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Identification of hands and wrist movements via surface electromyography using deep neural networks

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ABSTRACT

A simple and non invasive method of giving the user active control over the prosthesis is surface electromyography. Although, the results of earlier research utilizing surface electromyography for identifying wrist and hand movement range widely as the result of a number of variables. In this project, the wrist and hand movements based on the surface electromyography signal will be identified using deep neural networks approach. This model were trained and analizes the evaluation data that is taken from the sEMG sensor, the evaluation data and pre-trained data will compare using convolution neural network via deep neural networks and also utilizing the Ninapro project's accessible to the public database. Two datasets, DB7, DB5 with 12, 16 channels and 2 kHz, 200 Hz sampling rate setups and the overall accuracy of DB7 and DB5 is 91.69 ± 4.68% and 93.87 ± 1.49%, were used for this project. Based on the output taken from the CNN we can identify the gestures. Our approach could be a method for operating flexible prosthetic hands with a number of predetermined gestures.

Keywords - Surface electromyography, prosthetics, deep neural networks, convolution neural network, Ninapro database.

1. INTRODUCTION

Paralyzed hand using machine learning along with non invasive sensors operating capabilities where as thanks to recent developments in mechatronics, sensor technology and signal processing have made it possible. However, there are presently few actual uses for these prostheses and little acceptance of them by amputees. Control problems, lack of dexterity and skill, and the cost of the prosthesis are a few of the key contributing factors. Additionally, consistently misclassifying planned behaviours may cause dissatisfaction and prosthesis abandonment. As a result, it is necessary to attain a high level of dependability and consistency in interacting components for the customer experiences and its acceptance of the paralyzed hand.

There are a number of non invasive control methods for artificial arms were developed then studied in recent years, including surface electromyography (sEMG), electroneurography (ENG), mechanomyography (MMG), and force myography (FMG). The application of sEMG, a non invasive technology for monitoring the neural signals of muscle just on surface of the skin. It is a straight forward and easy way to allow the user to actively control the prosthesis. The general overview of the prosthetic hand's for identification of movements utilizing sEMG. The movement categorization process uses the input as muscle signal.

Even though numerous research teams have looked into and reported in the identification of movements with sEMG, these results reported in the literature can differ greatly, with accuracy ranges from 60 to 98%. A few aspects which impact the results include the range of classes, the quantity of data, the setup and conduct of the acquisition, and the analysis techniques. Therefore, research with a comparable amount of classes and similar chance levels, should be taken into account to evaluate the qualitative outcomes of the experiment.

The objective of this project is to research using a DNN technique to identify movements with sEMG signals. The investigations took into account functional hand movements as well as movements of the hand, wrist, and for grasping. The sEMG signal's feature extraction approaches were researched and chosen for their ability to reconcile computational complexity with classification performance. Ninapro, a sizable public surface EMG database, was utilized to verify the efficiency of the suggested deep neural networks classifier.

Ninapro is a database for advance hands myoelectric prostheses. To develop spontaneously operated, non invasive robot arm prostheses for transradial amputees, The continuous Ninapro research is aimed at creating complete and accurate references in scientifically analysis just on the connection among wrist or hand motions, sEMG, and clinical features. This Ninapro project's procedure was followed when collecting the data used in tests, and this data were then added to Ninapro database.

	DB8	DB7	DB6	DB5	DB4	DB3	DB2	DB1
Sampling rate	2 kHz	2 kHz	2 kHz	200 Hz	2 kHz	2 kHz	2 kHz	100 Hz
Movements	9	41	7	53	53	50	50	53
Type of Sensors	Delsys	Delsys	Delsys	Myo	Cometa	Delsys	Delsys	Otto
Repetitions	12	6	70	6	6	6	6	10

