these characteristics will contribute major problem of plant nutrient leaching, causing loss of nutrients from cassava root zone (Duangpatra, 1988; Tongglum et al., 2000; Astier et al., 2006; Kaewkamthong et al., 2014). In fact, cassava is very drought tolerant and grows better than other crops on coarse-textured soils of low fertility, providing a more stable income for poor farmers who farmed on eroded and/or infertile soils. Moreover, cassava or any other crop has been cultivated continuously on a low fertility soil without adequate application of fertilizer, manure or any soil amendment, therefore soil fertility will continually decrease, result in yield decline due to loss of nutrients by crop removal and leaching. Although, cassava extracts large amount of nutrients, especially K (following by N and P) from soil. This is because of its high level of productivity of cassava tubers (Howeler, 1991; Putthacharoen et al., 1998; Anusontpornperm et al., 2005). So insufficient addition and leaching of plant nutrient are major problems affecting cassava yield in northeast regions, ranging them the lowest among other cassava producing regions (OAE, 2014). Farmers should at least be aware of the long-term detrimental effect on soil productivity and should imply some soil management practices such as minimum tillage, closer plant spacing, mulching, fertilizer application, intercropping, planting of contour live

barriers and soil conditioners application, which result in an improved soil structure that allow plant roots to absorb plant nutrient better (Putthacharoen et al., 1998; Buarach et al., 2014). It is very important to examine the appropriate soil conditioners that can reduce leaching of plant nutrient and maintaining water in coarse-textured soil (Chen et al., 2016). Soil conditioner can be anything from natural source to synthetic materials used for improvement of soil chemical or soil physical properties or both. There were bountiful reports in many countries dealing with application of soil conditioners to improved soil properties, water retention, and yield of crops (Warrington et al., 1989; Agassi et al., 1990; Duangpatra, 2010). Also, there were many researches on applying soil conditioners to improve yield of economic crops or soil properties such as, zeolite and it was found that crop yield was increase and nutrient use efficiency was promoted. Other possible uses being investigated included applications as a carrier of slow-release fertilizers, insecticides, fungicides, and herbicides, and as a trap for heavy metals in soils. Research efforts are underway in many countries to exploit the potential of zeolites for the maintenance of plant nutrient and soil productivity (Ramesh & Reddy, 2011; Gholamhoseini et al., 2013). Research on other conditioner indicated beneficial effects from pumice for its rich pore structure, strong water absorbent capacity, reducing nitrogen loss and high CEC, absence of aluminum toxicity and promotion of P retention (Gama et al., 2000; Wu et al., 2015). Organic fertilizer can retain water and helps soil particles to bind and resist against soil compaction. Preservation of an adequate amount of soil organic matter stabilized soil structure which made the soil more resistant to degradation (Celik et al., 2010). So this study was conducted to determine the effect of fertilizer management in combination with soil conditioners; zeolite, pumice and organic fertilizer on growth, yield, yield components of cassava and soil properties after harvested.

2. Method

2.1 Study Area and Land Preparation

Field experiment was performed on coarse-textured soil in a farmer's field at Dan Makham Tia, Kanchanaburi province. Properties of topsoil prior to conducting the experiment were revealed that the soil was slightly acid, non-saline, very low amounts of organic matter, low available P, very low exchangeable K, cation exchange capacity was very low, available water capacity was 6.08% by mass and soil texture was loamy sand as given in Table 1. The experiment was arranged in a randomized complete block design with 9 treatments 3 replications; control (no fertilizer and soil conditioner) (T1), chemical fertilizer 100% (T2), chemical fertilizer 100% combined with zeolite (T3), chemical fertilizer 100% combined with pumice (T4), chemical fertilizer combined with organic fertilizer rate 1,018.75 kg ha^{-1} (T5), chemical fertilizer 75% (T6), chemical fertilizer 75% combined with zeolite (T7), chemical fertilizer 75% combined with pumice (T8) and chemical fertilizer combined with organic fertilizer rate 762.5 kg ha^{-1} (T9). The description of treatment was show in Table 2.

Table 1. Initial properties of soil used in this experiment

Soil properties	Topsoil (0-30 cm)
pH (1:1 H_2O)	6.15
Electrical conductivity, EC_e (dS m^{-1})	0.22
Organic matter (%)	0.45
Available P (mg kg^{-1})	5.13
Exchangeable K (mg kg^{-1})	16.62
Cation exchange capacity (cmol kg^{-1})	2.42
Available water capacity, AWCA (% by mass)	6.08
Texture	loamy sand

2.2 Cassava Planting, Chemical Fertilizer and Soil Conditioner Preparation

Huay Bong 60 cultivation by using cassava stake cutting, 20 cm long, were planted on top of ridge at spacing of 1x1 m. Chemical fertilizer applied following recommended fertilizer based on soil analysis (Department of Agriculture [DOA], 2005) as were given in Table 3 (100-50-100 N-P_2O_5-K_2O kg ha^{-1}) for T2-T4. Chemical fertilizer 75% of soil analysis (75-37.5-75 N-P_2O_5-K_2O kg ha^{-1}) for T6-T8. T5 and T9 applied chemical fertilizer rate 75.06-0-83.81 and 56.38-0-62.88 N-P_2O_5-K_2O kg ha^{-1} respectively, half of the total amount was applied to cassava root zone at 2 and 4 month after planting. Soil conditioner was added to cassava root zone at 2 month; for T3 and T7 zeolite was applied at 312.5 kg ha^{-1}, T4 and T8 pumice was applied at 312.5 kg ha^{-1} and for T5 and T9 organic fertilizer was applied at 1,018.75 and 762.5 kg ha^{-1}, respectively. Cation exchange capacity of zeolite and pumice was 100-300 and 30 cmol kg^{-1}, respectively (Panuccio et al., 2009; Duangpatra, 2010). Properties of

organic fertilizer; pH was 6.30, electrical conductivity (EC) was 3.97 dS m^{-1}, organic matter (OM) was 30.89 %, Total N, P$_2$O$_5$ and K$_2$O were 2.45, 4.91 and 1.95 %, respectively.

Table 2. Treatment description

Treatment	Description	N-P$_2$O$_5$-K$_2$O kg ha^{-1}
T1	Control (no fertilizer+no soil conditioner)	0-0-0
T2	Chemical fertilizer 100%	100-50-100
T3	Chemical fertilizer 100%+Zeolite rate 312.5 kg ha^{-1}	100-50-100
T4	Chemical fertilizer 100%+ Pumice rate 312.5 kg ha^{-1}	100-50-100
T5	Chemical fertilizer$_{75.06-0-83.81}$ +Organic fertilizer rate 1,018.75 kg ha^{-1}	100-50-100
T6	Chemical fertilizer 75%	75-37.5-75
T7	Chemical fertilizer 75%+Zeolite rate 312.5 kg ha^{-1}	75-37.5-75
T8	Chemical fertilizer 75%+Pumice rate 312.5 kg ha^{-1}	75-37.5-75
T9	Chemical fertilizer$_{56.38-0-62.88}$ +Organic fertilizer rate 762.5 kg ha^{-1}	75-37.5-75

Table 3. Recommended rates of fertilizer based on soil analysis for cassava

Soil properties	Rates of fertilizer
Organic matter (%)	
<1	N 100 kg ha^{-1}
1-2	N 50 kg ha^{-1}
>2	N 25 kg ha^{-1}
Available P (mg kg^{-1})	
<7	P$_2$O$_5$ 50 kg ha^{-1}
7-30	P$_2$O$_5$ 25 kg ha^{-1}
>30	P$_2$O$_5$ 0 kg ha^{-1}
Exchangeable K (mg kg^{-1})	
<30	K$_2$O 100 kg ha^{-1}
3-60	K$_2$O 50 kg ha^{-1}
>60	K$_2$O 25 kg ha^{-1}

2.3 Sample Collection and Analysis

Soil sampling were collected before and after cultivation at depth 0-30 cm then it was analyzed in laboratories for certain soil physical and chemical properties including soil pH measured by using soil to water ratio 1:1 (National Soil Survey Center [NSSC], 1996). Electrical conductivity (EC$_e$) was measured on water saturated extract (Rayment & Lyons, 2011). Organic matter (OM) was measured by Walkley and Black method (Walkley & Black, 1934)**.** Available P was measured by Bray II method (Bray & Kurtz, 1945). Exchangeable K was measured by extraction with NH$_4$OAc at pH 7.0 (Pratt, 1965) and cation exchange capacity (CEC) was measured on saturated extract using NH$_4$OAc at pH 7.0 (Chapman, 1965).

Plant data comprised growth, yield and yield component. Growth data included plant height and above ground biomass. Plant height was collected at 3, 6, 9 and 12 months after planting. Above ground biomass was collected at 12 month after planting. Yield and yield components were collected at 12 month after planting including fresh tuber yield, starch content, starch yield and concentration of total N, P and K in fresh tuber yield.

2.4 Statistical Analysis

Plant data and soil properties under difference rate of chemical fertilizer and type of soil conditioners were analyzed for statistical significance by method of analysis of variance (ANOVA) and difference between means by Duncan's multiple range test (DMRT).

3. Results and Discussion

Effect of fertilizer management in combination with soil conditioners on soil properties, cassava growth, yield and yield components.

3.1 Soil Properties

Sole use of chemical fertilizer in various rates or combined with soil conditioners had highly significant effect on

soil properties (Table 4) including soil pH, electrical conductivity (EC_e), organic matter (OM), cation exchange capacity (CEC), available P and exchangeable K. Soil pH level was classified between moderately to slightly acid and found lowest soil pH for chemical fertilizer 100% combined with zeolite which was not different from chemical fertilizer combined with organic fertilizer rate 1,018.75 kg ha^{-1}. Lowest soil pH of chemical fertilizer 100% combined with zeolite was the result of ammonium sulfate (21-0-0) that can release H^{+} from hydrolysis process and zeolite can absorb H^{+} and another cation well. The phenomenon of soil pH reduction causing by nitrogen fertilizer has been verified by other researchers (Mitchell & Smethurst, 2004; Kongkaew, 2007; Costa, 2012). Smaller effect on soil pH was found for chemical fertilizer combined with organic fertilizer rate 1,018.75 kg ha^{-1}. This treatment although applied chemical fertilizer at lower rate but the combination potentially released organic acids from decomposition of organic matter that could lower soil pH. (Kongkaew, 2007; Sampanpanish, 2012). Soil EC_e level was not affected by this experiment (non-saline soil). The level of organic matter in soil after the experiment was classified between low to moderately low. Organic matter was highest for chemical fertilizer combined with organic fertilizer rate 1,018.75 kg ha^{-1} followed by chemical fertilizer combined with organic fertilizer rate 762.5 kg ha^{-1} and higher than conditioner treatments since organic fertilizer has organic matter more than soil conditioners (Kongkaew, 2007; Kaewkamthong et al., 2014; Guo et al., 2016). Cation exchange capacity after this experiment was found between moderately low to moderate levels. All treatments of chemical fertilizer combined with soil conditioners caused negligible effect on cation exchange capacity since the soils acquired additional cation exchange sites from soil conditioners. Levels of available P in soil were found between low to moderate but level of exchangeable K in soil is still very low due to leaching in coarse-textured soil and crop removal according to previous reports that consistently suggested that cassava drawn large amount of K from soil. The content of P was not greatly affected by the treatments (Howeler & Cadavid, 1983; Howeler, 1991; Kongkaew, 2007). Moreover, chemical fertilizer combined with organic fertilizer rate 1,018.75 kg ha^{-1} resulted highest available P and exchangeable K in soil followed by chemical fertilizer 100% combined with zeolite and pumice respectively. Chemical fertilizer combined with organic fertilizer rate 1,018.75 kg ha^{-1} contributed highest organic matter, available P and exchangeable K in soil due to the fact that organic fertilizer can reduce leaching of plant nutrients and release plant nutrients to soil. Besides, organic fertilizer has various plant nutrients in organic form that continuously decomposed by microbial activity and released plant nutrients in mineral form. Therefore the combination results increase in levels of organic matter, available P and exchangeable K in soil, which corresponds to previous reports (Kaewkamthong et al., 2014; Brady & Weil, 2008).

3.2 Cassava Growth

The results revealed that application of sole chemical fertilizer at various rates or combined with soil conditioners significantly affected plant height and above ground biomass at 3 and 6 months after planting (Figure 1). Application of chemical fertilizer in combination with organic fertilizer at 1,018.75 kg ha^{-1} gave highest plant height and was not difference from chemical fertilizer 100% applied solely or combined with zeolite and pumice. Furthermore, at 9 and 12 month after planting, application of chemical fertilizer combined with organic fertilizer rate 1,018.75 kg ha^{-1} gave highest plant height and above ground biomass (Figure 1 and 2), and was not different from chemical fertilizer 100% combined with zeolite. During the period 3 and 6 months, all treatment receiving chemical fertilizer 75% applied solely or combined with soil conditioners gave insufficient plant nutrients for growth. Thus, plant height of cassava received chemical fertilizer 100% was better than cassava received chemical fertilizer 75% (DOA, 2005; Kongkaew, 2007), during this period considering on plant heights revealed that nutrient leaching was not pronounced but during 9 and 12 month periods, cumulative nutrient leaching in coarse-textured soil contributed significant loss of nutrients for plant uptake (Duangpatra, 1988; Astier et al., 2006). So application of sole chemical fertilizer in coarse-textured soil plant nutrient could be easier leached than application of chemical fertilizer in combination with soil conditioner except pumice since pumice has lowest cation exchange capacity among soil conditioners used in this experiment (Panuccio et al., 2009; Duangpatra, 2010). Moreover, chemical fertilizer combined with organic fertilizer rate 1,018.75 kg ha^{-1} gave highest plant height and above ground biomass at all periods due to the fact that organic matter has more plant nutrients in organic form than other soil conditioners that continuously decomposed and released for plant, according to previous reported (Kaewkamthong et al., 2014; Brady & Weil, 2008). Observed plant height at all periods and above ground biomass were affected by rate of chemical fertilizer, application of sole chemical fertilizer 100% or combined with soil conditioners gave plant height and above ground biomass more than application of sole chemical fertilizer 75% or combined with soil conditioners (Kongkaew, 2007; Costa, 2012; Kaewkamthong et al., 2014). On the other hand, control treatment gave the lowest above ground biomass and plant heights in all growth stages since plant nutrients in soil was insufficient for plant.

Table 4. Soil properties as affected by fertilizer management used in combination with soil conditioners

Treatment	pH	EC_e (dS m^{-1})	OM (%)	CEC (cmol kg^{-1})	Available P (mg kg^{-1})	Exchangeable K (mg kg^{-1})
Initial soil	6.15	0.22	0.45	2.42	5.13	16.62
T1	6.12b	0.24f	0.50f	2.85d	5.22g	16.77e
T2	5.94c	1.01d	0.75cd	10.58bc	12.46cd	24.85b
T3	5.76d	1.62a	0.84c	12.36a	13.54b	26.42ab
T4	6.10b	1.46ab	0.76cd	11.42ab	12.87bc	25.88ab
T5	5.86cd	1.58a	1.36a	12.12ab	14.56a	26.85a
T6	6.22ab	0.68e	0.64e	9.45c	8.89f	18.51de
T7	6.18ab	1.38bc	0.71de	11.89ab	10.56e	19.68cd
T8	6.28a	1.26c	0.68de	10.85abc	9.25f	18.99cd
T9	6.15ab	1.32bc	1.17b	11.68ab	11.87d	20.65c
F-test	**	**	**	**	**	**

Note. **significant at 0.01 probability levels, the figures containing the same letter(s) in the same column indicated a non-significant different according Duncan's Multiple Range Test (DMRT).

