

Brain Computer Interface Systems To Assist Patients Using EEG Signals

Thejaswini S¹, Sumathi M S¹, Manasa C², Raashi Saxena², Tarun R Prasad², Akash Tiwari²

Assistant Professor, Department of Telecommunication Engineering, BMSIT&M, Bengaluru, India.¹

Students, Department of Telecommunication Engineering, BMSIT&M, Bengaluru, India²

ABSTRACT: Brain computer interface (BCI) facilitates a connection between the human brain and external device like computer and is used for assisting the physically disabled and impaired people. The BCI system can be used for analysis and classification of EEG signals corresponding to different emotions, including self-report, startle response, behavioral response, autonomic measurement, and neurophysiologic measurement. The EEG signals can play an important role in detecting the emotional states for developing the BCI based analysis and classification of emotions. Since the BCI based on emotion detection can be useful in many areas like as entertainment, education, and health care. Here in this project we have proposed a prototype embedded controller based model to assist patients which can control home appliances. We have used DWT algorithms for feature extraction and features like energy, entropy, mean are computed. The KNN classifier is used to classify EEG signal into two states through which the controller controls the home appliances. The two applications namely switch on/off bulb and turns on/off dc motor are implemented successfully

KEYWORDS: BCI, EEG, KNN, DWT.

I. INTRODUCTION

Brain computer interface (BCI) facilitates a smooth connection between the human brain and other external devices. The BCI system can be used for assisting the physically disabled patients and impaired people. The BCI system requires analysis, evaluation, monitoring and measurement, of electrical activity of the brain which is extracted by either a set of electrodes over the scalp or electrodes implanted inside the brain. The figure1.1 illustrates the working principle of BCI systems [1].

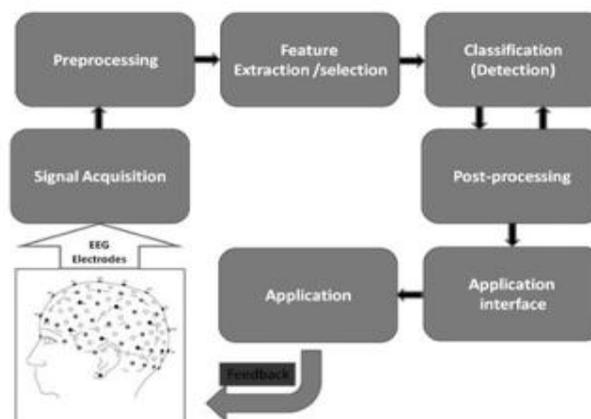


Figure1.1 Working Principle of BCI [1]

The types of BCI available are: 1) Invasive Brain Computer Interfaces, 2) Partially Invasive Brain Computer Interfaces. 3) Non Invasive Brain Computer Interfaces 4) the Emotiv Education Edition SDK. Generally non-Invasive BCI method is used for implementation. In this implementation, EEG signals are extracted by placing electrodes on the

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scalp as shown in Figure 1.2. [2] Electrodes are placed over scalp of a participant based on an international 10/20 system. EEG signals are classified into 5 types alpha, beta, gamma, theta and delta based on frequencies as shown in figure1.3 [1].

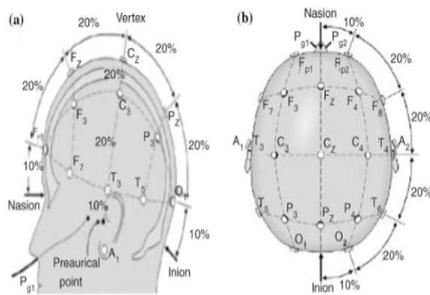


Figure 1.2 Electrode placement over scalp according to the international 10/20 system

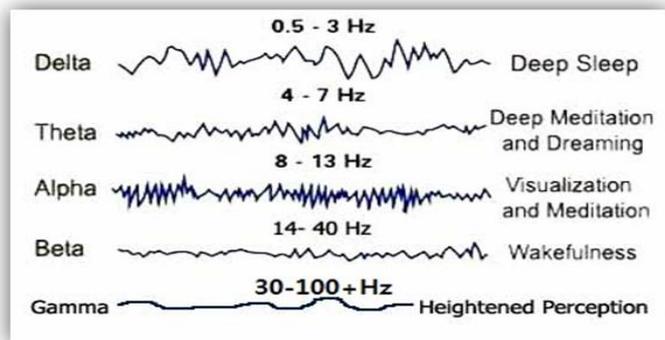


Figure 1.3 Types of EEG Waveforms

EEG signals are classified into 5 types alpha, beta, gamma, theta and delta based on frequencies as shown in Figure1.3 [1].