TABLE: Datasets in the Ninapro

2. METHODOLOGY

A. Existing Methodology

Dexterous Hand

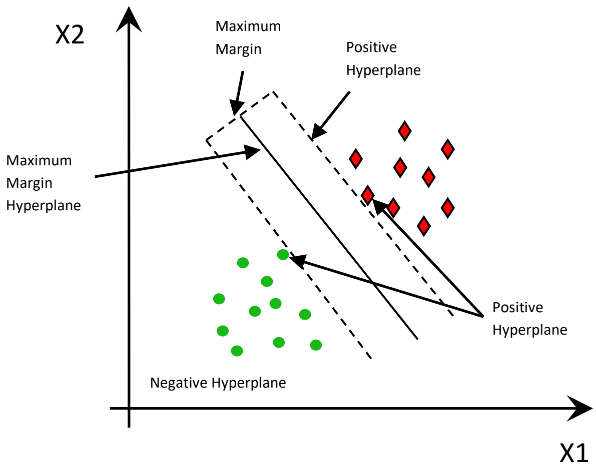
The Dexterous Hand is connected to a glove worn by a human. The human hand can then receive feedback from the robotic hand via haptic responses while the robotic hand is being carefully controlled. Future robot hands that are capable of performing whatever task a human hand can are represented by the Dexterous Hand.

Multiple manipulators, or fingers, work together to grab and manipulate things in the field of robotics known as dexterous manipulation.

Support Vector Machine (SVM)

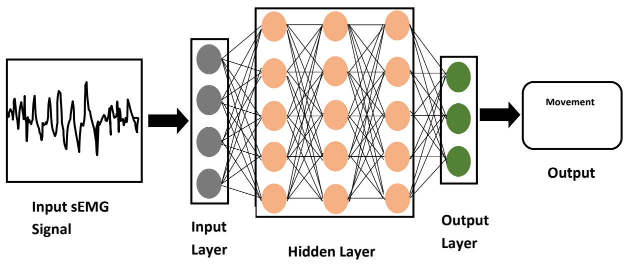
For identification of hands and wrist movements another method was Image processing using Support Vector Machine by the help of sEMG signals. It is one of the most used supervised learning algorithms and it is used to address both regression and classification problems. It is mostly used in machine learning identification problems.

The objective of the Support vector machine is to define the optimal line or decision boundary that can categories the n-dimensional space, enabling us to easily classify new data points in the future. The name of this optimal decision boundary is a hyperplane. SVM determines the extreme points and vectors to make the hyperplane.



B. Proposed Methodology

In proposed method we use Deep Neural Networks instead of Support Vector Machine, a subclass of deep neural networks called convolutional neural networks. It is a deep learning algorithm that has the ability to process an input signal, evaluate different aspects and objects in the image, and distinguish between them. It has several layers, including fully linked, convolutional, and pooling layers. In order to extract features from the input picture, the convolutional layer applies filters. To reduce computation, the pooling layer down samples the image, and the fully connected layer produces the final result. The classification of image and signal data using CNN is also highly effective.



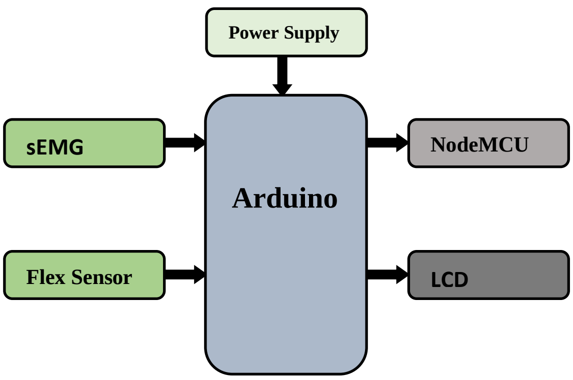
Input layers- This layer is where we add data to our model. In this layer, the same amount of neurons represents all of the qualities in our data.

Hidden layer- The input from the input layer is subsequently passed to the hidden layer. There may be a huge amount of hidden layers, depending on our model and the size of the data. Each hidden layer may have a different number of neurons, although they are usually more than the number of characteristics.

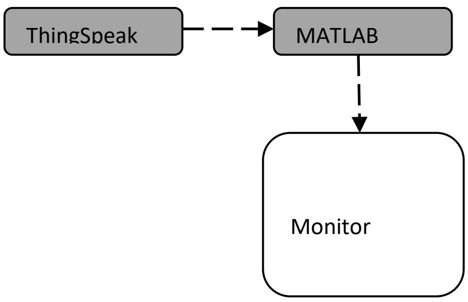
Output layer- Using a logistic function, such as sigmoid or softmax, and the information from the hidden layer as input, each class's output is then transformed into the probability score for each class.