3.3 Yield and Yield Components

The results revealed that application of sole chemical fertilizer at various rates or combined with soil conditioners had highly significant effect on fresh tuber yield, starch content and starch yield (Figure 2). At 12 month after planting, application of chemical fertilizer combined with organic fertilizer rate 1,018.75 kg ha^{-1} gave the highest fresh tuber yield and was not difference from chemical fertilizer 100% combined with zeolite, application of chemical fertilizer 75% gave lower fresh tuber yield than application of chemical fertilizer 100% (Costa, 2012). Moreover, zeolite and organic fertilizer have higher cation exchange capacity than pumice that can reduce plant nutrient leaching better than pumice and sole chemical fertilizer (Panuccio et al., 2009; Duangpatra, 2010). Starch content of all treatments of sole chemical fertilizer at various rates or combined with soil conditioners was not different, being in the range of 27.56-26.42%. The result agreed with another report (Kaewkamthong et al., 2014). Furthermore, application of chemical fertilizer combined with organic fertilizer rate 1,018.75 kg ha^{-1} gave highest starch yield and was not different from application of chemical fertilizer 100% combined with zeolite and pumice. Chemical fertilizer combined with organic fertilizer gave better fresh tuber yield, starch content and starch yield than used in combination with other soil conditioners. This contributed to the fact that organic fertilizer contains organic matter and plant nutrients more than other soil conditioners and can improve soil physical properties and enhance yield and yield components as reported previously (Kaewkamthong et al., 2014; Brady & Weil, 2008). Nevertheless, control treatment gave the lowest fresh tuber yield, starch content and starch yield in all growth stage because plant nutrient in soil was insufficient for plant.
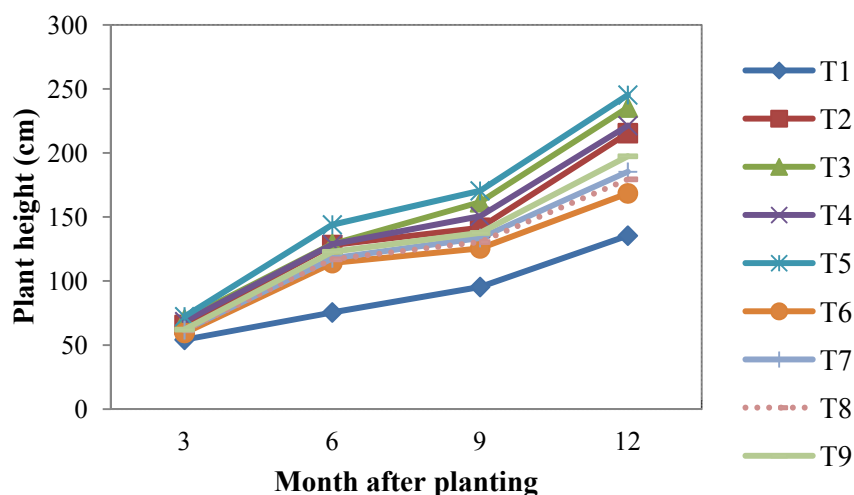
Figure 1. Plant height of cassava measured at 3, 6, 9 and 12 month after planting
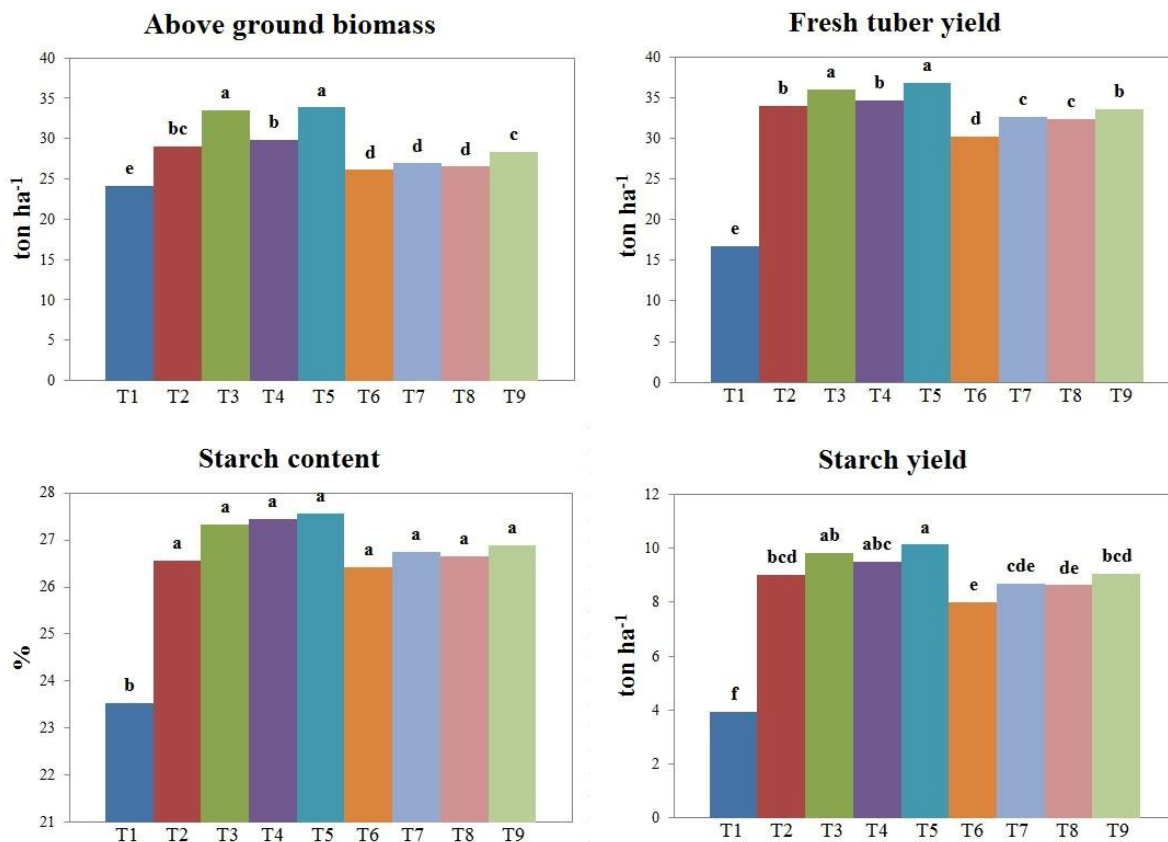
Figure 2. Above ground biomass, fresh tuber yield, starch content and starch yield of cassava at 12 month after planting

3.4 Concentration of Primary Nutrient

Considering the concentration of primary nutrient, it was found that application of sole chemical fertilizer at various rates or combined with soil conditioners had highly significant effect on total N, P and K content in fresh tuber yield (Figure 3). Application of chemical fertilizer combined with organic fertilizer rate 1,018.75 kg ha^{-1} gave highest total N and K, and was not different from chemical fertilizer 100% combined with zeolite and pumice. Although, chemical fertilizer combined with organic fertilizer rate 1,018.75 kg ha^{-1} gave highest total P, and was not difference from applied chemical fertilizer 100% combined with zeolite. Because zeolite and organic fertilizer can reduce plant nutrient leaching better than pumice according to their higher CEC (Panuccio et al., 2009; Duangpatra, 2010), therefore, cassava can uptake plant nutrient and accumulated in fresh tuber better. Higher accumulation of K were detected because cassava could accumulate highest K in tuber, followed by total N and P respectively, which corresponded with previous reports (Howeler & Cadavid, 1983; Howeler, 1991).
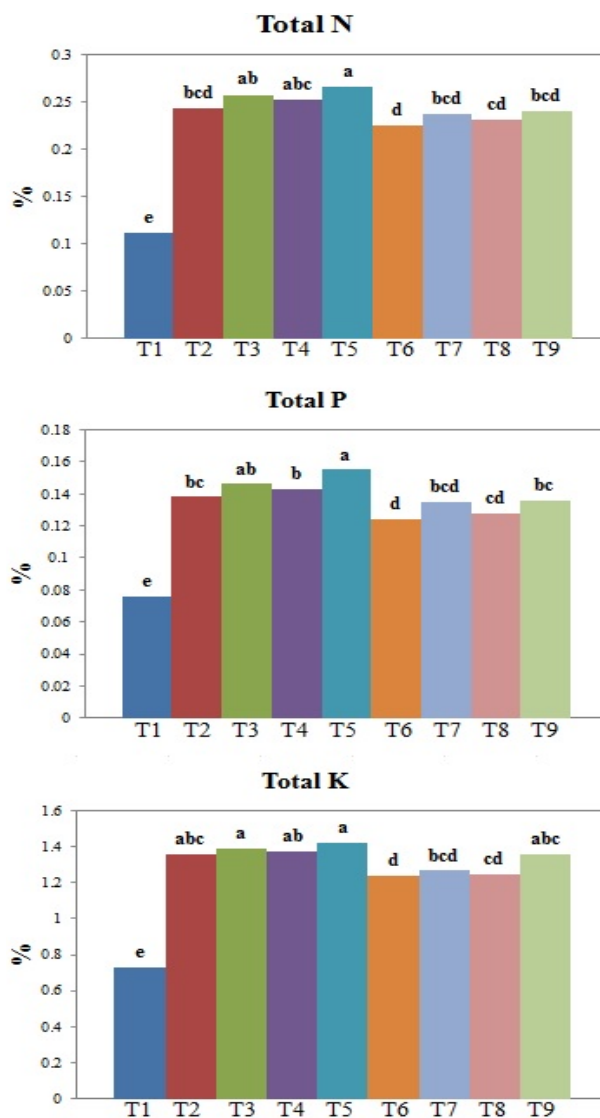
Figure 3. Concentration of primary nutrient in cassava fresh tuber yield

4. Conclusion

The results of this experiment suggested that chemical fertilizer combined with organic fertilizer rate 1,018.75 kg ha^{-1} was suitable for cassava cultivated in coarse-textured soil since it gave highest plant height, above ground biomass, fresh tuber yield, starch content and starch yield. However, such treatment was not different from chemical fertilizer 100% combined with zeolite. The treatments of chemical fertilizer 100% combined with pumice and chemical fertilizer 75% combined with soil conditioners were less efficient. Furthermore, chemical fertilizer combined with organic fertilizer rate 1,018.75 kg ha^{-1} could increase plant nutrient and organic matter in soil better than combine use with zeolite and pumice, respectively. Moreover, soil pH was found to decrease when applied sole chemical fertilizer at high rate or use in combination with soil conditioners.

Acknowledgments

References

Agassi, M., Morin, J., & Shainberg, I. (1990). Slope, aspect and phosphogypsum effects on runoff and erosion. *Soil Sci. Soc. Am. J., 54*, 1102-1106. http://dx.doi.org/10.2136/sssaj1990.03615995005400040030x

Anusontpornperm, S., Nortcliff, S., & Kheoruenromne, I. (2005). Hardpan formation of some coarse-textured upland soils in Thailand. *Proceeding of the International Symposium on Management of Tropical Sandy Soils from Sustainable Agriculture*, Khon Kaen, Thailand.

Astier, M., Maass, J. M., Etchevers Barra, J. D., Pena, J. J., & Gonzalez, F. (2006). Short-term green manure and tillage management effects on maize yield and soil quality in an Andisol. *Soil Till. Res., 88*, 153-159. http://dx.doi.org/10.1016/j.still.2005.05.003

Brady, N. C., & Weil, R. R. (2008). *The Nature and Properties of Soils* (14th ed.). New Jersey: Prentice Hall.

Bray, R. A., & Kurtz, L. T. (1945). Determination of total, organic and available forms of phosphorus in soils. *Soil Science, 59*, 39-45.

Buarach, K., Thongjoo, C., Udomprasert, N., & Amkha, S. (2014). Effects of tillage system and soil organic matter amendment on growth, yield of Pathumthani 80 rice and carbon sequestration in paddy soil. *Modern Applied Science, 8*(4), 1-7. http://dx.doi.org/10.5539/mas.v8n4p1

Celik, I., Gunal, H., Budak, M., & Akpinar, C. (2010). Effects of long-term organic and mineral fertilizers on bulk density and penetration resistance in semi-arid Mediterranean soil conditions. *Geoderma, 160*, 236-243. http://dx.doi.org/10.1016/j.geoderma.2010.09.028

Chapman, H. D. (1965). Cation-exchange capacity. In C. A. Black (Ed.), *Methods of Soil Analysis - Chemical and Microbiological Properties*, *Agronomy* (Vol. 9, pp. 891-901). Madison, Wisconsin: American Society of Agronomy.

Chen, Z., Chen, W., Li, C., Pu, Y., & Sun, H. (2016). Effects of polyacrylamide on soil erosion and nutrient losses from substrate material in steep rocky slope stabilization projects. *Sci. Total Environ., 554-555*, 26-33. http://dx.doi.org/10.1016/j.scitotenv.2016.02.173

Costa, M. C. G. (2012). Soil and crop responses to lime and fertilizers in a fire-free land use system for smallholdings in the northern Brazilian Amazon. *Soil Till. Res., 121*, 27-37. http://dx.doi.org/10.1016/j.still.2012.01.017

Department of Agriculture. (2005). *Fertilizer recommendation for economic crop*. Bangkok, Thailand: Department of Agriculture.

Duangpatra, P. (1988). Soil and climatic characterization of major cassava growing areas on Thailand. *Proceedings of the CIAT Workshop on Cassava Breeding and Agronomy Research in Asia* (pp. 157-184). Bangkok, Thailand.

Duangpatra, P. (2010). *Soil Conditioners*. Bangkok, Thailand: KASETSART UNIVERSITY PRESS.

Gama Castro, J. E., Solleiro Rebolledo, E., & Vallejo Gómez, E. (2000). Weathered pumice influence on selected alluvial soil properties in west Nayarit, Mexico. *Soil Till. Res., 55*, 143-165. http://dx.doi.org/10.1016/S0167-1987(00)00114-8

Gholamhoseini, M., Ghalavand, A., Khodaei, J. A., Dolatabadian, A., Zakikhani, H., & Farmanbar, E. (2013). Zeolite-amended cattle manure effects on sunflower yield, seed quality, water use efficiency and nutrient leaching .*Soil Till. Res., 126*, 193-202. http://dx.doi.org/10.1016/j.still.2012.08.002

Guo, L., Wu, G., Li, Y., Li, C., Liu, W., Meng, J., ... Jiang, G. (2016). Effects of cattle manure compost combined with chemical fertilizer on topsoil organic matter, bulk density and earthworm activity in awheat–maize rotation system in Eastern China. *Soil Till. Res., 156*, 140-147. http://dx.doi.org/10.1016/j.still.2015.10.010

Howeler, R. H., & Cadavid, L. F. (1983). Accumulation and distribution of dry matter and nutrients during a 12-month growth cycle of cassava. *Field Crop. Res., 7*, 123-139. http://dx.doi.org/10.1016/0378-4290(83)90017-5

Howeler, R. H. (1991). Long-term effect of cassava cultivation on soil productivity. *Field Crop. Res., 26*, 1-18. http://dx.doi.org/10.1016/0378-4290(91)90053-X

Kaewkamthong, Y., Thanachit, S., Anusontpornperm, S., & Wiriyakitnateekul, W. (2014). Alleviation of Soil Compaction Problem for Growing Cassava on a Typic Paleustult, Northeast Thailand. *Asian J. Crop Sci., 6*, 334-344. http://dx.doi.org/10.3923/ajcs.2014.334.344

Kongkaew, T. (2007). Utilization of by-Product of Monosodium Glutamate Industry (Ami-Ami) as Fertilizer for Cassava. *Khon Kaen Agric. J., 35*, 411-418.

Mitchell, A. D., & Smethurst, P. J. (2004). Surface soil changes in base cation concentrations in fertilised

hardwood and softwood plantations in Australia. *For. Ecol. Manage., 191*, 253–265. http://dx.doi.org/10.1016/j.foreco.2003.12.011

National Soil Survey Center. (1996). *Soil survey laboratory methods manual*. Soil Survey Investigations Report (No. 42, Version 3.0), Natural Conservation Service, USDA.

Office of Agricultural Economics. (2014). *Agricultural statistics of Thailand 2014*. Bangkok, Thailand: Office of Agricultural Economics.

Panuccio, M. R., Sorgona, A., Rizzo, M., & Cacco, G. (2009). Cadmium adsorption on vermiculite, zeolites and pumice: Batch experimental studies. *J. Environ. Manage, 90*, 364-374. http://dx.doi.org/10.1016/j.jenvman.2007.10.005

Pratt, P. F. (1965). Potassium. In Method of Soil Analysis, Part II. *Chemical and Microbiological Properties*, Black, C. A. (Ed.). American Society of Agronomy, Madison, WI., USA., 1023-1031.

Putthacharoen, S., Howeler, R. H., Jantawat, S., & Vichukit, V. (1998). Nutrient uptake and soil erosion losses in cassava and six other crops in a Psamment in eastern Thailand. *Field Crop. Res., 57*, 113-126. http://dx.doi.org/10.1016/S0378-4290(97)00119-6

Ramesh, K., & Reddy, D. D. (2011). Chapter Four – Zeolites and Their Potential Uses in Agriculture. *Adv. Agron., 113*, 219-241. http://dx.doi.org/10.1016/B978-0-12-386473-4.00004-X

Rayment, G. E., & Lyons, D. J. (2011). *Soil chemical methods-Australasia*. Collingwood, Australia: CSIRO Publishing.

Sampanpanish, P. (2012). Effect of organic fertilizer on CO_2, CH_4 and N_2O emissions in a paddy field .*Modern Applied Science, 6*(12), 13-21. http://dx.doi.org/10.5539/mas.v6n12p13

Tongglum, A., Suriyapan, P., & Howeler, R. H. (2000). Cassava agronomy research and adoption of improved practices in Thailand: Major achievements during the past 35 years. *Proceedings of the 6th Regional Workshop on Cassava's Potential in Asia in the 21st Century: Present Situation and Future Research and Deveropment Needs* (pp. 228-258). Ho Chi Minh City, Vietnam.

Walkley, A., & Black, I. A. (1934). An examination of the Degtjareff method fordetermining soil organic matter, and a proposed modification of thechromic acid titration method. *Soil Science, 37*, 29–38. http://dx.doi.org/10.1097/00010694-193401000-00003

Warrington, D., Shainberg, I., Agassi, M., & Morin, J. (1989). Slope and Phosphogypsum's Effects on Runoff and Erosion. *Soil Sci. Soc. Am. J., 53*, 1201-1205. http://dx.doi.org/10.2136/sssaj1989.03615995005300040035x

Wu, C., Li, W., Wang, K., & Li, Y. (2015). Usage of pumice as bulking agent in sewage sludge composting. *Bioresource Technol., 190*, 516-521. http://dx.doi.org/10.1016/j.biortech.2015.03.104

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Development of a Self-Assessment, Performance Measurement and Quality Insurance Repository

Case of Two Higher Education Institutions in Morocco

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Abstract

The self-assessment repositories are used in a perspective of quality management. They are intended to guide higher education institutions in building their training offer and enable the evaluation and performance measurement based on explicit and consistent objectives. These are essential tools for posterior training evaluation, facilitating a development based on changes affecting the science and socio economic fields.

The self-assessment thus enables a diagnosis, and identification of the strengths and possible improvement actions.The purpose of this is to increase the institutional progress capacity and evolution through a self-reflection.

In this regard, the aim through this article is the development of a self-assessment repository for the training institutions adapted to the Moroccan higher education specificities. To do this, we first recalled the state of the art in terms of the main standards and benchmarks used as the basis of our research: ISO 29990, ISO 9001, AERES repository, NF Training Service, Aqi- Umed, CTI self-assessment Guide and eduqua Manual 2012. We underlined, then, the self-assessment issues in higher education and the major elements that feed the interest and approach adopted in the case of our study. We presented the proposed repository, including the evaluation axes and criteria, and explained the choice for modifing certain references or criteria related to the particularity of Moroccan context and the appropriate evaluation methodology in order to reach results and thus allow the evaluator to find the required information and help its analysis and objective judgment.