Beta: They are the ranges of waves which are between 13 and 30 Hz. They usually have a low voltage between 5-30 μ V. BETA is the brain wave concerned with solving mathematical problems, active thinking, and active attention, focus on the outside world. It can reach frequencies near 50 hertz during intense mental activity.

Alpha: Alpha Waves have amplitude of 30-50 μ V. The rate of change lies between 8 and 13 Hz. These waves have been assumed to indicate both a relaxed awareness and also in attention. They are stronger than the occipital (back of the head) cortex and also over the frontal cortex. Alpha is the most integral wave in the whole realm of brain activity and has a very high reach.

Theta : Theta waves have amplitude which is usually greater than 20 μ V and lie within the range of 4-7 Hz. Theta arises from emotional stress, especially disappointment and frustration. Theta has been also associated with access to unconscious material, creative inspiration and deep meditation. 7Hz is the large dominant peak of the theta waves.

Delta: Delta waves are characterised with variable amplitude and lie within the range of 0.5 to 4 Hz. Delta waves are primarily associated with deep sleep and in the waking state and were thought to indicate physical defects in the brain.

Gamma : Gamma waves lie within the range of 35Hz and up. This band is primarily associated with the mechanism of consciousness. This involves the binding together of distinct modular brain functions into coherent precepts capable of behaving in a re-entrant mode (feeding back on them over time to create a sense of stream-of-consciousness).

Movement restoration for patients with chronic stroke or other brain damage remains a therapeutic problem and BCI systems have promising solutions to these challenges. The BCI systems assist or help people suffering from severe neuromuscular disorders to operate various devices and applications through their mental activities.

So in this paper we are developing a prototype model which can assist paralyzed patients through emotion states. We are developing a feature extraction algorithm using DWT and KNN classifier which can classify the EEG signals into two states. The classified output is fed as to the controller which can switch on /off light and opening /closing of the door through motor.

II. RELATED WORK

Since the BCI based on emotion detection can be useful in many areas such as entertainment, education, and health care, from the survey we found that surface Laplacian (SL) filtering, time-frequency analysis of wavelet transform (WT) and Multi Wavelet transforms are used for feature extraction and the classification is done using LDA, SVM

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KNN[4][5][6]. So we proposed a prototype model based on two classes (Emotion states) to assist patients in operating house hold appliances.

III. PROPOSED ALGORITHM

The block diagram of the proposed methodology is shown in figure 3.1.

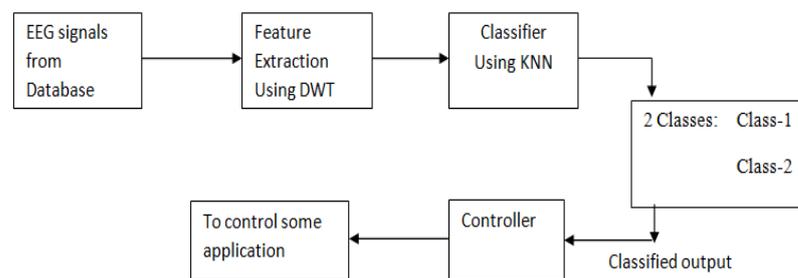


Figure 3.1 Block diagram of proposed methodology

A. Data Acquisition :

EEG signals are downloaded from DEAP database [8].The details of data acquisition as per DEAP Data base website is as follows Electroencephalography (EEG) and physiological signals were recorded from 32 participants while each one watched segments of music videos. Participants were asked to rate each video in terms of the levels of valence, arousal, dominance, like/dislike, and familiarity. Frontal face video was also recorded for each participant. A stimuli selection method was used, utilizing retrieval by affective tags from the video highlight detection and an online assessment tool. Based on the signal patterns, the 32 signals are classified into class-1 and class-2 and stored separately. The class-1 classified signals are renamed as s01 to s16 and those of class-2 are renamed as s17 to s32.

B. Feature Extraction :

Standard deviation in one word it is 'mean of mean' it is statistic that tell which tell how closely various features a There are certain statistical parameters like energy, entropy and standard deviation and mean are chosen and calculated at each decomposition level for all categories of signals from s0 to s32 of EEG DEAP database.