Advantages of CNN over SVM

- To train the system, convolution neural network needed a huge dataset. Support vector machine is able to train systems using tiny datasets, thus you may choose a classifier based on the dataset as a starting point.
- It takes less time to predict the output compare to SVM
- Easy to train the sample compare to SVM and it performs well feature extraction and gives better accuracy.



3. BLOCK DIAGRAM



Hardware

Software

4. DATA ANALYSIS

A. Hardware Analysis

Using sEMG sensor we collect the data in the format of signal by the contraction and relaxation of muscle from the forearm, it's not possible to collect the accurate data from the sEMG sensor due to that we are considering flex sensor as a reference sensor to collect the additional data. Microcontroller (Arduino) is used to collect the data from the sensors and the data is forwarded to the NodeMCU. It is WiFi based module and used to transfer the data to particular software (Thinker CAD, Think speak etc.,) by the help of WiFi. Similarly, the output is shown in the LCD.

B. Software Analysis

In MATLAB we had already pre-trained dataset .From data collected by the NodeMCU is received by Thinker CAD and it is shown in the format of the CSV file (coma separated values), the evaluation data present in the CSV file is fed as input to the MATLAB. The MATLAB compare and analizes the features of evaluation data and pre-trained dataset with the help of the convolution neural network via deep neural networks and the final output is shown in the MATLAB software.

5. COMPONENTS DESCRIOTION

Arduino Uno

The Microchip ATmega328P microprocessor serves as the foundation for the Arduino Uno microcontroller board. It includes with everything needed to support the microcontroller, so you can start using it by connecting a USB connection or charging it with a battery.

The microcontroller is programmed using IDE and the Arduino programming language. Uno can detect information from its surroundings. In this scenario, a variety of sensors are utilized as input, and these sensors can affect the environment via managing actions like lights ,motors on/off, etc. Multiple I/O components are connected, the inputs are effectively read, and the output is effectively produced. The user may use this output to carry out desired purposes. It offers a user-friendly interface, and creating original solutions is simple.

NodeMCU

The NodeMCU is an open-source environment for developing software and hardware that is focused on the affordable ESP8266 and it was System-on-a-Chip. The essential computer parts, including as a CPU, Memory, networking (Wi-Fi), as well as a SDK and modern operating system, are included in the ESP8266. Because of this, it's a fantastic option for all kinds of projects in Internet of Things .The chip hardware can grasp its machine instructions which are low-level. The serial output and ESP8266 may be flashed on a PC using the USB chip and built-in programmer, simplifying the prototype applications. The ESP8266 Microcontroller is a board with an ADC, voltage regulator, GPIO pins, and a Micro-USB interface similar to Arduino boards. In addition to the previously described functions, the ESP8266 NodeMCU offers a comprehensive Wi-Fi that manages Wi-Fi access to a server or client.

Flex Sensors

It is a sort of sensor which calculates how much bending or deflection has taken place. This sensor may be constructed out of carbon and plastic . When the carbon surface is moved aside supported by the plastic strip , the resistance of the sensor will be changed. Hence it is referred as a bend sensor. Because the amount of turn can immediately relate to the resistance's variation. The conductive layer is stretched when the sensor is bent, reducing its cross section (similar to stretching a rubber band) and increasing resistance.

sEMG Sensor

Neurologists frequently employ the electro diagnostic method known as needle EMG. Several specialists, employ surface EMG a non-medical approach, to evaluate muscle activity.

Electrodes are positioned on the skin surface of a muscle to detect the electrical activity of the muscle using a technique known as surface electromyography (sEMG). When a muscle is contracted, its length reduces and the electrodes, skin, and muscle all move in relation to one another.