Keywords: institution, quality, repository, self-assessment, training

1. Introduction

1.1 State of the Art

The quality assessment in higher education is a fast expanding sector since the mid 1980: quality assurance certification, institutional and program accreditation, certification, accreditation agencies, international scientific publications ranking, national higher education quality indicators, etc (Zouaoui, 2009). Assessment authorities are varied: public agencies, semi-public and private or transnational agencies, governments, professional associations, consulting firms and consultants (Vinokur, 2006).

However, the institutional self-assessment is an internal process of the higher education establishment used to periodically analyze the institution's quality. This process may allow the institution positioning control in relation with the adopted reference (Boubakour, 2014).

The Self-assessment is also used to assess the institution dynamic progress taking into account its specific activities and its environment (Boubakour, 2014). It leads to the production of a self-evaluation report for the institution internal use and serves too as another reference document for the external evaluation process (Haute Autorité de Santé, 2007).

The self-evaluation process thus is an ad hoc operation performed at a regular time intervals that must be clearly

distinguished from the institution continuous tasks and the organization of his steering on the areas defined by the selected repository (Boubakour, 2014).

The main aim is to collect the most complete possible data relating to the field of activities that the institution has decided to submit to the self-evaluation process (Côté, 2009). For this purpose, the following table presents the main standards and benchmarks in the field of higher education evaluation. The choice of these standards is mainly justified by their relevance, and the quality and reputation of organizations and agencies.

Table 1. Principal standards for the quality assessing in Higher Education

Standards	Scope
ISO 9001 (Bouzid, 2010) (Norme internationale ISO9001, 2008)	- Gives a primordial role to the organization management in the implementation of quality insurance; - Considers the internal clients (training establishment employees) as the quality actors; - Takes Into account the legal and regulatory requirements; - Measures the ad hoc client satisfaction; - Analyzes the training institution as a process rather than services and departments.
NF training services (Norme française service formation, 2005)	- Describes what must be doing and how to do the core business ; - homogenizes practices through a professional standard; - Combines the management requirements and service performance with a notion of social sensitivity ; - Measure the customer satisfaction level, the claims processing ...
The AERES Repository (Section des unités de recherche de l'AERES, 2012)	- Measures the ability of the entity to be recognized in the research community, by acquiring notoriety and visibility ; - Analyzes different activities by which research leads impacts on the economy, society or culture; - Analyzes the entity investment in the training through research in conjunction with the educational authorities; - Applied not only to research entities, but also to their "components".
ISO 29990 (Norme internationale ISO/DIS 29990, 2009)	- Represents a common framework reference for training providers and their clients ; - Destined for the design, supply, monitoring, and evaluation of training providers ; - Describes the requirements for a successful process; - Facilitates the implementation of quality management tools: strategy, management review, nonconformity management, internal audits, and stakeholder satisfaction.
Aqi - Umed (Tempus Aqi-umed Project, 2011)	- Contributes to the development of practical quality insurance and evaluation within the Mediterranean universities; - Develops quality insurance practices in the partner countries universities; - Improves the training institutions governance; - Supports national implementation policies of quality assurance systems in higher education; - Disseminates an internal and external quality and development of evaluation mechanisms culture, in higher education ; - Promotes the experiences and self-assessment practices exchange around the Maghreb and Europe universities.
Self evaluation guide of CTI (Commission des Titres d'ingénieur CTI, 2006, 2012, 2015)	- Gather the coherent evaluation criteria with the documents of international organizations of higher education evaluation, standardization and quality assessment ; - Takes into account the concepts of competence in the training management; - Distinguish different degrees of investigations and tracking ; - Each evaluation criteria correspond to different purposes related to the institution quality and its training.
Manuel of éduQua 2012 (Kocher, 2012).	- Improves transparency of training provision descriptions and clients services ; - Ensures the continuous training services quality basing on standards and promotes their optimization ; - Provides a basic decision for the authorities ; - Meets the requirements of a common basic principles of the Quality Management System (process approach , customers orientations …)

Since the last decade, the higher education training quality has become a constant concern of the public authorities in many countries. The international quality insurance harmonization in higher education has accompanied and encouraged the improvement of the existing mechanisms for national plans. Many reforms have been undertaken abroad, with the aim of improving the attractiveness of higher education and research competitiveness (Bourdin, 2008).

On the other hand, the standards and guidelines for quality management in the European higher education area, adopted at the Bergen Conference (May 2005) relate firstly the internal evaluation, by institutions, for their own practices and, secondly, the external evaluation by specialized agencies. Finally, they provide a framework for the evaluator's evaluation (Bourdin, 2008).

In the US, the higher education institutions assessment is carried out as a part of the accreditation process. The accreditation agencies are responsible for the evaluation of higher education institutions and they are the only authorized to assess the university education quality (Bourdin, 2008).

For the Chinese government, universities evaluation is a powerful lever for creating a network of excellence institutions (Project 211) and developing key disciplines at the national level (Bourdin, 2008).

Therefore, multiple convergences emerge from this overview of reforms in several countries. The dominant model is a regulation by independent agencies in order to ensure the results legitimacy.

1.2 Interest of the Study

The Self-assessment is useful for higher education institution to know, by itself, its strengths and weaknesses. Subsequently, the institution would benefit from an external look to ensure the neutrality and quality insurance of its courses and management (Boubakour, 2014).

Quality insurance and self-assessment project (part of the school project) are an opportunity to take into account both the different requirements of the environment, and also the domestic management.

This is the opportunity to explore the different components of management and develop an integrated approach that allows grouping and synergistically treat a large number of transverse themes (Agence Nationale d'Accréditation et d'Evaluation en Santé ANAES, 2002).

Thus, the self-evaluation process is a gradual process. It aims to obtain the training institution improvements on priority issues. It corresponds to a targeted effort justified by the issues importance and the need to develop and implement a solution (ANAES, 2002).

It is question of solving a problem or improving an unsatisfactory operation, but also increasing performance in a specific area. As the development of the approach, the institution develops its ability to conduct high quality actions. Prioritization criteria have to be determined by the institution which can then build and use the appropriate tools.

Thus, after explaining the interest of the self-evaluation process in higher education institutions, we saw inevitable to provide a reliable tool to carry out this process. Therefore, we have made sure that this tool will be adapted to the Moroccan context, given its peculiarity and the specific constraints which characterize it.

2. Methodology

The development and implementation process of the quality self-assessment repository requires a prior definition of the concerned target institutions. When the unit is a university, we must lead a common approach to all integral parts of the university. When the unit is a school or institute, the approach will cover the main components of management and training.

For the committee in charge of the self-assessment, several configurations are possible. The actors involved in this committee should be representative of the institution. They have to be able to engage a laborious work for the whole evaluated institution. The active actors will not have as mission to represent their original entity but an overall mission for the institution's service. The approach by the evidence will ensure impartiality. The management team involvement remains inevitable. Several variants can be adopted for the composition of the self-assessment team, in particular depending on the culture of each institution and the level of collective quality issues ownership.

To corroborate the above statement, we conducted a survey in two higher education institutions in Morocco (public institution and private institution). In our case of study, we worked in collaboration with the quality cells of these institutions while incorporating representatives of various staff categories of the two target institutions.
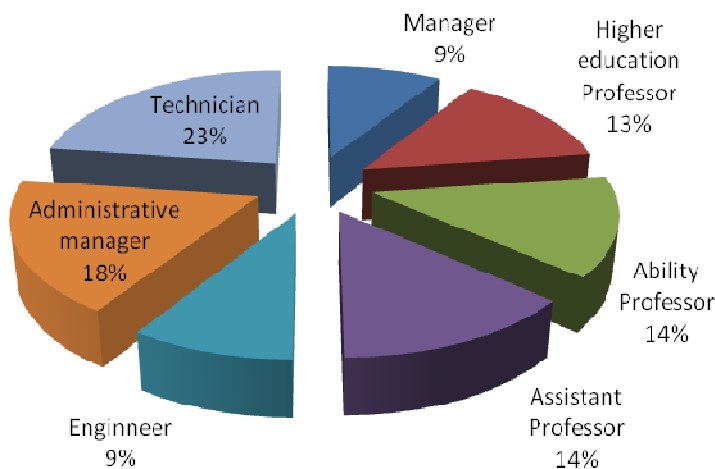
Figure 1. Constitution of the evaluation unit

In addition to the standards and norms set forth above and which are a reference in the field, we sought the already established evaluation team in order to highlight the priorities that will be the pillars of our repository and, depending on the needs expressed and / or explicit in each institution on the one hand and each stakeholder category in the other hand.

Also, the expected purpose of this survey is to highlight the real need for governance and quality insurance through a targeted questionnaire in order to measure the satisfaction, monitoring and reporting tools as well as the need for periodic self-assessment (Boubakour, 2014). The results of this survey are listed below:
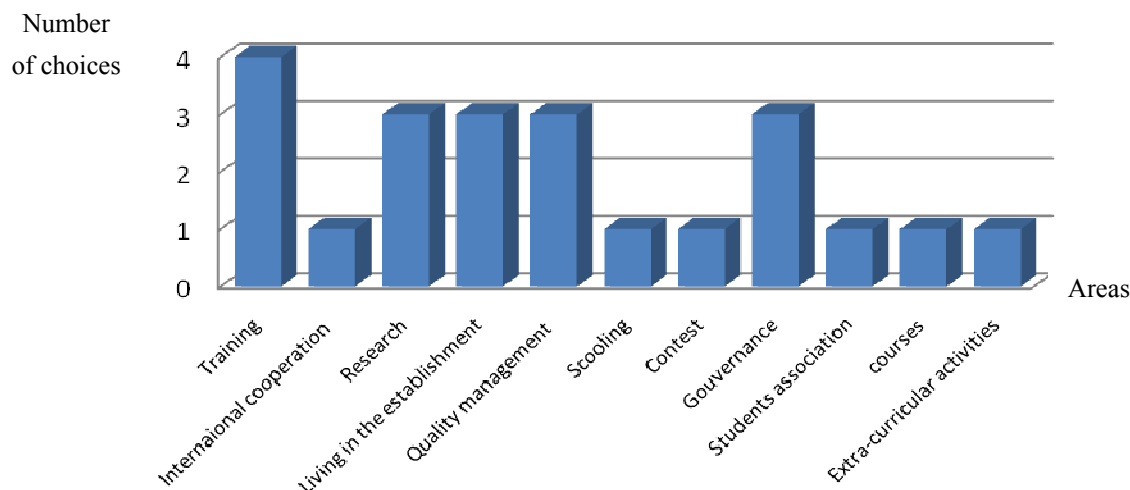
Figure 2. Results obtained by the members of the work team

According to the results, we found that the priority areas are: training, research, governance, life in the institution and the quality management system.

Based on the results, the working team has looked at a reflection intending to develop assessment criteria for each priority. It is during this step that the team highlighted the various aforementioned standards and norms, in the aim of highlighting criteria adapted not only to the specificities of the Moroccan context but also to the real needs of both our subject study institutions.

3. Results and Discussion

As described above, the proposed repository attempts to take into account the quality factors in higher education.

It is based on data obtained from the combined experiences of the team work members. For this purpose it is supposed to be applicable to many training devices, when therefore, they come within the scope of higher education training (Groupe d'assurance qualité du réseau des écoles de service public, 2006).

This repository has been made, however, taking into account the specific characteristics of the two target institutions. Indeed, some criteria may be more or less relevant or have more or less important depending on the contexts in which training is offered and expectations of different beneficiaries. Note that the references gathered here describe what is expected of each institution to be recognized as competent to provide higher education, in terms of values, norms and knowledge (UM5A-Rabat, 2006). Thus, the proposed self-evaluation repository is structured into 5 axes and 27 criteria. For each selected criterion, performance measurement indicators may be proposed depending on the specificities of each institution.

The first axis "training" is interested to the training actions administration, internal functioning, resources, as they can potentially have effects on provided training, as well as the training content relevance, methods and progress into line with its contents.

The axis "Research" accurates expectations regarding to the organization purposes in terms of research policy and strategic position.

The axis "Governance" defines expectations in steering and suitability of different resources (human, logistic, documentary, environmental, and financial) to the needs of the training and management.

The axis "Life in the institution" is interested to the students hosting and living conditions in the institution whose effectiveness is likely to promote a learning meeting specified requirements and recognized by stakeholders.

Finally, the axis "evaluation and procedures for quality management policy" specifies the main elements for a controlled development of a quality insurance project whose adherents are aware of the results they want to produce. It also specifies the management and control conditions for the prioritized improvement actions taking into account the strategy, the organization's resources and the recommendations of the external quality insurance agencies.

Table 2. The proposed repository

Axis	criterion
Training	Definition of the training offer and its management
	Development, implementation and periodic review of programs and degrees
	Student Support during training
	Student and lessons evaluation
	Educational tools and support to the students
	Orientation and professional integration
	Doctoral training
	Continuing training
Research	Organization, structuring and research development
	Scientific production and quality
	Academic Outreach and attractiveness
	Interaction with the social, economic and cultural environment
	Research promoting
	Innovation
Governance	Terms of governance policies development
	Organization and management of components and services
	Information system
	Public Information
	Internal communication
	Social responsibility
Living in the establishment	Hosting and support for students
	Living conditions (health, hygiene, security ...)
	cultural and sport activities

Assessment procedures and policy for Quality Management	The institution mission, vision and goals
	Management system
	The quality process organization, structure and resources
	The quality assessment

4. Evaluation Method

The evaluation methodology chosen by the working group is described in the diagram below (Figure 3) (Haute Autorité de Santé, 2007):

Figure 3. Evaluation Method

Note that the proposed evaluation methodology was selected basing on international assessment standards and benchmarks.

5. Conclusions

The integration of the self-assessment process in higher education institutions contributes to a significant performance improvement.

Consider this as a social building and internal management tool should help to give meaning to the institutional realities and, then, allow stakeholders to give value to their professional practices and standardize therefore internal management modes for the concerned entities.

The quality repository is a development tool for organizations. The actors of each higher education institution can position themselves to participate in the quality development and have a support to design and implement an internal quality insurance policy. This can be done on the basis of evaluation and quality insurance standards and repositories like: ISO 9001 type, 29990 ... etc.

In this context, we looked through this article to highlight the practice of self-assessment and its vital role in

achieving the intended objectives.

To do so, after recalling various international standards that govern this process and in light of the data collected and the Moroccan context, we described the adopted approach in order to develop our repository and the appropriate methodology for its implementation, as part of the higher education institutions evaluation in Morocco.

Finally, in order to succeed the evaluation process, all institutional concerned actors must join effectively the self-assessment process.

References

Agence nationale d'accréditation et d'évaluation en santé (2002, April). *Principes de mise en œuvre d'une démarche qualité en établissement de santé.*

Boubakour, F. (2014, August). *Assurance qualité interne et autoévaluation: des principes à la mise en œuvre.* 4ème session de formation des responsables d'assurance qualité des établissements d'enseignement supérieur.

Bourdin, J. (2008, July). Rapport d'information N° 442, délégation du Sénat pour la Planification (1) sur le défi des classements dans l'enseignement supérieur.

Bouzid, A. (2010). *Normes IS0 9001 ou Lignes Directrices ENQA pour l'Enseignement Supérieur.*Colloque International sur Les Enjeux de l'Assurance Qualité dans l'Enseignement Supérieur, SKIKDA.

Commission des Titres d'ingénieur (2012). *Guide auto-évaluation.*

Commission des Titres d'Ingénieur (2012-2015). Références et orientations, 7e édition, TOME 2 Mise en œuvre.

Commissiondes Titres d'Ingénieur. (2006, December). Guide d'Autoévaluation des Formations d'Ingénieurs, 2ème édition.

Côté, S. (2009). Organisation internationale dela francophonie. Conception et réalisation d'un référentiel d'évaluation, les guides méthodologiques d'appui à la mise en œuvre de l'approche par compétences en formation professionnelle, Guide 5, ISBN 978-92-9028-319-5

Groupe d'assurance qualité du réseau des écoles de service public (2006, June). *Assurance qualité de dispositifs de formations supérieures professionnelles.* Référentiel qualité.

Haute Autorité de Santé (2007, February). Service Qualité de l'Information Médicale. Complément au référentiel d'évaluation des centres de santé. Aide à la mise en œuvre de l'auto-évaluation.

Kocher, H. (2012). *Manuel éduQua.* Certificat suisse de qualité pour les institutions de formation continue.

Norme française service formation. (2005). *Règles de certification NF214- AFAQ AFNOR Certification.*

Norme internationale ISO/DIS 29990 (2009). *Services d'apprentissage pour éducation non formelle et formation - Exigences de base pour fournisseurs de service.*

Norme internationale ISO9001 (2008). *Systèmes de management de la qualité - Exigences.*

Section des unités de recherche de l'AERES. (2012, May). *Critères d'évaluation des entités de recherche: Le référentiel de l'AERES.*

Tempus Aqi-umed Project (2011, October). Référentiel Aqi-umed version finale, renforcement de l'assurance qualité interne dans des universités de la méditerranée.

UM5A-Rabat (2006, June). *Rapport d'autoévaluation institutionnelle.* Projet EVAL-UM5A.

Vinokur, A. (2006). La qualité de la mesure de la qualité dans l'enseignement supérieur: Essai d'analyse économique. *Education et sociétés 2/* (n° 18),109-124. http://dx.doi.org/10.3917/es.018.0109

Zouaoui, M. (2009, December). L'enseignement supérieur depuis l'Indépendance: La dégradation de la qualité était-elle inéluctable.*Cinquante ans de développement humain au Maroc et perspective, 2025,*159-195.

