Mind Machine Interface using Internet of Things

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***Abstract*: Sometimes, many people face issues, especially the ones who are physically disabled who are not able to control some types of equipment in their surroundings due to their disability. So, we decided to build a system that could help them to control the objects just by their nerve signals. The research paper represents the methodology that can be followed to develop the system on a basic level. Here, user will just have to control their movements and accordingly the actions will be performed. IoT sensors will record the electrical activity of the muscles and accordingly the devices will act. The project "mind-machine interface" is based on the cognitive computing and analysis of signals from the brain and transforming the signals to electrical pulse or in form that could be utilized by the hardware used. This project for the research paper will be based on cognitive computing and it can be used to control objects by the signals produced inside the body.**

***Keywords*: Brain Computer Interface (BCI), Electromyogram sensor, Internet of Things (IoT), Mind Machine Interface (MMI)**

1. Introduction

A. Brain Computer Interface

Brain Computer Interface (BCI) is also known as Neural Network Interface (NNI) or Mind-machine Interface (MMI) is a new emerging technology developed, which make machines work on human body/muscles movements. It could be the muscle movements or the neural movements occurring in brain. It is a direct communication pathway between an enhanced or wired human brain and an external device. BCI allows bidirectional information flow i.e. from humans to machine and vice versa. To describe mind machine interface in comparison to other similar technologies like neuro prosthetics, BCI does not only focus on developing prosthetics rather it has also played a vital role in each and every field to connect humans with machines and let them control each other by means of sensors. For instance, MMI while connecting brain neurons to machines a few sensors and electrodes are connected and sometimes a gel is applied to the scalp for gathering up the electrical signals and utilizing them for making an interface with the machine. After the electrodes are attached on the brain scalp the electronic signals are collected and sent to an interface machine, it can be a computer which will perform the tasks like Pre-processing, classification, feature extraction and database update which is lastly sent to the machine that is being controlled. This is the general methodology followed in every BCI or MMI project.

This research paper is based on the MMI project that focuses on controlling the appliances with the help of signals generated from the electrodes and electromyography. For many medical research and treatment of neural muscle disorders, electromyography has been used. With the proliferation of a shrinking, yet more powerful microcontrollers and integrated circuits, such as, EMG circuits and sensors have found a way to prosthetics, robotics and other machineries.

B. Internet of Things

Internet of Things, widely known as IoT, is a new emerging technology that connects various devices without human to human or human to machine interference. For achieving the outcomes of the project, an IoT sensors kit containing EMG sensor and NodeMCU is used which performs the major task for executing the project.

1) NodeMCU

An important part of this project is NodeMCU which is an interface to process the signals gathered by the electrodes of the EMG sensor. NodeMCU is basically a single board microcontroller which is usually used for Internet of Things (IoT) application. It includes firmware that runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware is based on the ESP-12 module. The Code of this project will be written in Arduino development environment (IDE). Here the developer writes the Arduino code in the IDE, then uploads it to any microcontroller in our case it is NodeMCU ESP8266.

2) EMG sensor

Electromyogram sensor popularly known as EMG sensor has been used in the project for serving the purpose of project by gathering the signals from the electrodes connected and later on reacting upon the signals gathered from the electrodes. For the given project the electrodes are connected at three points at hand muscle to control a device for an instance a servo motor. A diagram is shown below represents some of the electrode placements.

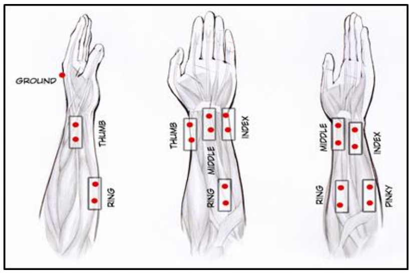

Fig. 1. Muscle points for electrodes placement according to fingers

2. Methodology

We have proposed a simple approach as shown in below figure firstly, to support data collection for user secondly, to provide real-time event detection and lastly for refining the event detection using processing layer. Hence the proposed architecture consists 3 layers namely, (1) Sensing Layer (2) Processing Layer and (3) Action.

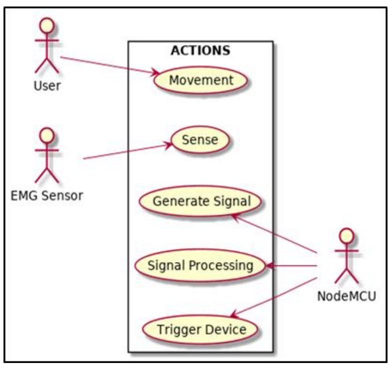

Fig. 2. Use case diagram

The three layers for the process can be defined below:

A. Sensing Layer

It is composed of the EMG sensor embedded with a pre-processor. The electrodes of the EMG sensor unit are attached to the user's body as shown in the below figure. With the help of this 3 electrodes electrical activity of the user is recorded and equivalent raw graph plotted and then it is sent to the processing layer for further processing. The placement of the electrode should have 1-2 cm space between them for proper effect and should be placed between the tendinous insertion of muscle and the motor unit, over the protensive or the lengthwise midline of a muscle. It can also be placed at the belly of the muscle of accurate results. Proper placement of electrodes is important for the system to work efficiently and the given diagram depicts an example of placement.