6. SOFTWARE REQIRED

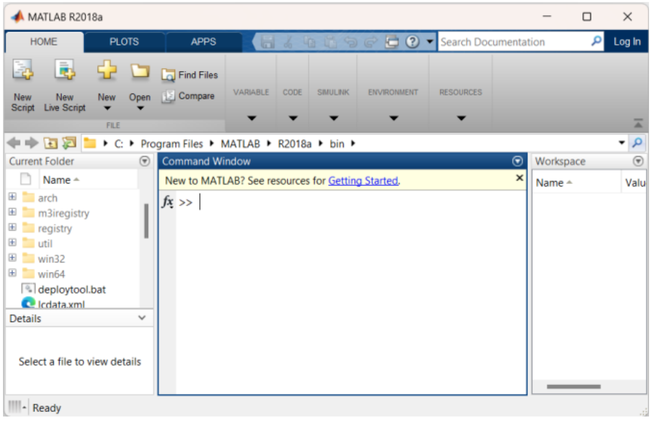
A. MATLAB

For the creation of algorithms, numerical calculation, data analysis and data visualization, MATLAB is a high-level technical computer language and interactive environment. Technical computer issues may be resolved more quickly using MATLAB than with conventional programming languages like C and C++.Control design, communications, testing, image processing, signal processing and analysis, and biomedicine are just a few of the many areas it may be employed in the MATLAB.

The MATLAB platform is developed by add-on toolboxes to address specific kinds of issues in certain application domains. MATLAB offers a variety of tools for sharing and documenting work.

Key Features of MATLAB

- Technical computer language at the highest level
- Using 2-D and 3-D graphics to visualize data
- MATLAB-based algorithms may be integrated with other programming and languages, like C, C++, and Microsoft Office excel, using special functions.



Importing and Exporting Graphic Files

Common visual and data file types including JPG, GIF and PNG are all supported by MATLAB for reading and writing. As a consequence, you may export MATLAB plots to pc publishing tools or other programmes like Ms PowerPoint and Word. To comply with publication requirements, you can create and use style templates that cover aspects like layout, line and thickness font before exporting.

B. Arduino IDE

To write code and upload it to Arduino boards, utilize the open-source Arduino IDE programme. The IDE application is appropriate for a wide range of operating systems. It supports the computer languages C ++ and C.

Writing a code or programme in the Arduino IDE is referred to as "sketching." The Arduino UNO board need to be linked to the IDE in order to upload the sketch developed in the Arduino IDE programme. The drawing is stored with the .ino file extension. It supports every Arduino board that is currently available, including the Mega, Leonardo, Ethernet, and others.

How Arduino IDE works

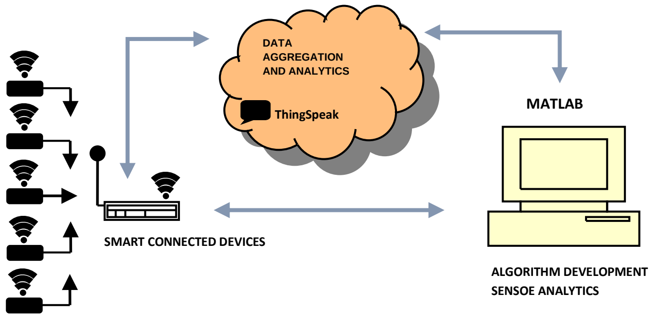
As a user creates and compiles code, the IDE will generate a Hex file, which is then sent to the board using a USB. It also includes an inbuilt microprocessor, which reads the hex file and executes the programme.

C. ThingSpeak

The creators of Simulink and MATLAB, both from MathWorks, provide an Internet of Things platform network called ThingSpeak. Internet data sources may be gathered, visualised, and evaluated using it. This gives you a quick representation of the information given by the devices or equipment. Online data processing and analysis can be done by running MATLAB code in ThingSpeak. IoT systems can be created without the need for web servers or web software.

Connect Your Hardware to ThingSpeak

ThingSpeak works with any device that has an Internet connection. With well-known embedded hardware prototype technologies as ESP8266, Arduino and Raspberry Pi users may utilize native libraries for receiving data from your gadgets. Using a REST API or a MQTT API, you can also transfer data to ThingSpeak from machines or local gateways.



Access Online and Offline Data

ThingSpeak keeps all the data you send it in a single location in the cloud, making it simple for you to access your information for online or offline analysis. An API key that you manage is used to protect your sensitive data. You can safely download the information kept in the cloud using the browser while logged onto your ThingSpeak account. With a REST API call and the proper API key, you may also read your data programmatically in CSV forms.