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Competitiveness of the Sugarcane Cluster in Goianesia-GO, Brazil

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Abstract

The present study aims to analyze the competitiveness of the chain of sugarcane cluster that is located in Goianesia (Goiás state, Brazil) and in nearby municipalities like Barro Alto, Santa Rita and Vila Propicio. It was used Michael Porter's Diamond of Competitiveness, which lets to study the competitiveness of a company, cluster or country, by four factors: demand conditions, factor conditions, context for firm strategy and rivalry and related and supporting industries. To build the Diamond of Competitiveness was used secondary and primary information, where the latter was collected by interviewing the key actors inside and outside the Jalles Machado, central company of the cluster analyzed. In terms of results they were found several interesting aspects that affect (positively and negatively) competitiveness of the cluster. It was identified, for instance, how investment in research and development, as well as the adoption of technology, are key for the central company of the cluster to facing the physical constraints of the Goianesian soil, and how this contribute to the cluster competitiveness against other actors that are in better conditions. In addition, the cooperation between cluster's stakeholders - which makes the central company and its partners identify together the cluster's weaknesses and work on a solution- was identified as a key factor in creating competitive advantage. The paper presents the factors that affect both positively and negatively the competitiveness of Goianésia's cane sugar cluster, leaving available the necessary inputs for policy makers drawing strategies for improving the competitiveness of this cluster.

Keywords: diamond of competitiveness, cluster, stakeholder

1. Introduction

The sugarcane in Brazil is one of the better-organized agro industrial activities and one of the more traditional in the country. According to FAO (2015), for 2013 the cane occupied 9.8 million hectares in Brazil and reached a production of 739 million tons, which is nearly twice the area and the production of the second largest producer, India, which reached 5 million hectares and 341 million tons of cane that year. These figures make Brazil the main producer of this crop worldwide, positioning itself also as the largest exporter of sugar in the world, since in 2011 Brazil exported 63% of world raw sugar (FAO, 2015).

This agro industrial activity has gained relevance in Goiás, which currently ranks as the second state with the largest sugarcane production in Brazil with 10% of national production, after São Paulo who leads the production with 57% of the total. In the state of Goiás stands out, among others, the municipality of Goianésia, which has turned an important sugarcane production cluster. This paper seeks to study the relationships between actors inside the value chain of sugarcane in the municipality of Goianésia (GO, Brazil) and its environment and in this sense to identify the actual and future competitiveness of the cluster. By studying these relationships, the study attempts to answer the question: what are the factors related to the competitiveness of the sugarcane cluster in Goianésia-GO, Brazil?

The study of this value chain is done in order to identify its potential regional, national and even internationally competitiveness, based on an analysis of its components, focusing on a microeconomic competitiveness approach but without ignoring some relevant macroeconomic aspects. The study, making use of the competitiveness diamond methodology, aims to be useful at the microeconomic level as it provides useful

information to producers of sugarcane industry, so they can design strategies aimed at adding value to their production and to increase their productivity. It is also useful to public policy makers, so that they intervened at the macro level in order to ensure the increasing of cluster competitiveness bringing prosperity to both farmers and workers.

The study of the competitiveness of a chain requires the adoption of an epistemological position from where competitiveness will be understood. Both the methodology and the results of the study will vary depending on the concept of competitiveness to be used. In this sense it was been consulted some popular definitions of the concept as well as some schools of thought that have addressed the competitiveness from different angles, in order to recognize the most suitable for the study.

Among the best known definitions of competitiveness in the Brazilian agribusiness, it was found Callado's concept (2011, p. 24) which says that competition is " the sustainable ability to survive and preferably grow in competitive markets or in new markets through an information system able to fulfill the management needs derived from long-term planning". Another definition used in Brazil is the Haguenauer (1989, p. 13) which states that "competitiveness could be defined as the ability of an industry (or company) to produce goods with specific quality standards, required by certain markets, using resources at levels equal to or lower than those prevailing in such industries around the world during a certain period of time". The latter author states that the competitiveness definitions can be classified into two large groups consisting of those based on competitiveness as performance (ex-post concept) and those who focused on the competitiveness as efficiency (ex-ante concept).

In the present work it was decided to use the concept of competitiveness that presents the economist Michael Porter, which states that "prosperity is determined by the productivity of an economy" (...) "productivity supports high wages, a strong currency, and attractive returns to capital- and with them a high standards of living. Competitiveness, then, is measured by productivity" (Porter, 2008b, p. 44). The Porter's position is that an increase in productivity (of a company or a nation) leads to increased competitiveness. The real important thing, besides finding a complete definition of competitiveness applicable to any economy, is to identify the factors that increase productivity and promote the gains in competitiveness. As Porter mentioned (2008b, p. 44), "the central challenge for any economy is to create the conditions in which companies and employees throughout the economy can upgrade their productivity." When deciding to use this concept, the focus of this work is to recognize the factors related to the increasing of the competitiveness of the cluster studied.

Therefore, the next step is to identify what are the factors that affect competitiveness, to recognize these factors in the cluster studied. Fajnzylber (1988, apud Nunes, 2006, p. 89) recognizes a group of conditioning factors of international competitiveness, which can be summarized as:

- High levels of investment;
- Allocation of resources for investment in strategic sectors;
- Favorable labour legislation (flexibility, social security, education, quality of labour);
- Harmonious labor relations and constructive cooperation between the different economic, social and political actors;
- Organizational innovations (cooperative relations firms intra and inter firms);
- Educational system suitable for the formation of qualified human resources adequate for restructuring process with the incorporation of technical progress;
- Construction of comparative advantage with the absorption of technical progress;
- Use of policy instruments and institutional dimension.

Porter (2008a, p. 172) states that "according to prevailing thinking, labor costs, interest rates, exchange rates, and economies of scale are the most potent determinants of competitiveness", but he has shown that there are economies that are competitive even without possessing the characteristics "demanded" by orthodox economists. The limited view of orthodox economists about competitiveness requires identifying a more comprehensive approach on this issue. A more unorthodox insight about the factors affecting competitiveness is Schumpeter's theory of innovation. As Sledzik noted (2013, p. 90) "Schumpeter argued that anyone looking for profits have to innovate (...) Schumpeter believed that innovation is regarded as an essential driver of competitiveness and economic dynamics".

The relevance of innovation in relation to the competitiveness was taken decades later by Porter, who related the concept of innovation to productivity and competitiveness. According to him "the only meaningful concept of competitiveness at the national level is productivity" (Porter, 2008a, p. 176), and it always focuses on a few

specific sectors or segments. Concerning to the firm, Porter states that "companies achieve competitive advantage through acts of innovation" (Porter, 2008a, p. 179).

As it recognizes the importance of productivity and innovation, Porter goes on to identify the factors that create these competitive generators. Here, the author assures that "macroeconomic competitiveness indicators create opportunities for productivity but are not sufficient for high productivity to emerge. Microeconomic competitiveness indicators have a direct impact on company productivity" (Porter, 2008b, p. 53).

Focused on competitiveness at the micro level, Porter studied the national business environment and find that this is explained by four factors that are responsible for competitiveness and constitute what he calls the diamond of competitiveness. These factors, which are shown in Figure 1, are demand industries, factor conditions, context for firm strategy and rivalry, relating and supporting industries. Those factors are the tool used in this work to study the competitiveness of the Goianesian sugarcane cluster.
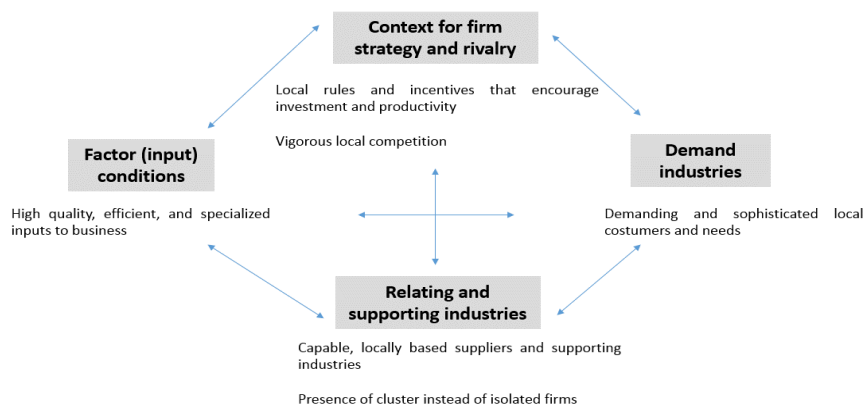
Figure 1. Diamond of competitiveness at the micro level

The objective is to analyze the competitiveness of the Goianesian sugarcane cluster, by constructing the diamond of competitiveness relative of that cluster. For this, the work is presented in four parts where this introduction conforms the first one. The methodology provides a second part while the results are presented on the third part. The discussion is presented in the final chapter.

2. Method

The present research project, classified as exploratory, qualitative and applied, was developed in the sugarcane cluster located in the municipality of Goianésia in the state of Goiás, Brazil. It is a case study on the sugarcane cluster of Goianesia-GO, Brazil. In this municipality took place two visits, the first in order to recognize the sugarcane chain value by identifying the processes and key stakeholders in each link in the chain, and the second in order to conduct key informant interviews to collect primary information that was used in the construction of the diamond of competitiveness.

The interviews focused on the cluster's central industry, the Jalles Machado company, which is the largest and most important industry of the region and which owns more than 40,000 hectares planted with sugarcane in Goianésia and nearby municipalities. In this company were interviewed five leaders and managers of the processing areas, planting and research, warehouse and inputs, market and competitors, and finance. Interviews were done exclusively to leadership area, who have more and most quality information. In addition to these actors in the cluster's central industry, three interviews were conducted with other actors, including a leading supplier of raw materials, an important research partner and a leading researcher in the field of Brazilian agro-energy.

Additional to the collection of primary information, and of equal importance to this, it was compiled secondary information to contribute in building the diamond of competitiveness and to corroborate or completed the testimony given by the respondents. In this case, they were consulted articles published by public organizations or researchers of the studied sector as the EPE (Energy Research Company) or FIEG (Federation of Industries of the State of Goiás), as well as information published on the website of organizations concerned with the sector like the SIFAEG (Ethanol Manufacturing Industry Union of the State of Goiás), or Novacana portal, among

others.

The union of primary and secondary sources let to construct the diamond of competitiveness which, by its complexity, was divided into two parts, a cross-sectorial diamond and a cluster diamond. It was done in that way because some of the factors affecting the studied cluster are common to all or most Brazilian sugarcane producers, while others are particular to Goianésia.

Qualitative data of interviews and analysis of documents and materials were basis to build the diamond of the cluster.

3. Results

3.1 Cross-Sectorial Diamond of Competitiveness

Factor conditions

- Stands out in Brazil the high availability of arable land compared to other international producers of ethanol or sugar. However, it has been evident the presence of cultivation in areas not suitable for sugarcane.

- There is a huge burden represented by the level of indebtedness of the processing industries where 29% of them were in recovery with high leverage and 18% had no way to recover and must undergo mergers or acquisitions (Novacana, 2012). This scenario worsened by the increase that took the dollar against the real during most of 2015.

Demand industries

- The government has contributed historically to create a domestic ethanol demand with the launch of Pro-Alcohol program in 1975, the introduction of MEG blend (60% hydrous ethanol, 34% methanol and 6% gasoline), the creation of flex-fuel engine in 2003, among others. These initiatives have acted as a huge incentive for the entire sugar industry (Montenegro, 2012, pp. 55-57).

- International demand has also attractive dynamics in the sugar market and, according to Ministry of Agriculture projections, it can be expected a continued growth in international sugar demand, especially in China, Algeria, Egypt, Malaysia and others (Montenegro, 2012, pp. 67-68).

- The high US energy demand is an opportunity, but trade restrictions in that country currently make difficult taking advantage of that opportunity, which could be useful in the medium or long term with the signing of a Free Trade Agreement with the US. According to Trevisan, Monteiro & Silva (2015) the Brazilian government is interested in joining of new trading blocs and "until it doesn't build a broad agreement with the United States, Brazil will give priority to trade facilitation measures (with them)".

- The growth of demand for new goods that serve as energy sources in the form of biofuels and bioelectricity, is unquestionable. In the case of sugarcane, there are market opportunities like the development of second-generation ethanol, also known as lignocellulosic ethanol, which make attractive the cultivation of sugarcane for energy and biofuel markets (SIFAEG, 2015a).

- The demand is increasingly geared to value raw materials friendly to the environment. The sugarcane can be differentiated with other competing crops in world energy markets, because of its energy efficiency measured by generated units of energy compared to used units. In the case of sugarcane, life cycle analyzes indicate that this ratio of generation and energy consumption is 8 to 1, while crops that compete directly with sugarcane to generate biofuels, such as corn has a relation of 1 to 1 (EPE, 2008, p. 9).

- The demand for ethanol can be affected by the global economic slowdown as it discourages the growth of the price of ethanol that is strongly linked to crude oil prices. According Plinio Nastari of Datagro, referring to the case of the national economy specifically, "the slowdown of the Brazilian economy is slowing the will of consumption of fuel and electricity" (SIFAEG, 2015b).

- The artificially low gas prices hinder the growth of ethanol prices.

Context for firm strategy and rivalry

- The existence of subsidies in some countries producers of ethanol and sugar distorts the quantities of sugarcane produced, pushing the market equilibrium.

- In addition to the subsidies, some countries imposed tax rates to protect local producers against the

entry of Brazilian products. For instance, the US imposes a fee per gallon of the Brazilian ethanol, creating an advantage for countries competitors of Brazil like those of the Caribbean Basin Initiative (CBI) in Central America (EPE, 2008, p. 25).

• The government's lack of clarity in gasoline prices create uncertainty in the sector and affect it directly. The partial removal of the collection of CIDE (Contribution of Intervention in the Economic Domain) on gasoline, generated troubles to ethanol for competing with fossil fuels in recent years.

• The growing role of some competitor countries has threatened the possibility of entry of Brazilian products in other markets. Montenegro (2012, p. 43) emphasizes the growth of exports of raw sugar from Thailand who has good climatic conditions for sugarcane production at a competitive cost, small domestic consumption and proximity to the Asian consumer markets.

Related and supporting industries

• The Brazilian sugarcane industry has sufficient organizations and research centers, public and private, working in technological innovation. There is a specialization in research by each of them, which makes it face different needs as well as specificities of each region of the sugarcane industry.

Figure 2 summarizes the factors affecting competitiveness, cross way for most sugarcane producers in Brazil. These factors should be added to the particular factors affecting the Goianesian sugarcane cluster for having a complete diagnosis of the cluster. These other factors will be exposed to continuing.

Factor conditions

+ High availability of arable land compared to other producers of ethanol.
- Expansion of cultivation sometimes is made in areas not suitable for sugarcane.
- Worsening debt levels by the dramatic increase in the dollar price in 2015.

Context for firm strategy and rivalry

- Existence of subsidies to ethanol (US and Europe) and sugar producers (India and Thailand) that generate distortions in world markets.
- Imposition of fees to ethanol entry into the US.
- Government lack of clarity in gasoline prices setting.
- The growth of Thailand as a producer of sugarcane threatens the position of Brazil in the Asian markets.

Relating and supporting industries

+ There is a network of specialized research centers, public and private, working on technological innovations in the sector.

Demand industries

+ Domestic demand familiarized with ethanol for decades.
+ Big possibilities for exporting sugar to emerging markets.
+ Sugarcane biomass is attractive for energy and fuel markets.
+ Sugarcane can still innovate in second-generation biofuels (lignocellulosic).
+ Biofuels demand may prefer sugar cane on other crops, because of its energy efficiency.
- Global economic slowdown prevents the growth of ethanol prices.
- Artificially low crude oil prices distort negatively the demand for ethanol.
+ It is still possible to export ethanol to the US through exports of anhydrous ethanol to Central American countries for further processing and export to the US in form of hydrated ethanol.
+ Despite protectionism, the US has a large market demand for Brazilian ethanol.

Figure 2. Cross-sectorial diamond of competitiveness of sugarcane in Brazil

3.2 Cluster Diamond of Competitiveness

Factor conditions

• Goianésia is located in a state that is at the center of the country where there is "easy flow of production to the large Brazilian centers" (Alves & Wander, 2000, p. 10). This is an advantage for interior trade but also a disadvantage for exports since the municipality is far from the sea ports. This situation is even worse by the poor condition of the roads.

• The North-South Railway will create new options of transport to the products of the cluster. The project "planned the construction of 1,550 km, from Açailândia/MA to Anapolis/GO, in order to cross the states of Maranhão, Tocantins and Goiás. With the Law No. 11,772 of 2008 were incorporated into this layout the stretches of Barcarena/PA to Açailândia/MA and Ouro Verde/GO to Panorama/SP" (VALEC, 2015). At the present time, it has been built Palmas-Annapolis stretch (delivered in May 2014) and is already operating Palmas/TO-Açailândia/MA stretch. The other parts are in stages less

advanced, which means that Goianésia is still disconnected from seaports South and North.

- The GO-MG-SP ethanol pipeline project will integrate Goiás to Brazilian ethanol exports circuit. This project involves the construction of a logistics system covering Goiás, Minas Gerais and São Paulo. The Goiás municipalities that directly will receive the benefit of the system are Aparecida do Rio Doce, Itumbiara and Senador Canedo. The distance between Goianésia and Senador Canedo is less than 200 km, in this sense Goianésia will be beneficiated, reducing its transportation costs from the ethanol required to be exported to São Paulo's terminal (PAC, 2015).

- Labour is scarce in the region both for cultivation and for the processing industry. However, the Jalles Machado has made efforts to reduce dependence on labour, by automating the agricultural link. In the process of irrigation, for example, the use of pivots allowed "reduce labour from 130 operators to 77" (Folha da cana, 2014c).