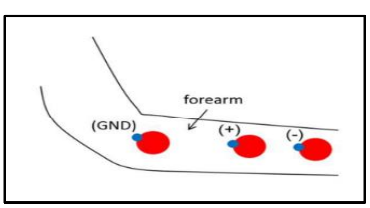

Fig. 3. Electrodes placement for forearm muscle

B. Processing Layer

Every signal received by the sensing layer is analyzed by the processing layer with the help of NodeMCU. This microcontroller is convenient to use as it consumes low power and has good processing power up to 80MHz and in some cases can be extended up to 160MHz.

The second part of this processing layer is signal enhancement or Signal-to-Noise enhancement. There are 2 ways to enhance our signal, namely, Analog Filtering and Digital Filtering. In this proposed method we will apply digital filtering method such as Ensemble Averaging or Boxcar Averaging method to enhance our signal. Digital signal is basically software based whereas Analog Filtering is hardware based.

The third stage is feature extraction also known as dimension reduction is required for better performance and accuracy. Here, we do this step to minimize the response time. In other words, minimizing the time between the user's movement and output. The third stage and fourth stage work together.

In the last part of the processing layer we will analyze the maxima and minima in the signal and decide the threshold value which will trigger the electrical device with the help of CUMSUM algorithm (Cumulative Sum).

C. Action

Once the threshold is set by the processing layer, we need to check the condition if the threshold is achieved by the signal or not. If it is achieved, then, we need to trigger the electrical device and if it is not, then, we just need to skip those parts in signal and again loop back to the sensing layer.

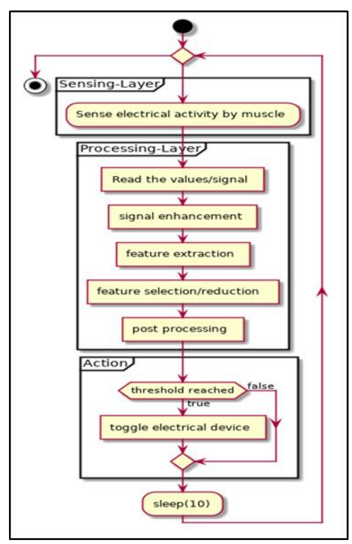

Fig. 4. Flow chart

After following the flow chart in the starting stage one can operate any electrical device by just contracting and relaxing the muscle where the electrodes are placed. We can also operate multiple electrical device by having multiple thresholds which can act as a trigger to control the device.

3. Literature Survey

A. SVM-based Brain-Machine Interface for controlling a robot arm through four mental tasks

Methodology: A robot arm controlled by user thoughts by using volunteers for moving the robot arm to reach its targets that are placed inside the robot workspace.

Architecture: There is a workspace defined in front of the robot arm and besides it the volunteers sit in front of the robot arm to see the device clearly. In the observational work area, the robotic arm can move freely.

Proximity sensors: Ground sensor, EEG

Applications: Compatible for picking and placing tasks.

B. Brain-Computer Interface Operation of Robotic and Prosthetic Devices

Methodology: The prosthetic arm can be operated by using 2 different signals i.e. one for angular direction and the other for the speed and later on sensors would work to achieve the desired outcome.

Architecture: Here the architecture can be defined as the electrodes of the sensor sensing the control signals later on passing to the translation algorithm and then towards the device commands.

Proximity sensors: sensorimotor, EEG sensor

Applications: For operating Robotic Prosthetic devices and wheelchairs.

C. Human-Machine interfaces on EMG and EEG applied to robotic systems

Methodology: Taking the feedback from the brain using EEG and passing on to the computer where data acquisition, preprocessing, feature extraction, classification and control signal generation occurs and later on passing the output to the device for example the robot.

Architecture: The workspace contains sensors connected to a computer software or interface giving the output to the robot or other devices.

Proximity sensors: EMG and ECG

Applications: For controlling robots.

D. Visual evoked potential-based brain–machine interface applications to assist disabled people

Methodology: Connecting EEG sensor to the scalp of humans and reading the signals using the 16 electrodes along with the gel applied to improve the surface contact between the skin and the electrode reducing the impedances. The amplifier is attached and 2 screens are connected for the process of classification and sampling.

Architecture: EEG Cap connected with amplifier which is connected to the computer screens for classifying the signals. BCI2000 software is used for the sampling and processing part.

Proximity sensors: EEG

Applications: A web browser that allows an access to the internet and for controlling computers, robotic arm, and also used as a communication tool for disabled people.

E. Brain EEG Signal Processing for Controlling a Robotic Arm

Methodology: The steps followed are signal acquisition, pre-processing of the control signals received from the brain followed by feature extraction and classification and lastly the result analysis.

Architecture: The architecture comprises of EEG sensor sensing the control signals, the computer system working of the pre-processing of signals, feature extraction and classification and the robotic arm unit.

Proximity sensors: EEG

Applications: Controlling the robotic arm

4. Conclusion

The project carried out is based on controlling an equipment using muscle movements which comes under Brain Computer Interface and the output can be received that a person can operate the equipment with the help of muscle contraction and relaxations at a starting level. Furthermore, more functionalities can be added to upgrade this project to control devices more efficiently not just turning on and of the device. A flowchart is given for in depth knowledge of the process happening. Also, the placement of the electrodes is being specified which can help to achieve desired outcomes.

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