7. RESULT

The Microcontroller will collect the data from the sEMG, flex sensor and it will display in the LCD screen in the same way the data is uploaded in the ThingSpeak.

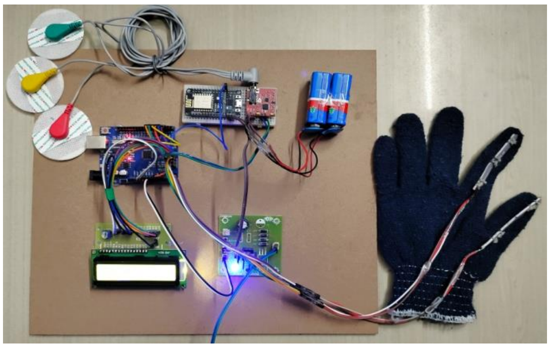
Flex Value:

sEMG Value:

Hand movement:

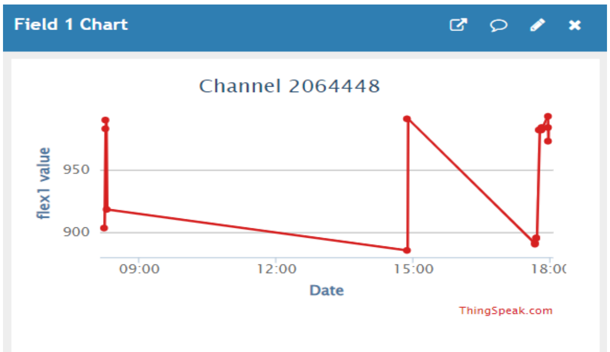
Data uploading to the ThingSpeak:

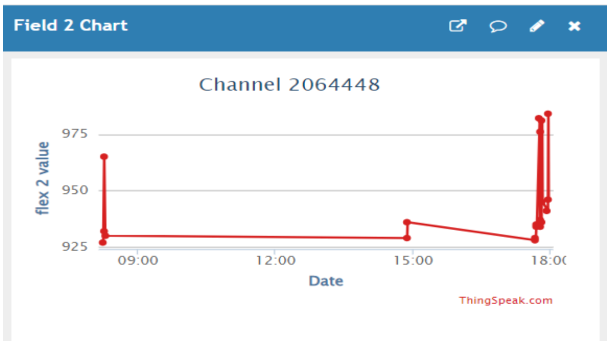
Real-time circuit:



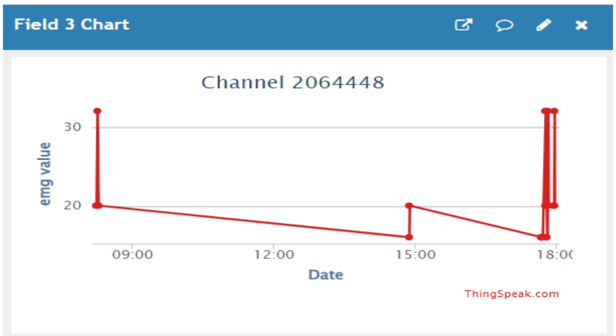
Thingspeak graphical representation:

Flex values representation





sEMG vales Representation



MATLAB output:

```
>> Main
Enter the signal value for flex1: 892
Enter the signal value for flex2: 931
Enter the signal value for EMG: 16

output =

    'Relax position'
```

```
>> Main
Enter the signal value for flex1: 982
Enter the signal value for flex2: 932
Enter the signal value for EMG: 20

output =

    'Thumbs-up'
```

```
>> Main
Enter the signal value for flex1: 972
Enter the signal value for flex2: 970
Enter the signal value for EMG: 32

output =

    'Fist position'
```

8. CONCLUSION

This paper presents an application of a deep neural networks model for identifying hand and wrist movements based on surface electromyogram. To overcome the Disadvantages in SVM instead of that we are using convolution neural network for classifying the data received from the sEMG sensor. The analyzed data by CNN is used to identify the movements of prosthetic hands with the help of MATLAB software.

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