- Labour is not sufficiently specialized in the area. Nevertheless, the Jalles Machado has made a series of investments to training personnel, setting a competitive advantage. Examples are the public partnership established between Jalles Machado and SESI and SENAI (Folha da cana, 2014a); the creation of the Trainee Program in 2014 (Folha da cana, 2014b); the partnership with SENAR and the Rural Union of Goianésia which has trained 7,032 participants including employees of Jalles Machado and people in the community (Folha da cana, 2015a), among other initiatives.

- The agricultural suitability of Goianésia results in a disadvantage against the sugarcane leaders in Brazil. There is little presence of rain and poor soils in the region but are compensated with application of organic matter, correction made with straw, irrigation and "fertirrigation", among other things, that lets the company get high yields without privileged soil and climate.

- The Cerrado biome, in which is located Goianésia, has a high biodiversity, which can create opponents to the establishment of monocultures as that of sugarcane. However, it is recognized that it is preferable the sugarcane to cattle that was once typical in the region.

Demand industries

- The state of Goiás has an attractive demand for electricity supply from alternative sources due to extensive dry seasons, which hampers the power generation by hydroelectrics. The bagasse and sugarcane straw are great alternatives sources.

- The organic sugar demand does not grow on expected proportions and the pace of production will not support the low growth rate of the demand.

Context for firm strategy and rivalry

- The cluster has a structure characterized by an important spatial concentration of sugarcane plantation and industrial processing, because it has no great distances between the farms and the mill. In addition, there is proximity between service providers and the central company of the cluster.

- The cluster has an advantage over its competitors in relation to the use of sugarcane by-products. The use of bagasse to generate bioelectricity, for instance, is a differentiating factor in Goianésia. In addition, it makes use of the filter cake in the planting furrow, allowing higher productivity.

- The ICMS regime (tax on movement of goods and services) in Goiás has not the flexibility it has in other states like São Paulo (direct competitor), generating production overcosts (SIFAEG, 2015b).

- There are tax benefits and other economic benefits like the programs "Fomentar", "Produzir" or the credit given on the anhydrous ethanol, that are offered by the state of Goiás and partially reduce the disadvantages caused by the unfavorable ICMS.

- The central company of the cluster has implemented a technology leadership strategy investing significantly in the adoption and creation of technologies that favor the increasing cluster's productivity. This strategy includes a successful partnership policy with other stakeholders who identifies in Jalles Machado company a chance to test its innovations, generating benefits for all stakeholders.

Related and supporting industries

- The research environment of the cluster is favorable, since in addition to the Jalles Machado, a number of input suppliers, as well as research centers, are constantly working on innovations adapted to the cluster's needs.

- Although the cluster has spatial concentration of production and service providers, there are no

important input suppliers nearby the cluster, causing that several major inputs have to be brought in from other states or even countries.

- Both, suppliers of inputs and agricultural machinery are in the most supporting industries, but in neither case these suppliers are unique to the cluster, since they benefit the other producers of sugarcane in Brazil.

- The respondents of relating and supporting industries interviewed highlighted the quality of relations with the cluster's central industry, stating that this environment favors the technological development of the cluster.

Context for firm strategy and rivalry
+ The cluster has high spatial concentration of cultivation and processing.
+ The cluster strategy of using by-products is an advantage compared to the use of by-products of its competitors.
+ The Jalles Machado strategy of adoption and creation of technology generate a competitive advantage over its rivals.
- The Goiás ICMS regime is disadvantageous in compared to what exists in São Paulo and other states
+ Goiás has tax benefits that do not exist in other states.

Factor conditions
+/- Goianésia and nearby municipalities have intermediate agricultural suitability for sugarcane, but the relatively poor characteristics of climate and soil are compensated with high technology investments.
+ Despite the relative scarcity of labour, especially skilled, the cluster's central industry has several programs for the training of personnel.
+ The location of the plant in the heart of Brazil is an advantage for domestic trade because of its proximity to several states.
+ In the medium and long term, infrastructure projects like north-south railway and GO-MG-SP ethanol pipeline, Goianésia will be integrated with various states.
- The location of Goianésia is a disadvantage for exports of goods and imports of inputs for the distance with major marine terminals.

Demand industries
+ Extensive seasons of drought in Goiás are appealing the electricity supply with renewable sources of energy as generated by bagasse and cane straw.
- Demand for organic sugar is not growing at the same pace than production, which is hindering the sale of this product.

Relating and supporting industries
- Most of supplies have to be brought in from other states, generating higher production costs and an increase in stocks.
+ The main suppliers are competitive and innovative and contribute to the cluster technologies development environment.
+ There are extensive partnerships with other research centers and universities that generate productivity gains from innovation.

Figure 3. The Diamond of Competitiveness of the Goianésia's Sugarcane Cluster

Diamond of competitiveness of the Goianésia's sugarcane cluster who was presented in this chapter, is summarized in Figure 3. Thus, figures 2 and 3 together, present in a synthetic way the factors, positive and negative, that affect Goianésia's sugarcane cluster classified according to the four components proposed by Porter.

4. Discussion

The purpose of this paper was to examine various aspects of the competitiveness of the Goianésia's sugarcane cluster, using the Porter's diamond of competitiveness. With this tool, several factors that affect positively and negatively the competitiveness of the cluster were founded. It was identified that some factors are common to most cane mills in Brazil, and they were included in a cross-sectorial diamond, but exists another that are exclusive of Goianésia's cluster (or that belongs to nearby municipalities or to Goiás), that were included in a cluster diamond. The union of these two diamonds shows all the factors affecting the competitiveness of the Goianesia's sugarcane cluster.

It was shown that this cluster despite having several opportunities for improvement can be regarded as competitive, especially in the domestic sugarcane scenario. Among the most remarkable features is the initiative of the Jalles Machado to have a policy of investing in science and technology, which contributes to the high productivity that typifies the production of the cluster. These high yields that characterize the production of both agricultural and industrial links (which has been recognized as among the most representative of the country), act as a shield against weaknesses like the little presence of rainfall and poor soil quality of the region, as well as from threats such as the virtual decrease in gasoline prices, or the high ICMS of the state of Goiás, letting the cluster being competitive without depending on measures generated by others.

In addition, it was identified the way in which Jalles Machado has faced difficulties in the cluster as the scarce of

labor in the region (especially qualified labor) through a staff training policy to improve the skill levels of workers. In addition, the Jalles Machado has implemented an automation policy of some agricultural activities that required a great number of workers, who is difficult to be supplied with the labour available in the region.

Another very important factor recognized is the harmony between its main actors. Relations between the Jalles Machado with its suppliers, as well as research centers, are characterized by the cooperation that is guided by common goals. The availability of Jalles Machado to serve as testing ground for new products, the high rates of adoption of technology of Jalles Machado and the initiative of suppliers of quality and research centers for respond to the cluster demands, are factors that create competitive advantages of immeasurable value to the region and the actors studied.

However, despite these qualities, which are not common in the Brazilian sugarcane industry, it is impossible to deny the existence of challenges arising from weaknesses of the cluster and from external factors that threaten the sector's competitiveness. The infrastructure of the state serves as an important bottleneck of the cluster as it hinders the flow of production to other states and, even worse, to other countries, due to the distance of Goianésia to Brazilian seaports and the poor condition of roads. Infrastructure projects that are in process will contribute, undoubtedly, to the competitiveness of the Goianésia's cluster but will only be available in the medium or long term, which is an important reason to keep the current area of influence of the cluster products to achieve flow the production without having to incur in additional transportation costs.

In addition, there is an urgent need to find new export markets for the production of organic sugar, since it has been showed that the growth of demand for this product is insufficient and will only be satisfactory by identifying new buyers or to create them through a strategy of promoting the goodness of organic sugar. That kind of strategy will only be possible by linking inter-institutional cooperation, including other domestic organic producers.

Therefore, for taking advantage of the factors identified from the diamond of competitiveness presented in this work, it will be necessary another studies that draw strategies to improve the competitiveness of the cluster. Strategies that will, if it is possible, link public and private actors to establish a continuous improvement policy that positions the Goianésia's sugarcane cluster as a national industry leadership and make it a more prominent actor internationally.

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References

Alves, N. C. G. F., & Wander, A. E. (2010). Competitividade da produção de cana-de-açúcar no Cerrado Goiano. *Informações Econômicas, 40*(7), 5-17.

Callado, A. (Org.) (2011). Agronegócio. 3a ed. São Paulo, Atlas.

EPE. (2008). Perspectivas para o Etanol no Brasil. Retrieved from http://www.epe.gov.br/Petroleo/Documents/Estudos_28/Cadernos%20de%20Energia%20-%20Perspectiva%20para%20o%20etanol%20no%20Brasil.pdf

Fajnzylber, F. (1988). Competitivad Internacional: Evolución y Lecciones. *Revista de La Cepal, 36,* 7-24.

FAO. (2015). *FAOSTAT database.* Retrieved from http://faostat.fao.org/site/567/DesktopDefault.aspx?PageID=567#ancor

Folha da cana. (2014a). Cursos profissionalizantes são disponibilizados aos colaboradores e à comunidade. *Folha da cana, 48,* 10.

Folha da cana. (2014b). Jalles Machado aposta em desenvolvimento de Programa Trainee. *Folha da cana, 48,* 15.

Folha da cana. (2015a). Empresa investe na qualificação dos colaboradores. *Folha da cana, 53,* 19.

Haguenauer, L. (1989). Competitividade: Conceitos e Medidas: Uma resenha da Bibliografia recente com ênfase no caso brasileiro. *Texto para discussão, 211,* 1-20.

Montenegro, I. (Coord.) (2012). *Cadeia Produtiva Sucroenergética*. Goiânia, FIEG.

Novacana. (2012). *Setor sucroalcooleiro chegará ao fundo do poço em 2014.* Retrieved from http://www.novacana.com/n/industria/financeiro/setor-sucroalcooleiro-fundo-poco-2014-291112

PAC. (2015). Infraestrutura energética. Combustíveis renováveis. Sistema de logística de etanol. Retrieved from http://www.pac.gov.br/obra/2509

Porter, M. (2008a). *On competition.* Harvard Business School Publishing, Boston.

Porter, M. (2008b). *Moving to a New Global Competitiveness Index.* The Global Competitiveness Report 2008-2009. World Economic Forum, Génova.

SIFAEG. (2015a). Lignocelulose. Produção de etanol facilitada. Retrieved from http://www.sifaeg.com.br/noticias/lignocelulose.

SIFAEG. (2015b). Entrevista Plínio Nastari. 2015: ano de transição. Retrieved from http://www.sifaeg.com.br/noticias/entrevista-plinio-nastari

Sledzik, K. (2013). Schumpeter's View on Innovation and Entrepreneurship. In Stefan Hittmar (Ed.), *Management Trends in Theory and Practice.* Faculty of Management, Science and Informatics, University of Zilina & Institute of Management by University of Zilina.

Trevisan, C., Monteiro, T., & Silva, Jr. A. (2015). *Governo brasileiro defende acordo de livre comércio com os Estados Unidos.* Estadão, 28 June. Retrieved from http://politica.estadao.com.br/noticias/geral,governo-brasileiro-defende-acordo-de-livre-comercio-com-os-estados-unidos,1715275

VALEC. (2015). *Ações e programas – Ferrovias VALEC.* Retrieved from http://www.valec.gov.br/acoes_programas/FNSFerroviaNorteSul.php

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Utilization of Silicon Fertilizer Application on Pepper Seedling Production

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Abstract

The purpose of this research was study the rate and application method of calcium silicate (Ca_2SiO_4) fertilizer appropriated for pepper seedling production. This study was divided into two experiments. Experiment 1, the effect of Ca_2SiO_4 fertilizer application in pepper seedling by mixed in growing media was arranged in 2x6 factorials in Completely Randomized Design (CRD) with 4 replications. Factor A was seed preparation methods (seed primed with Ca_2SiO_4 fertilizer at a rate 2 g L^{-1} and non-seed primed) and factor B was application rates of Ca_2SiO_4 fertilizer at 0, 30, 60, 120, 240 and 480 kg ha^{-1}. Experiment 2, the effect of Ca_2SiO_4 fertilizer application in pepper seedling by foliar method was arranged in 2x6 factorials in CRD with 4 replications. Factor A was seed preparation methods and factor B was application rates of Ca_2SiO_4 fertilizer at 0, 2, 4, 6, 8 and 10 g L^{-1}. All experiments data were collected such as plant growth and total silicon content in plant at 28 days after sowing (DAS). From experiment 1, the results showed that seed primed with Ca_2SiO_4 fertilizer application at a rate 120 kg ha^{-1} gave the good plant growth and total silicon in plant. Experiment 2, the results showed that seed primed with Ca_2SiO_4 fertilizer application at a rate 2 g L^{-1} gave the highest of plant growth and total silicon in plant. To conclude, Ca_2SiO_4 fertilizer application can be employed for enhancing plant growth of pepper seedling and increasing silicon content in plant.

Keywords: foliar, fertilizer, pepper seedling, silicon, mixed in growing media

1. Introduction

Pepper (*Capsicum* sp.) is the fruit of plants from the genus *Capsicum*, and family, Solanaceae. Pepper is a high nutrition value and consists of a protein, vitamin and mineral. Peppers are a rich source of spicy-hot capsaicin. They are also very high in antioxidant carotenoids, which are linked with numerous health benefits. Capsaicin is a one of the most studied plant compounds in peppers. It is responsible for their pungent (hot) flavor and many of their health effects. Pepper is a vegetable popular consumption in Thailand. It can be seen that pepper was composed in many Thai foods. It very famous in Thai people because high antioxidant and it can be improves the good health. In Thailand, the area plantation pepper it found that in the northern part and northeastern part. In 2015, pepper area plantation was 31,000 ha^{-1} and trend to decreasing from 2010 (56,570 ha^{-1}) (Department of Agriculture, 2015). The reason for the decline of area because farmer change plant for cultivate and pepper yield less quality destruction caused by disease and insects, also low seed quality and expensive seed. Total pepper yield production in Thailand was 0.25 tons ha^{-1} and crop removal in pepper amount of 1.04 kg Si ha^{-1} (2.23 kg SiO_2 ha^{-1}) (Department of Agriculture, 2015). Then, silicon (Si) is necessary for pepper, because Si loss of crop removal and therefore Si not enough for pepper and soil. So that we must add Si for pepper, since preparation seed, seedling and add direct in soil. Also, Si is the second most abundant element on the surface of the earth. It is not considered to be an essential element for higher plant (Neumann et al., 2001). Si can be classified as beneficial element (Epstein, 2005). Si in soil solution is mainly present in the form of an uncharged monomeric molecule, silicic acid. Many plants show the better growth as the Si form available (H_4SiO_4 or SiO_4^{2-}). Si is reported to the component of cell (Ma et al., 2001), improve plant resistance to a range of biotic and abiotic stresses (Ma & Yamaji, 2006), stimulate on growth and yield (Ma & Takahashi, 2002), leaf erectness, haulm stability and lodging and increase photosynthesis (Epstein & Bloom, 2005). In addition, calcium (Ca) is relatively abundant in soil and rarely limits corps production. It makes up about 3.6% of earth's crust. It present in soil minerals such as amphibole, apatite, calcite, dolomite and feldspar. Ca is a component of cell wall and is

also important for cell division and elongation permeability of cell membranes. Moreover, seed priming is a pre-sowing treatment in which seeds are soaked in osmotic that allows the seeds to imbibe water and go through the first stages of germination. In addition, seed priming enhanced germination speed and uniformity of seeds (McDonald, 2000). The primed seed increase germination speed and uniformity of seeds and gave the good seedling. It can be improve the growth rate and yield in pepper production. Now, utilization of Si fertilizer has many variants. Kunlinda *et al.*, (2014) reported that sweet pepper "vega 1288" seeds were primed with Ca_2SiO_4 at 2 g L^{-1} gave the highest of germination index (GI) and germination percentage. While, seed-primed with Ca_2SiO_4 at 4 g L^{-1} by foliar application gave the good of sweet pepper seedling. From the above, thus purpose of this research was to study the rate and application method of Ca_2SiO_4 fertilizer appropriated for pepper seedling production.

2. Methods

The experiment was conducted in greenhouse at soil science experimental field, Department of Soil Science, Faculty of Agriculture at Kamphaeng Saen, Kasetsart University, Nakhon Pathom, Thailand. The each experiment was used peat for cultivated. In addition, Si fertilizer is a calcium silicate (Ca_2SiO_4) and calcium silicate used in this experiment was component as silicon ($25\%SiO_2$), calcium ($40\%CaO$) and magnesium ($2\%MgO$). This study was divided into two experiments. The effect of Ca_2SiO_4 fertilizer application in pepper seedling by mixed in growing media (experiment 1) was used 2x6 factorials in Completely Randomized Design (CRD) with 4 replications. Factor A was seed preparation methods (seed primed with Ca_2SiO_4 fertilizer at a rate 2 g L^{-1} and non-seed primed) and factor B was application rates of Ca_2SiO_4 fertilizer at 0, 30, 60, 120, 240 and 480 kg ha^{-1}. The effect of Ca_2SiO_4 fertilizer application in pepper seedling by foliar method (experiment 2) was used 2x6 factorials in CRD with 4 replications. Factor A was seed preparation methods (seed primed with Ca_2SiO_4 fertilizer at a rate 2 g L^{-1} and non-seed primed) and factor B was application rates of Ca_2SiO_4 fertilizer at 0, 2, 4, 6, 8 and 10 g L^{-1}. All treatments used foliar Ca_2SiO_4 fertilizer for pepper seedling at 14 and 21 days after sowing (DAS).

2.1 Seed Preparation Methods

Chilli pepper seeds were primed with Ca_2SiO_4 fertilizer at a rate 2 g L^{-1} for 5 hours at temperate room (Kunlinda *et al.*, 2014).