1) Energy:

The energy indicates the strength of the signal as it gives the area under the curve of power at any interval of time. The energy of EEG signal of finite length is given by:

$$\text{Energy } (E_i) = \sum_{j=1}^N |D_{ij}^2| \quad i=1, 2, 3, \dots, l$$

2) Entropy:

Entropy is numerical measure of uncertainty of outcome where signal contained thousands of bits of information. The mathematical representation is:

$$\text{Entropy } (EN) = \sum_{j=1}^N D_{ij}^2 \log(D_{ij}^2) \quad i=1, 2, 3, \dots, l$$

3) Standard Deviation:

Standard deviation in one word it is 'mean of mean' it is statistic that tell which tell how closely various features are near to mean.

$$\text{Standard Deviation } (\sigma) = \sqrt{\frac{1}{N} \sum (x_i - \varphi_i)^2} \quad i=1, 2, 3, \dots, l$$

4) Mean:

X is random variable with mean μ :

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$$\text{Mean } (\mu) = \frac{1}{N} \sum_{j=1}^N D_{ij} \quad i=1, 2, 3, \dots, l$$

In this paper we are creating a GUI using MATLAB. In the GUI, the click on each push button would deliver some implementation. The steps for creating GUI are as follows:

For the push button display

1. Reading the brain wave signal from the query signal repository for which the emotion has to be found will take care as the first work.

How to plot 2 graphs using the 2 axes and 2 push buttons? I have created 2 axes and 2 push buttons namely as below:

axes1, axes2, pushbutton1, pushbutton2

In the pushbutton1 property I have inserted the "Callback" column with

```
>>plot (simout.time, simout.signals.values) from my simulink.
```

In the pushbutton2, I did the same thing to the "Callback" as

```
>>plot (simout1.time, simout. signals. values)
```

2. The read brain wave would be displayed on the figure window of the Matlab .Then the comparison or the emotion detection portion would be carried out using both test and database signals available.

3. The wavelet transform of the signal in the query is found. The 1D wavelet coefficients are taken and stored.

4. The wavelet transform of the signal in the database is also taken in to as coefficients.

5. Both the coefficients are taken and the Euclidean distance is calculated.

6. The minimum Euclidean distance is sensed and for which class it is giving the minimum distance the brain wave belongs to that class.

The flowchart to create GUI is as shown in figure 3.2

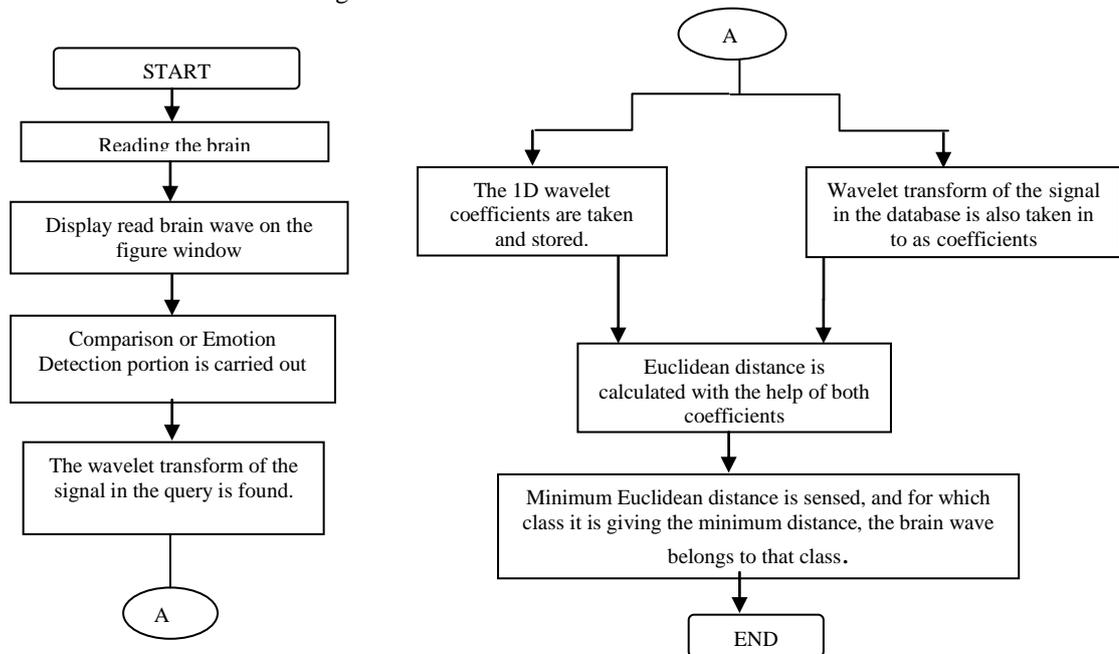


Figure 3.2 Flow charts to create GUI

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C. Classification:

In pattern recognition, the K-Nearest Neighbor algorithm (KNN) is a method for classifying objects based on the closest training examples in the feature space. KNN is a type of instance-based learning, where the function is only approximated locally and all computation is deferred until classification. The KNN algorithm is amongst the simplest of all machine learning algorithms: an object is classified by a majority vote of its neighbours, with the object being assigned to the class most common amongst its k nearest neighbors (k is a positive integer, typically small). If $k = 1$, then the object is simply assigned to the class of its nearest neighbour.