2.2 Data Collection

The plant samples were measured at 28 DAS. All experiments data were collected such as plant height, leaf number (larger than 1 centimeter), fresh and dry weight (Kunlinda *et al.*, 2014). Total Si content in plant was using Nayer *et al.,* (1975) method.

2.3 Statistical Analysis

The data were analyzed for Statistical analyses carried out using the R program. By method of analysis of variance (ANOVA) and Comparisons of the means among treatments were done using LSD at a significance level of $P < 0.01$.

3. Results

3.1 Effect of Ca_2SiO_4 fertilizer application in pepper by mixed in growing media (Experiment 1)

3.1.1 Plant Height of Pepper Seedling

Seed preparation methods showed that seed primed with Ca_2SiO_4 fertilizer application at a rate 2 g L^{-1} was significantly different and gave the plant height higher than non-seed-primed (Table1). In addition, Ca_2SiO_4 fertilizer application by mixed in growing media at a rate 120 kg ha^{-1} was significantly different and gave to trend the plant height of pepper seedling (Table1). While, relationship between factor A (seed preparation methods) with factor B (application rate of Ca_2SiO_4 fertilizer) were significantly different that seed-primed with application rate of Ca_2SiO_4 fertilizer at 120 kg ha^{-1} gave to trend the high of plant height (Table1).

Table 1. Plant height (cm) of pepper seedling at 28 day after sowing (experiment 1)

Factors	Seed preparation methods (A)		Average
	Non- seed primed	seed primed	(A)
Ca_2SiO_4 fertilizer application (kg ha^{-1}) (B)			
0	9.04e	10.56cd	9.80D
30	9.53de	11.97ab	10.75C
60	11.07bc	12.67a	11.87A
120	10.40cd	12.85a	11.63AB
240	11.11ab	10.37cd	10.74C
480	10.84c	11.27bc	11.06BC
Average (B)	10.33B	11.62A	
F-test : A	**		
B	**		
A×B	**		
CV. (%)	6.39		

Note. ** = significantly different at P<0.01

3.1.2 Leaf Number of Pepper

The results showed that seed preparation methods and Ca_2SiO_4 fertilizer application by mixed in growing media were non significantly different of the leaf number of pepper (Table 2)

Table 2. Leaf number of pepper seedling at 28 day after sowing (experiment 1)

Factors	Seed preparation methods (A)		Average
	Non- seed primed	seed primed	(A)
Ca_2SiO_4 fertilizer application (kg ha^{-1}) (B)			
0	8	8	8
30	8	8	8
60	8	8	8
120	8	8	8
240	8	8	8
480	8	8	8
Average (B)	8	8	
F-test : A	ns		
B	ns		
A×B	ns		
CV. (%)	2.44		

Note. ns = non-significantly different at P>0.01

3.1.3 Fresh Weight of Pepper Seedling

The results showed that seed preparation methods were significantly different and seed primed gave the fresh weight higher than non-seed primed (Table3). Ca_2SiO_4 fertilizer application at a rate 240 kg ha^{-1} was significantly different and gave to trend the fresh weight of pepper seedling (Table3). While, relationship between factor A with factor B were significantly different that seed primed with application rate of Ca_2SiO_4 fertilizer at 120 kg ha^{-1} gave to trend the high of Fresh weight of pepper seedling (Table3).

Table 3. Fresh weight (g) of pepper seedling at 28 day after sowing (experiment 1)

Factors	Seed preparation methods (A)		Average
	Non- seed primed	seed primed	(A)
Ca_2SiO_4 fertilizer application (kg ha^{-1}) (B)			
0	2.54c	2.58c	2.56B
30	2.86abc	2.84abc	2.83A
60	2.81abc	1.97d	2.39B
120	2.73bc	3.16a	2.94A
240	3.01ab	2.94abc	2.97A
480	2.86abc	3.02ab	2.94A
Average (B)	2.66B	2.89A	
F-test : A	**		
B	**		
A×B	**		
CV. (%)	8.72		

Note. ** = significantly different at P<0.01

3.1.4 Dry Weight of Pepper Seedling

The results showed that seed preparation methods was gave the same as the fresh weight (Table4), but Ca_2SiO_4 fertilizer application at a rate 120 kg ha^{-1} was significantly different and gave to trend the dry weight of pepper seedling (Table4). While, relationship between factor A with factor B were significantly different that seed primed with application rate of Ca_2SiO_4 fertilizer at 120 kg ha^{-1} gave to trend the high of dry weight of pepper seedling (Table4).

Table 4. Dry weight (g) of pepper seedling at 28 day after sowing (experiment 1)

Factors	Seed preparation methods (A)		Average
	Non- seed primed	seed primed	(A)
Ca_2SiO_4 fertilizer application (kg ha^{-1}) (B)			
0	0.25b	0.25b	0.24B
30	0.26b	0.28ab	0.26AB
60	0.24b	0.26ab	0.21C
120	0.17c	0.31a	0.28A
240	0.29ab	0.25b	0.27AB
480	0.35b	0.27ab	0.25AB
Average (B)	0.24B	0.27A	
F-test : A	**		
B	**		
A×B	**		
CV. (%)	11.31		

Note. ** = significantly different at P<0.01

3.1.5 Total Silicon Content in Pepper Seedling

Our treatments results demonstrated that in total silicon, seed preparation methods the results showed that was non significantly different of total silicon in pepper seedling (Table5). In addition, Ca_2SiO_4 fertilizer application at a rate 480 kg ha^{-1} was significantly different and gave to trend the total silicon in pepper seedling (Table5). While, relationship between factor A with factor B were significantly different that seed primed with application rate of Ca_2SiO_4 fertilizer at 480 kg ha^{-1} gave to trend the total silicon in pepper seedling (Table5).

Table 5. Total silicon content (mg kg^{-1}) in pepper seedling at 28 day after sowing (experiment 1)

Factors	Seed preparation methods (A)		Average
	Non- seed primed	seed primed	(A)
Ca$_2$SiO$_4$ fertilizer application (kg ha^{-1}) (B)			
0	1.00c	2.00c	1.00b
30	24.00ab	17.00b	21.00a
60	25.00ab	16.00b	20.00a
120	20.00b	22.00b	20.00a
240	21.00b	24.00ab	22.00a
480	17.00b	34.00a	25.00a
Average (B)	18.00	19.00	
F-test :A	ns		
B	**		
A×B	**		
CV. (%)	27.27		

Note. = non-significantly different at P>0.01, ** = significantly different at P<0.01

3.2 The effect of Ca$_2$SiO$_4$ fertilizer application in pepper by foliar method (Experiment 2)

3.2.1 Plant Height of Pepper Seedling

Seed preparation methods the results showed that seed primed with Ca$_2$SiO$_4$ fertilizer application at a rate 2 g L^1 was significantly different and gave the plant height higher than non-seed primed (Table6). In addition, Ca$_2$SiO$_4$ fertilizer application by foliar method was non-significantly different of the plant height of pepper seedling (Table6). While, relationship between factor A with factor B were non-significantly different of plant height of pepper seedling (Table6).

Table 6. Plant height (cm) of pepper seedling (experiment 2)

Factors	Seed preparation methods (A)		Average
	Non- seed primed	seed primed	(A)
Ca$_2$SiO$_4$ fertilizer application (g L^{-1}) (B)			
0	11.86	11.80	11.83
2	11.98	12.89	12.43
4	12.29	16.37	14.33
6	12.09	14.23	13.16
8	12.00	14.00	13.00
10	12.39	13.54	12.96
Average (B)	12.10B	13.80A	
F-test : A	**		
B	ns		
A×B	ns		
CV. (%)	12.98		

Note. ns = non-significantly different at P>0.01, ** = significantly different at P<0.01

3.2.2 Leaf Number of Pepper

The results showed that seed preparation methods and Ca$_2$SiO$_4$ fertilizer application by foliar method were non-significantly different of the leaf number of pepper (Table 7).

Table 7. Leaf number of pepper seedling (experiment 2)

Factors	Seed preparation methods (A)		Average
	Non- seed primed	seed primed	(A)
Ca_2SiO_4 fertilizer application (g L^{-1}) (B)			
0	8	8	8
2	8	8	8
4	8	8	8
6	8	8	8
8	8	8	8
10	8	8	8
Average (B)	8	8	
F-test : A	ns		
B	ns		
A×B	ns		
CV. (%)	2.44		

Note. ns = non-significantly different at P>0.01

3.2.3. Fresh Weight of Pepper Seedling

The results showed that seed preparation methods were significantly different and seed primed gave the fresh weight higher than non-seed primed (Table8). Ca_2SiO_4 fertilizer application at a rate 4 g L^{-1} was significantly different and gave to trend the fresh weight of pepper seedling (Table8). While, relationship between factor A with factor B were significantly different that seed-primed with application rate of Ca_2SiO_4 fertilizer at 4 g L^{-1} gave to trend the high of fresh weight of pepper seedling (Table8).

Table 8. Fresh weight (g) of pepper seedling (experiment 2)

Factors	Seed preparation methods (A)		Average
	Non- seed primed	seed primed	(A)
Ca_2SiO_4 fertilizer application (g L^{-1}) (B)			
0	2.61d	2.73d	2.67C
2	3.58ab	3.79ab	3.69A
4	3.52ab	3.88a	3.70A
6	3.64ab	3.47b	3.56AB
8	3.08c	3.66ab	3.37B
10	3.52ab	3.73ab	3.62A
Average (B)	3.32B	3.54A	
F-test : A	**		
B	**		
A×B	*		
CV. (%)	6.69		

Note. ** = significantly different at P<0.01, * = significantly different at P<0.05

3.2.4 Dry Weight of Pepper Seedling

The results showed that seed preparation methods significantly different and seed primed gave the dry weight higher than non-seed primed (Table9). Ca_2SiO_4 fertilizer application at a rate 2 g L^{-1} was significantly different and gave to trend the dry weight of pepper seedling (Table9). While, relationship between factor A with factor B were non significantly different of dry weight of pepper seedling (Table9).

Table 9. Dry weight (g) of pepper seedling (experiment 2)

Factors	Seed preparation methods (A)		Average
	Non- seed primed	seed primed	(A)
Ca$_2$SiO$_4$ fertilizer application (g L^{-1}) (B)			
0	0.25c	0.25c	0.25C
2	0.34a	0.34a	0.34A
4	0.30ab	0.32ab	0.31AB
6	0.33a	0.31ab	0.32AB
8	0.27bc	0.32ab	0.29B
10	0.31ab	0.34a	0.32AB
Average (B)	0.30	0.31	
F-test : A	ns		
B	**		
A×B	ns		
CV. (%)	10.74		

Note. ns = non-significantly different at P>0.01, ** = significantly different at P<0.01

3.2.5 Total Silicon Content in Pepper Seedling

Our treatments results demonstrated that in total silicon, seed preparation methods the results showed that was non significantly different of total silicon in pepper seedling (Table10). In addition, Ca$_2$SiO$_4$ fertilizer application at a rate 2 g L^{-1} was significantly different and gave to trend the total silicon in pepper seedling (Table10). While, relationship between factor A with factor B were non-significantly different of the Total silicon in pepper seedling (Table10).

Table 10. Total silicon content (mg kg^{-1}) in pepper seedling (experiment 2)

Factors	Seed preparation methods (A)		Average
	Non- seed priming	seed priming	(A)
Ca$_2$SiO$_4$ fertilizer application (g L^{-1}) (B)			
0	0.54e	3.10de	1.80c
2	11.10ab	0.13.30a	12.00a
4	0.69bcd	8.60abc	7.80b
6	5.9cd	8.50abc	7.20b
8	7.9bc	8.80abc	8.40b
10	8.7abc	9.10abc	8.90b
Average (B)	6.90	8.60	
F-test : A	ns		
B	**		
A×B	ns		
CV. (%)	28.62		

Note. ns = non-significantly different at P>0.01, ** = significantly different at P<0.01

4. Discussion

Experiment 1, the effect of Ca$_2$SiO$_4$ fertilizer applied in pepper by mixed in growing media. The results showed that seed-primed with Ca$_2$SiO$_4$ fertilizer application at a rate 2 g L^{-1} was significantly different and gave the plant height, fresh weight and dry weight higher than non-seed-primed. In addition, Ca$_2$SiO$_4$ fertilizer application in soil was significantly different plant height, fresh and dry weight and Si content in plant. By the time, Ca$_2$SiO$_4$ fertilizer application at a rate 120 kg ha^{-1} gave to trend the high of plant height, fresh and dry weight and Si content in plant. While, relationship between seed preparation methods with application rate of Ca$_2$SiO$_4$ fertilizer were significantly different that seed-primed with application rate of Ca$_2$SiO$_4$ fertilizer at 120 kg ha^{-1} gave to trend the high of plant height, fresh and dry weight and Si content in plant. In addition, experiment 2, the effect of Ca$_2$SiO$_4$ fertilizer application in pepper by foliar method the results showed that seed-primed by Ca$_2$SiO$_4$ fertilizer application at a rate 2 g L^{-1} was significantly different and gave the plant height, and fresh weight

higher than non-seed primed. In addition, seed-priming and non-seed priming was not significantly different of plant leaf number, dry weight and total Si content in plant. Ca_2SiO_4 fertilizer application by foliar method was significant different of seedling fresh weight, seedling dry weight and total Si content in plant. Ca_2SiO_4 fertilizer application by foliar method at a rate 2 g L^{-1} gave to trend the seedling fresh weight, seedling dry weight and total Si content in plant. However, relationship between seed preparation methods with application rate of Ca_2SiO_4 fertilizer application by foliar method were not significantly different at $P<0.01$. Seed-primed with Ca_2SiO_4 fertilizer application at a rate 2 g L^{-1} by foliar method gave to trend the high of plant height, leaf number, seedling fresh weight, seedling dry weight and total Si content in plant. Each experiment, it was found that seed primed increased the growth rate of pepper seedling higher more than non-seed primed. Which was in accordance with the finding of primed seeds stimulate and enhanced germination speed and uniformity of seeds (McDonald, 2000). In additions, Hanson (1984) reported the Ca stimulated seed germination and is the cofactor of amylase enzyme. It helped digestion of starch in sperm seeds of a smaller and to promoted seed germination. In addition, Korhmaz (2005) reported that primed sweet pepper seed with KNO_3 with 0.1 mM acetylsalicylic acid gave the good seedling more than non-primed seed. All of above seed primed gave the growth rate and total Si content more than non-seed primed. Moreover, each experiments the results showed that seed primed by Ca_2SiO_4 fertilizer application at a rate 120 kg ha^{-1} (mixed in growing media) and Ca_2SiO_4 fertilizer application at a rate 2 g L^{-1} (foliar method) were gave to trend the growth rate of pepper seedling. It found that Ca_2SiO_4 fertilizer used in this experiment was component as Si and Ca. Then, Si and Ca gave the cell membrane is strong (Epstein & Bloom, 2005) and Si fertilizer is applied to crops in several countries for increased productivity and sustainable production. Which, plants uptake Si in the form of silicic acid, which is transported to the shoot, and after loss of water, it is polymerized as silica gel on the surface of leaves and stems. enhance the strength of the tissue (Ma & Takahashi, 2002) consist of Si accumulated in the cell wall there is characteristic lamination (Silica layer) influence to plant leaves are strong (Epstein & Bloom, 2005). Due to plants uptake Si to cell, Si changes to the solid from of Si in cell wall of plant. It can be improve the structure of cell wall and stronger resistance to disease and insect infestation (Marschner, 1995). In addition, Si can increase watering conditions, and it can also improve the growth of this crop in drought conditions by maintaining high leaf areas to insure high assimilatory capability, thickening leaves which are beneficial to reduce the transpiration loss of water (increasing the thickness of leaves) leaf erectness, haulm stability and lodging. Also, Ca_2SiO_4 used in this experiment was component as magnesium (Mg). Thus, Mg is composition of photosynthesis in plants as a result increased efficiency of photosynthesis (Gong $et\ al$., 2003). Then, plant also encourages the highest pepper seedlings growth. However, the utilization of Ca_2SiO_4 fertilizer application at a high dose in the pepper seedling could decrease plant growth.

5. Conclusion

Utilization of Ca_2SiO_4 fertilizer application by seed primed with Ca_2SiO_4 fertilizer application by mixed in growing media at a rate 120 kg ha^{-1} gave the good plant growth and total silicon in plant. And Ca_2SiO_4 fertilizer application by seed primed with Ca_2SiO_4 fertilizer application by foliar at a rate 2 g L^{-1} gave the highest of plant growth and total silicon in plant. By the time, Ca_2SiO_4 fertilizer application can be employed for enhancing plant growth of pepper seedling and increasing Si content in plant.

Acknowledgement

References

Department of Agriculture (2015). *The reported data of crop production annually2013/2014*. Retrieved from http://production.doae.go.th/report/report_main2.php?report_type=1

Epstein, E., & Bloom, A. J. (2005). *Minerals Nutrition of Plants: Principles and Perspective.* (2nd Ed.) Sinauer Associated, Inc. p. 400. http://dx.doi.org/10.1002/jpin.19721320211

Gong, H., Chen, K., Chen, G., Wang, S. & Zhang, C. (2003). Effects of silicon on growth of wheat under drought. *Journal of Plant Nutrition, 26*, 1055–1063. http://dx.doi.org/10.1081/PLN-120020075

Korkmaz, A. (2005). Inclusion of acetyl salicylic acid and methyl jasmonate into the priming solution improves low-temperature germination and emergence of sweet pepper. *Horticultural Science, 40*, 197-200.

Kunlinda, T., Thongchai, M., Pornpairin, R., & Suphachai, A. (2014). Utilization of calcium silicate on growth and yield quality of sweet pepper in hydroponics system. *KHON KAEN Agriculture Journal. 42 SUPPL.3*.

Ma, J. F., Miyake, Y., & Takahashi, E. (2001). *Silicon as a beneficial element for crop plants*. *In*: Silicon in Agriculture, Eds. L. E. Datnoff, G. H. Snyder and G.H. Korndorfer, 17–39.

Ma, J., & Takahashi, E. (2002). *Soil Fertility and Plant Silicon Research in Japan.* Elsevier Science. Amsterdam, London, Boston.

Ma, J., & Yamaji, N. (2006). Silicon uptake and accumulation on higher plants. *TRENDS in Plant Science, 11*, 392-397. http://dx.doi.org/10.1016/j.tplants.2006.06.2007

McDonald, M. B. (2000). Seed priming. pp. 287-325. In B. Michael, & J. D. Bewley, Eds. Seed Technology and its Biological Basis.Sheffield Academic Press, England.Gerhard, F. 2006.*The seed biology place.* Retrieved from http://www.seedbiology.de/seedtechnology.asp

Nayer, P. K., Misra, A. K., & Patnaik, S. (1975). Rapid micro determination of silicon in rice plant. *Plant and Soil, 42*, 491-494. http://dx.doi.org/10.1007/BF00010025

Neumann, D., & Nieden, U. (2001). Silicon and heavy tolerance of higher plants. *Phytochemistry, 56*, 685–692. http://dx.doi.org/10.1016/S0031-9422(00)00472-6

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Prioritizing Strategies of Relationship with Retail Customers in Several Levels of Life Cycle by Integrated Approach: KANO-IPA-QFD-TOPSIS

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Abstract

Today, customer orientation and relationship with customers is considered as one of the main strategies of development in organizations. In this regard, it is necessary to create a process that is able of making relationship with different costumers due to their needs and demands. Quality function development (QFD) is one of the common methods regarding to attention to customers' needs and adopting them with definitions and features of costumers in several life cycle levels. In this article, first technical features (relationship strategies) and relationship needs of retail customers (features of relationship strategies) are recognized; then, strategies of costumers relationship ion each level of life cycle are prioritized using integrated technique of quality QFD and TOPSIS. The results show prioritization of new relationship strategies, especially internet communications compared to other strategies. This study is considered as an efficient step to improve relationship with costumers and as a result, to keep and develop organizations' development status using information gathered from costumers in different levels of life cycle.

Keywords: customer relationship, Kano model, importance- performance matrix, TOPSIS, quality function development (QFD)

1. Introduction

In modern economy, changes in viewpoints and demands of costumers is considered as one of the most important factors effective on growth or decline process of firms. Organizations that are unaware of costumers' needs and expectations and/or do not understand their real needs, they will lose their market share. Organizations must always supervisor and protector of interaction between organization and its customers to present valuable products and services based on correct recognition and understanding of costumers' needs.

One of problems proposed in organizations about understanding and responding to needs, demands and complaints of customers is lack of using proper relational strategies; thus, identifying and implementing proper methods to communicate with several costumers is an efficient step overcoming this problem. Costumer life cycle is one of the items to classify costumers and attention to their different behaviors; it refers to several time levels that costumers and organization have communication with each other. Identifying levels of customer life cycle has a specific importance due to benefits gained by organization. The relationship between costumers and organization can change due to experiences they gain from each other through time.   The more information they have about each other, the more effective is growth and evaluation of their mutual interactions. There are several viewpoints proposed for costumers' life cycle including models presented by Tsiptsis & Chorianopoulos (2011), Blattberg & Thomas (2001). Customer equity: Building and managing relationships as valuable assets, Harvard Business Press (2008), Berry and Linoff (2006).

Our case study performed worthy actions in field of relationship with costumers as one of the most powerful food manufacturers In Iran. In this regard, we can refer to CRM unit. Generally, costumers of a firm are classified in three levels of wholesalers, retailers, and final costumers. Though information obtained from opinion of final costumers typically include exact data, but only considering them has usually some problems such as lack of easy access to these costumers. In addition to final costumers, we can study other chains of

costumes having effective information. Doing this, we can consider entailers as an appropriate option due to benefits below:

1. Retailers are the closest chain to final costumers; thus, they know more about detailed information of costumers.

2. Identification, classification, and making call with retailers are easier than doing this with final costumers.

3. Retailers are final decision maker in relation to shape and range of a brand appearing at retail level; thus, attention to their demands is one of success factors of products at this level.

According to items mentioned above, the importance of retailers in costumer chain is clearly visible and firms must prioritize for relationship with costumers and understanding their demands and viewpoints. The case study is one of the powerful firms with almost 100000 retail member throughout the country; thus, it is necessary to select proper strategies and correct and constructive interaction with this type of costumers.

In this article, we consider prioritizing strategies of relationship with retail customers in several levels of life cycle using TOPSIS integrated approach and QFD. One of the planning tools in QFD is quality unit. Firms are usually facing with some constraints in order to implement quality unit and to prioritize its technical features; therefore, some criterion are proposed to overcome available constraints and to obtain a suitable evaluation of technical features. In this study, TOPSIS multi-criterion decision method is implemented for final prioritization of strategies in several levels of life cycle using criterion determined by experts of the firm and the parameter 'voice of customers'.

1.1. Theoretical Principles of Research

1.1.1 Strategies of Costumer Relationship

Today, increase in demands and expectations of costumer gives power of selecting relational strategies for them. According to changes in communication technology, firms can focus on several options to communicate with costumers. Payne and Frow (2004) divided firm's relational strategies with costumers to 6 categories of sales power (presenting products in person), sales market (shops and kiosks), distant calls (phone, fax), direct marketing (TV, radio), e-trade (internet, e-mail etc.), and cell phone (call, SMS etc.). Sinisialo (2006) introduces proper strategies to create multiple communication environments including face-to-face communications, telephone, direct marketing, internet, self-service, and cell phone. Of possible strategies of communication with costumers in the studied firm, we can refer to face-to-face communication, post, telephone (call, answering and fax), internet (chat, e-mail, and web site), and cell phone (SMS, call, and MMS). It must be noted that strategies of mutual interaction are considered in this study, each one have some features that could be used for specific goals and applications.

1.1.2 Features of Face-To-Face Communications

Face-to-face relation is defined as information, thoughts, and feelings exchange when people are located in an equal spatial situation. Of features of face-to-face relationship are verbal and non-verbal communications, simultaneous relation with costumers, transfer of feelings, and ability of firm to establish a proper interaction atmosphere with costumers, increase in costumers' perception toward organization, possibility of personal communications, making trust, facilitating costumers' evaluation, security, and valuing costumers.

1.1.3 Features of Internet Communications

Internet is a global wide network of computers that are connected together for information exchange temporarily. This strategy is suggested when communication costs are important for firm and also firms want to gain information of their costumers continually. In this regard, features of this strategy include : simultaneous and non-simultaneous communications, possibility of 24 hours a day communications, verbal and non-verbal communications, business and non-business communications, personal and public communications, official and non-official communications with exact and clear details, being cheap and cost effective , easy and fast flow of information, online discussions, participation of costumers, presenting information about products, incentive activities, sales and developing interaction with costumers.

1.1.4 Features of Mobile Communications

Cell phone is considered as a capable communication channel in business interactions to access costumers; it has several features and benefits including: saving in time and cost, providing personal relations, presenting on time information to costumers, possibility of making first call by costumers, personal access to people everywhere and anytime, easy following, ease of use and its high response rate, permanent access to costumers, and high security.

1.1.5 Classification Models of Qualitative Features (Costumers' Needs And Demands)

There are several models for rating needs and expectations of costumers including models of Herzberg (2011),Zhang and Dran (2000),Swan and Combs (1976), Kano et al (1984), Brechan (2006), Cadotte and Turgeon (1988), and Oliver. In this regard, Kano's model is recognized as one of the perfect model sin field of classifying customers'' needs; it is still one of the most applied methods of the filed despite presenting new models. Firms might face with some problems when using this model such as lack of consistence between priorities presented for costumers' needs and firm's strengths and weaknesses. Accordingly, Wu et al (2010) proposed Kano integrated model and importance-performance matrix to solve this problem. They specified key factors for success of a Taiwanese firm using Kano's integrated model and importance-performance matrix. Therefore, they focused on determining classifications mentioned by Kano's model in addition to determining priorities, importance of these factors and firm's performance from costumers' perspective.

1.1.6 Quality Function Deployment (QFD)

QFD is a Japanese term translated to English as 'quality function deployment'; QFD makes organizations able to identify and remove problem before complaint of costumers. Thakkar et al (2006) perceive QFD as a customer-oriented design process responding to questions of 'what' and 'how' due to voice of costumers. In this technique, quality is broken to operative, manageable, and sensible actions to ensure providing costumers' needs at appointed time.

The first tool of planning used in QFD is quality unit; it transforms voice of costumer to design requirements. Most of mangers and engineers know quality unit as the first diagram in quality planning. Quality unit is a matrix determining the relation between 'what' and 'how' so that 'what' includes demands and needs of customers of products or services (costumer necessities), and 'how' determines presenting costumers' demands of product (technical necessities).

1.1.7. TOPSIS Method

TOPSIS is of one of the reparative multi-criterion decision models locating in compromise subgroup; it was suggested by Hwang and Yoon in 1981; this is one of the best and simplest multi-criteria decision models. In this method, 'm' options are evaluated by 'n' indicators. Generally, fundamental reality of this method is as below:

A. Utility of each indicator must be uniformly increasing or decreasing, so that the best value of an indicator shows positive ideal and the worth value shows negative ideal.
B. Distance of an option from positive ideal (or negative one) might be calculated as Euclidean distance and/or total absolute value from linear distances; this depends on exchange rate and replacement between indicators.

2. Literature Review

AL-Majali and Prigmore (2010) studied about used of online communication strategies in order to contact with costumers. The results showed that costumers' interest to achieve online services is more than that of offline one due to features of online services. Dakora (2007) presented multi-criterion strategies to sell products regarding growth strategy of firms. In this regard, he assessed strategies such as post, retailing, fairs, telephone (call center), internet, TV, reseller, and cell phone from costumers' viewpoint. One of the results of this research is difference between priorities of strategies on one hand, and different classifications of costumers on the other. Dfelice and Petrillo (2007) used an adoptive AHP, QFD model to evaluate needs of customers. They used AHP model in order to prioritize costumer needs and technical features emphasizing that multi-criterion decision techniques have logical approach and proper weighting and priority accuracy. Murad (2009) identified ways of improving communication of OLDI co. with retail customers. According to marketing strategies such as verbal contact, web site, e-mail, seminar and conference, advertisement and public relations, it was found that modern communication strategies like website and e-mail are interested by most costumers due to their proper informative aspect; it is possible to improve interaction between costumers and organization with cultural intentions. Najmi et al (2009) prioritize technical and engineering features of Fuzzy QFD model using TOPSIS method. In this research, they limit quality matrix to the weight related to costumers' demands and the relation between their demands and technical features; then, they prioritize technical features sing TOPSIS and weights obtained in fuzzy mood.

3. Research Method

This research is of applied type due to desired goals; it is also of survey type since it determines beliefs and viewpoints of costumers in association with relational features. The area of his research is Yazd city and population includes all retailers and sales experts of company interest. The sampling of this study is simple random and the population equal to 278 persons using Morgan table. Also 4 experts of firm were consulted to evaluate relational features and strategies. Doing this research, first relational features and strategies are identified through library studies and those features and strategies are determined that sound suitable in level of retail customers. Then, features of interest of costumers are identified and prioritized (priority requirements) in each level using Kano questionnaire and performance-importance matrix; at last, QFD and TOPSIS strategies are prioritized using mix method.

3.1. Kano Integrated Model and Performance-Importance Matrix

To implement this model, it is necessary to recognize Kano levels for each qualitative feature; then, we determine position of each feature in performance-importance matrix. To determine Kano levels for each feature, the standard questionnaire of this model is used including binary questions about the presence or absence of related feature. Wave et al used a mix questionnaire and also Kano questionnaire simultaneously to measure importance of success factors. accordingly, it is possible to measure importance of each feature simultaneously so that 'I am completely agree' and ' I am completely disagree' are the most (=5) and the least (=1) important weights, respectively. Thus, position of each feature is determined in performance –importance matrix; they are prioritized due to their location in the desired matrix and also Kano model. Finally, we emphasize on factors of customer satisfaction due to proper function of firm considering current strategy; thus priority of qualitative features in these locations is A>O>M>I. also if some of these factors are joint in one area of Kano levels, we can consider the importance weight of each factor for prioritization. For features located in 3rd and 4th regions due to improper function of firm, we should focus on basic needs of costumers and assign resources of firm for this purpose. Thus, the priority of features in this locations is M>O>A>I.

3.2. TOPSIS –QFD Integrated Model

Using QFD method, technical features are prioritized due to attention just to costumers' viewpoints and determining the relation between features and costumers' needs. In this regard, quality home matrix determines the relation between these definitions and technical features and costumer needs. But to obtain a proper response for prioritization of technical features, it is necessary to focus on factors such as competitive evaluation (costumer-technical), value of goal and … that are components of this method. Due to limit of interaction with costumers, it is not possible to propose most of these factors making their relationship complicated. We can attend to parameters of technical evaluation to compensate these constraints. Though most important parameter of decision making is costumers' opinions but condition and constraints of firm is so determinative for their evaluation and prioritization. Also weights obtained by quality home matrix are considered as weights of voice of costumers (results of feature prioritization using QFD method) in final prioritization of technical features through TOPSIS. Members of QFD team were used as experts and decision makers to determine weight of parameters. In this regard, final weight of parameters is determined using related questionnaire and calculating average of obtained answers.

3.3 Case Study

As said before, one of dominant firms in food industry was used to implement proposed model regarding prioritization of strategies of relationship with costumers in several levels of life cycle. The referred firm is one of the powerful firms in field of food products with 100000 retail costumers; the firm focuses on interaction with this level of costumers considering the importance of retailers in presenting their products as an intermediate between firm and final consumers.

3.4. Identification of Retailers' Needs in Several Levels of Life Cycle

a survey of food retailers was performed in Yazd to prioritize and identify features of relation with costumers in different levels of life cycle (here, life cycle includes probable costumer, new costumer, available costumer, moving out costumer, and former costumer). Accordingly, features of these costumers (retailers) are determined due to opinion of firms' sales experts (Table 1). There were 300 questionnaires distributed to determine costumers' status in life cycle model, and also levels of Kano model for each feature and their importance; among them, 251 questionnaires were fulfilled correctly and properly.

To measure stability of questionnaire, Cronbach-Alpha test was used that its value for responses related to performance, presence and absence of relational features is 0.9, 0.71, and 0.9, respectively. Stability of questionnaire is confirmed since these values are more than 0.7.

The assumption 'there is not any meaningful difference between features of relationship with costumers in several levels of life cycle' is studied after identifying costumers and before determining prioritized features of relation with them. To test assumption, non-parametric Kruskal-Wallis test was used. Since p-values of features discussion with firm and multi-person relationship are equal to 0.01 and 0.031, the assumption is rejected i.e. these features have a meaningful difference against each other in several levels of interaction with costumers. Also, the assumption is accepted for features of relationship with firm, continuity of relationship, presenting incentives, and exact information with p-values of 0.056, 0.063, 0.079, and 0.097, respectively. For other features, zero assumption is accepted with high p-value.

Nevertheless, relational needs of costumers are different in several levels of life cycle due to their behavioral conditions. In the first step of Kano integrated model and performance-importance matrix, Kano levels are determined for each of relational features; meaning that for each of these features , the level with highest frequency would be considered as costumer's need (Table 1). After determining Kano levels, the position of each feature, and then their priority is specified in four areas of performance-importance matrix (Figure 1 and Figure 2). Finally, relational features located in areas 1 and 4 of matrix are considered since success of firm is depended on viewpoints and priorities of costumers. Thus, relational needs of customers in different levels of life cycle are determined.

Figure 1. Location of relational features of new customers in importance-performance matrix

4.222	O-7	3.7756			4.6667	A-1
4.111	M-12				4.5556	A-3
4.111	M-13				4.5556	A-10
					4.4444	A-8
					4.5556	O-4
					4.4444	M-2

3.6667　　　　　　　　　　　　　　　　　　　　　　4.6667

4.222	A-11				4.5556	O-15
2.7778	I-17				4.4444	A-6
2.6667	I-16				4.3333	A-14
2	I-9	1.5556			4.4444	I-5

Figure 2. Priority of relational features of new customers in importance-performance matrix

Table 1. Futures of relation with costumers and Kano classification on different levels of life cycle

Life cycle level / Relational Features	Probable customer			New customers			Current customers			Moving out customers			Former customers		
	CR	I	O	CR	I	O	CR	I	O	CR	I	O	CR	I	O
1. Possibility of discussion with firm	I	3.94		A	4.67	3	M	4.28	3.17	I	3	2.2	I	3.92	2.31
2. Ease of relation with firm	O	4.76		M	4.44	3.33	O	4.43	3.45	I	3.8	2.6	O	4.23	3.23
3. Cost-effective	O	4.59		A	4.55	3.11	A	4.36	3.30	O	4.2	2.2	I	4.8	2.77
4. Time saving	I	4.35		O	4.55	3	I	4.32	3.27	I	3.8	2.6	I	4.08	2.69
5. Making contact anytime/ anywhere	I	3.94		I	4.44	2.67	I	4.25	3.11	I	3.4	3.2	I	4.31	2.54
6. Being responsive	O	4.65		A	4.44	2.89	O	4.41	2.96	A	4.4	3	M	4.23	2.46
7. Lack of disturbance	O	4.35		O	4.22	3.78	I	4.24	3.33	I	4	3	I	4.15	2.77
8. Non-verbal relation	A	4.35		A	4.44	3.33	I	4.23	3.26	M	4.4	2.8	A	4.46	3
9. Verbal relation	I	3.59		I	3.88	2.67	I	3.81	2.27	I	3.8	2.6	A	3.54	2.08
10. Accessibility of relational tools	I	4.35		A	4.55	3.33	A	4.36	3.23	A	4.6	3.8	I	3.85	3.08
11. Presenting entertainment	A	3.94		A	4.22	1.55	A	4.21	1.77	A	4	1.6	I	4.08	1.61
12. Possibility of poll	M	4.35		M	4.11	3.22	I	4.41	2.6	O	4.4	3	O	4.38	2.54
13. Exact information	M	4.53		M	4.11	3.67	A	4.62	3.38	M	4.2	3.2	I	4.69	3.92
14. Firm's mention to customers	I	3.94		A	4.33	2.67	I	4.18	2.17	I	3.2	2.6	I	3.61	1.69
15. Presenting incentives	O	4.82		O	4.55	2.89	A	4.58	2.22	I	4	2.2	O	4.31	2.23
16. many-to-many relations	I	4.18		I	3.67	2	I	3.67	1.69	I	3.4	2	I	2.85	1.38
17. Functional features of firm	I	3.88		I	4.11	2.78	I	4.07	2.65	I	3.2	2.4	I	3.61	2.23

CR: Customer Requirements　　　I: Importance　　　O: Operation　　　A: Incentive Necessities
O: Functional Necessities　　　M: Basic Necessities　　　I: Indifferent

Table 2. Priority features in each level of costumers' life cycle

Probable costumers	New costumers	Current costumers	Moving out costumers	Former costumers
Exact information about products and services	Possibility of discussion with firm	Exact information about products and services	Accessibility of Relational tools	Exact information about products and services
Possibility of poll	Cost-effective	Cost-effective	Being responsive	Non-verbal relation
Presenting incentives	Accessibility of Relational tools	Accessibility of Relational tools	Cost-effective	Possibility of poll
Ease of relationship with firm	Ease of relationship with firm	Ease of relationship with firm		Ease of relationship with firm
Being responsive Cost-effective	Being responsive	Being responsive		Being responsive Presenting incentives

Lack of disturbance
Non-verbal relation
Presenting
entertainment

3.5 Prioritizing the Strategies of Relation with Costumers in Several Levels of Life Cycle

According to results obtained by features of strategies of relationship with costumers, there were 11 features specified among 17 proposed ones.   It must be noted that 11 features are for all levels of life cycle and as seen in Table 2, relational features are similar in some levels. After determining priority features as relational needs of customers in each level of life cycle, relationship strategies are prioritized using QFD-TOPSIS mix technique; firstly, final weight of matrix elements including strategies as technical features and features as costumers' needs is considered due to frequency of responses of team members for each element. Thus, the priority of relational strategies is determined due to results obtained by communication matrix and weights of features (Kano model and performance-importance matrix).

But as said before, there are some limits to use this method. Therefore, some criteria were implemented by sales experts of firm to compensate these limits. Thus, parameters of cost, function of competitors and technical possibility were considered in addition to criterion of voice of costumers.

Therefore, relational strategies for probable costumers are specified using QFD due to priority features (costumers' needs), Kano model and performance-importance matrix, and determining technical features; finally, technical definitions having most importance to meet costumers' needs are identified. In this regard, absolute weight and percent of each strategy is calculated as below:

$$a_j = \sum_{i=1}^{n} R_{ij} c_i$$

Where a_j is row vector of absolute weights for relational strategies, R_{ij}: weights specified o communication matrix, c_i: column vector for features of strategies, m: number of technical definitions, and n: number of costumers' needs. The results obtained by this method are shown in Table 4. As said before, the firm might face with some problems regarding implementation of each strategy. In this regard, constraints are considered as parameters in evaluation and prioritization of strategies. In first step of TOPSIS method, the weights obtained by parameters become non-scale, and non-scale weighted matrix V is created:

$$n_{ij} = \frac{r_{ij}}{\sqrt{\sum_{i=1}^{m} r_{ij}^2}}$$

Then, positive and negative ideal options are formed for each criterion by the relations below:

Positive ideal option: $A^+ = \{(\max v_{ij} \mid j \in J), (\min v_{ij} \mid j \in J') \mid i=1, 2\ldots m\}$

$$= \{V_1^+, V_2^+, \ldots, V_j^+, \ldots, V_n^+\}$$

Negative ideal option: $A^- = \{(\min v_{ij} \mid j \in J), (\max v_{ij} \mid j \in J') \mid i=1,2,\ldots,m\}$

$=\{V_1^-, V_2^-, \ldots, V_j^-, \ldots, V_n^-\}$

so that, J={ j=1,2,…,n |J due to profit }   , J'={ j=1,2,…,n |J due to cost}

In the next step, distance of ideal option is obtained using Euclidean technique:

d_{i^+} :   Distance of ith option from positive ideal $= \left\{ \sum_{j=1}^{n} (V_{ij} - V_j^+)^2 \right\}^{0/5}$ i=1, 2… m

d_{i^-} :   Distance of ith option from negative ideal $= \left\{ \sum_{j=1}^{n} (V_{ij} - V_j^-)^2 \right\}^{0/5}$ i=1, 2… m

At last, relative proximity of each strategy to ideal option is calculated and final priority of relational strategies is obtained (Table 3):

$$cl_i^+ = \frac{d_{i^-}}{d_{i^+} + d_{i^-}} \qquad ; 0 \le cl_i^+ \le 1 \qquad ; \qquad i =. 1, 2 \dots m$$

Table 3. Decision matrix to prioritize strategies of relationship with probable costumers

strategy / criterion	In person	website	e-mail	chat	Cell phone	SMS	MMS	Answer machine	fax	post
Voice of costumers	0.4305	0.3829	0.3965	0.3311	0.2204	0.3242	0.2022	0.1932	0.1815	0.2171
cost	0.4233	0.1058	0.1587	0.2116	0.3704	0.2116	0.2645	0.3704	0.3175	0.4233
Competitor performance	0.3198	0.3198	0.2665	0.1066	0.3198	0.4264	0.2665	0.4264	0.3731	0.1599
Technical probability	0.2674	0.3820	0.3438	0.2674	0.3056	0.3056	0.3820	0.3438	0.2292	0.1910
Positive ideal	0.3992	0.2185	0.1760	0.1850	0.4067	0.3614	0.2613	0.4796	0.4485	0.4308
Negative ideal	0.2814	0.2814	0.4063	0.4187	0.1697	0.2798	0.3176	0.1621	0.1245	0.2689
Cl_{i+}	0.4134	0.6656	0.6977	0.6936	0.2944	0.4363	0.5486	0.2526	0.2173	0.3843

According to the results obtained by 2 mentioned approaches, the difference in strategy prioritization is clearly obvious after implementing criteria. Since this strategy is relatively expensive for firm, the face-to-face relationship with costumers would change. Thus, internet communications is considered as the 1st priority for interaction with costumers due to proper cost, better performance of firm compared to competitors, and appropriate technical probability. Table 4 shows home quality matrix and results obtained by prioritization of strategies using QFD and QFD-TOPSIS methods both. Also, Table 5 shows prioritization of strategies of relationship with costumers in several levels of life cycle.

Table 4. Prioritization of strategies of relationship with probable costumers using QFD-TOPSIS

Strategies of relationship with costumers

		Importance for costumer	In person relation	website	e-mail	chat	Cell phone	SMS	MMS	Answer machine	phone	fax	post
	Exact information about products and services	4.5294	◎	◎	○	○	○	○	Δ	Δ	Δ	○	Δ
Features of relationship with costumers	Possibility of poll	4.3529	◎	◎	○	○	◎	○	Δ	◎	○	○	○
	Presenting incentives	4.8235	◎	○	◎	○	○	◎	Δ	Δ	Δ	○	◎
	Ease of relation with firm	4.7647	○	○	◎	◎	◎	◎	◎	◎	◎	○	Δ
	Being responsive	4.6471	◎	○	◎	◎	○	Δ	Δ	○	◎	○	○
	Cost-effective	4.5882	◎	◎	◎	◎	Δ	◎	○	◎	Δ	Δ	Δ
	Lack of disturbance	4.3529	Δ	◎	◎	◎	Δ	◎	◎	◎	Δ	◎	◎

Non-verbal relation	4.3529	©			Δ			Δ			
Presenting entertainment	3.9412	Δ	©	○		Δ	○				○

Absolute weight and percent for strategies of relationship with costumers	268.23	238.59	247.06	206.29	137.35	201	137.35	185.82	120.41	113.12	135.29
Prioritization with help of QFD	1	3	2	4	7	5	9	6	10	11	8
Normalized weight of voice of costumers	0.4305	0.3829	0.3965	0.3311	0.2204	0.3242	0.2022	0.2982	0.1932	0.1815	0.2171
cost	0.4233	0.1058	0.1587	0.2116	0.3704	0.2116	0.2645	0.2645	0.3704	0.3175	0.4233
Competitors' performance	0.3198	0.3198	0.2665	0.1066	0.3198	0.4264	0.1066	0.2665	0.4264	0.3731	0.1599
Technical possibility	0.2674	0.3820	0.3438	0.2674	0.3056	0.3056	0.2292	0.3820	0.3438	0.2292	0.1910
Priority based on TOPSIS	0.4134	0.6656	0.6977	0.6936	0.2944	0.4363	0.5313	0.5486	0.2526	0.2173	0.3843
Final prioritization	7	3	1	2	9	6	5	4	10	11	8

© = 　strong relationship　　　　　○= medium relationship

Table 5. Results obtained by prioritization of strategies using QFD and QFD-TOPSIS methods

Life cycle and method / strategies	Probable costumer		New costumer		Current costumer		Moving out costumer		Former costumer	
	QFD	QFD-TOPSIS	QFD	QFD-TOPSIS	QFD	QFD-TOPSIS	QFD	QFD-TOPSIS	QFD	QFD-TOPSIS
In person relation	1	7	1	3	1	7	1	11	1	4
website	3	3	6	4	5	3	5	3	4	3
chat	2	1	5	2	2	2	2	2	2	1
e-mail	4	2	3	1	3	1	3	1	5	2
Cell phone	7	9	4	8	6	8	7	8	3	8
SSM	5	6	2	5	4	6	4	7	6	7
MMS	9	5	9	6	9	4	8	4	11	6
Answer machine	6	4	7	7	7	5	6	5	7	5
phone	10	10	8	10	8	9	9	9	8	10
fax	11	11	11	11	10	11	11	10	10	11
post	8	8	10	9	11	10	10	6	9	9

4. Discussion and Results

The current research was performed in order to develop activities of considered firm in field of relationship with retail costumers, and to identify strategies of their relationship in several levels of life cycle; afterwards, a comprehensive model was presented to determine methods and factors influential on relationship with retailers.

In this research, the relational strategies include in person relationship, posy, phone (call, answer machine, and fax), internet (chat, e-mail, and website), and cell phone (SMS, MMS, and call). Also, 11 relational features were identified as priority needs of customers in several levels of life cycle using Kano integrated model and

importance-performance matrix (Table 2).

At last, strategies of relationship with costumers are prioritized due to results of priority needs of customers in several levels of life cycle, quality home matrix and final weight obtained for each strategies using integrated QFD-TOPSIS method. Results show that costumers prefer 'in person' relationship to other relational strategies; though this strategy is not in favor of firm because of its relatively high cost.

Results obtained by prioritizing of strategies for probable costumers show that internet communication are in 1st place; this indicates importance of internet for probable costumers and transforming them to regular costumer. In fact, costumers are in search of information and increasing their awareness of firm's products and services. Other priorities of relational strategies include answer machine, MMS and SSM.

The priority of relational strategies for new customers include chat, e-mail, in person relation, website, SSM, and MMS. Since costumers are in beginning of their relation with firm, there must be a specific focus toward them transforming them to permanent costumers. Implementation of priority strategies is an effective move to meet costumers' needs due to possibility of discussion with firm, non-verbal relation, and cost-effectiveness for new costumers.

The priority of relationship with current costumers includes chat, e-mal, website, MMS, SMS, answer machine, and post. Costumers of this level include regular costumers, customers who purchase but are not satisfied, and costumers who are connected with firm inactively. Thus, it is necessary to attend to opinions and viewpoints of costumers and replying them at this evel.

The priority of relationship with moving out costumers includes chat e-mail, website, SMS, MMS, answer machine, and post. This type of costumers might have valuable experiences about firm; they want to lessen their relation with firm substituting it with another one. Receiving comments and replying them has 2 main benefits for organization.

Firstly, it is possible to transform new costumer to permanent ones through understanding and replying to their comments.

Finally, priority of relationship with former costumers includes e-mail, website, in person relation, aster machine, SMS, and MMS. Since in these level costumers leave the firm out to purchase from competitors, so reasons of their exit would have valuable information for firm. Also, it is possible to attract them again using incentives and replying their comments; though it seems not logic to spend for this type of costumers. As said before, Table 5 indicates prioritization of relational strategies about costumers in all levels of life cycle completely.

Results obtained by this study could be an effective action about relationship with retail costumers in all levels of life cycle using a specified system. Different companies enjoy this model to develop their interaction with costumers, and to develop their status in competitive markert using information and database of customers.

4.1 Recommendations

1. It is suggested to attend to other demographic features such as age, sex, level of education, etc in order to exact and proper prioritization of relational strategies.
2. It is suggested to study role of culture and use of modern communication strategies due to important role of culture in this field.
3. Each organization needs strategic planning in order to develop its status in different domain. In this regard, it is suggested to present proper strategies and policies to develop relationship with costumers using strategic planning techniques and external-internal analysis of organization.

References

AL-Majali, F., & Prigmore, M. (2010). Consumers channel choice behavior in multi-channel environments: what are the influences on consumers to choose the online distribution channels over other alternative offline channels.

Berry, M. A. (2000). Mastering Data Mining: The Art and Science of Customer Relationship Management20002Mastering Data Mining: The Art and Science of Customer Relationship Management. John Wiley & Sons, ISBN: 0-471-33123-6 Paperback £29.50. *Industrial Management & Data Systems, 100*(5), 245–246. http://dx.doi.org/10.1108/imds.2000.100.5.245.2

Blattberg, R. C., Getz, G., & Thomas, J. S. (2001). *Customer equity: Building and managing relationships as valuable assets*. Harvard Business Press.

Brechan, I. (2006). The different effect of primary and secondary product attributes on customer satisfaction.

Journal of Economic Psychology, 27(3), 441–458. http://dx.doi.org/10.1016/j.joep.2005.10.003

Cadotte, E. R., & Turgeon, N. (1988). Guest Satisfaction.

Dakora, E. A. N. (2007). *Multi-channel retailing as a growth strategy for SMME retail businesses in South Africa* (Doctoral dissertation, Cape Peninsula University of Technology).

De Felice, F., & Petrillo, A. (2011). A multiple choice decision analysis: an integrated QFD – AHP model for the assessment of customer needs. *International Journal of Engineering, Science and Technology, 2*(9), 25-38. http://dx.doi.org/10.4314/ijest.v2i9.63849

Herzberg, F., Mausner, B., & Snyderman, B. B. (2011). *The motivation to work* (Vol. 1). Transaction publishers.

Hwang, C. L., & Yoon, K. (2012). *Multiple attribute decision making: methods and applications a state-of-the-art survey* (Vol. 186). Springer Science & Business Media.

Kametani, T., Nishina, K., & Suzuki, K. (2010). Attractive Quality and Must-be Quality from the Viewpoint of Environmental Lifestyle in Japan. Frontiers in Statistical Quality Control, 9, 315–327. http://dx.doi.org/10.1007/978-3-7908-2380-6_20

Li, Y., Tang, J., Luo, X., & Xu, J. (2009). An integrated method of rough set, Kano's model and AHP for rating customer requirements' final importance. *Expert Systems with Applications, 36*(3), 7045–7053. http://dx.doi.org/10.1016/j.eswa.2008.08.036

Murad, J. M. (2009). Improving the Customer Service Level through efficient Business-to-Business Marketing Communication.

Najmi,M, et al. (2009). Prioritization of technical-engineering features of QFD using TOPSIS in Fuzzy mood, *Sharif scientific journal, 34*, 3-9.

Payne, A., & Frow, P. (2004). The role of multichannel integration in customer relationship management. *Industrial Marketing Management, 33*(6), 527–538. http://dx.doi.org/10.1016/j.indmarman.2004.02.002

Sinisalo, J., & Karjaluoto, H. (2007). Mobile Customer Relationship Management: a communication perspective. *International Journal of Electronic Customer Relationship Management, 1*(3), 242. http://dx.doi.org/10.1504/ijecrm.2007.017794

Sinisalo, J., Salo, J., Karjaluoto, H., & Leppaniemi, M. (2006). Managing Customer Relationships through Mobile Medium &#8212; Underlying Issues and Opportunities. Proceedings of the 39th Annual Hawaii International Conference on System Sciences (HICSS'06). http://dx.doi.org/10.1109/hicss.2006.262

Swan, J. E., & Combs, L. J. (1976). Product Performance and Consumer Satisfaction: A New Concept. *Journal of Marketing, 40*(2), 25. http://dx.doi.org/10.2307/1251003

Thakkar, J., Deshmukh, S. G., & Shastree, A. (2006). Total quality management (TQM) in self-financed technical institutions. *Quality Assurance in Education, 14*(1), 54–74. http://dx.doi.org/10.1108/09684880610643610

Tsiptsis, K. K., & Chorianopoulos, A. (2011). *Data mining techniques in CRM: inside customer segmentation*. John Wiley & Sons.

Zhang, P., & Von Dran, G. M. (2000). Satisfiers and dissatisfiers: A two-factor model for website design and evaluation. *Journal of the American society for information science, 51*(14), 1253-1268. http://dx.doi.org/10.1002/1097-4571(2000)9999:9999<::AID-ASI1039>3.0.CO;2-O

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