Steps for KNN Classifier:

1. Determine parameter k = number of nearest neighbours.
2. Calculate the distance between the query-instance and all the training samples.
3. Sort the distance and determine nearest neighbours based on the k th- minimum distance.
4. Gather the category of the nearest neighbour to classify into classes.
5. Use simple majority of the category of nearest neighbour and classify respected trained signals into Class-1 and Class-2.

The flowchart for KNN classifier is shown in Figure3.3.

D. Controller :

Figure 3.4 shows the implementation of controller to control two applications: switch ON /OFF bulb and Turn ON / OFF motor, based on the classifier output.

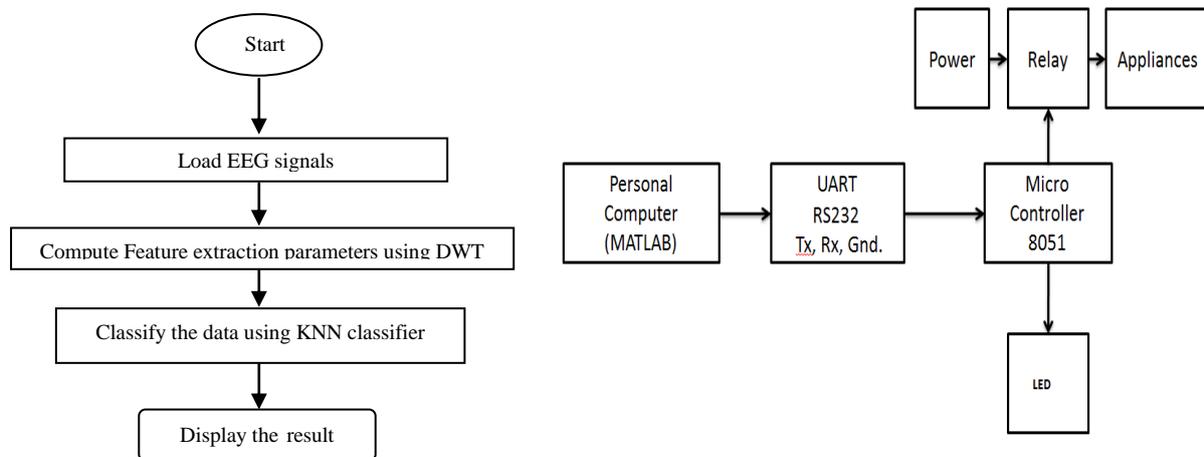


Figure3.3 Flowchart of KNN classifier

Figure 3.4 Implementation of Controller

The KNN classifier output which is segregated into Class-1 and Class-2 are fed on to a microcontroller through Serial UART RS232. The microcontroller uses Relay that will enable to run a few appliances. Class-1 and Class-2 are used to execute the desired applications.

IV. RESULTS

The hardware module is shown in Figure 4.1. The proposed algorithm is implemented in MATLAB. A typical sample of the MATLAB GUI window used in our program is shown below in Figure 4.2.

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Figure 4.1 Hardware Module

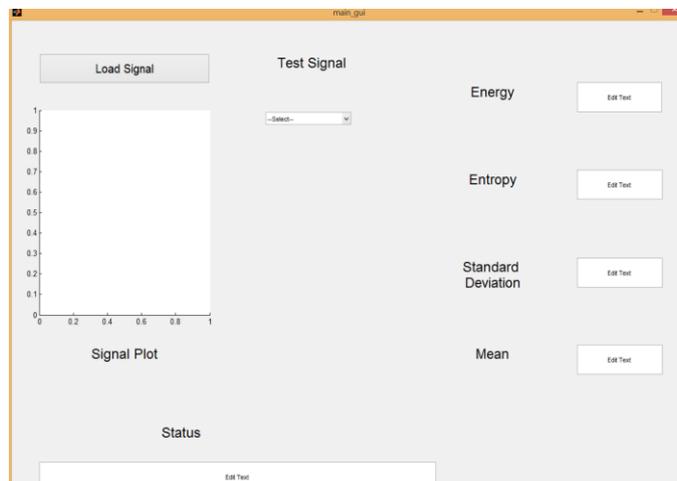


Figure 4.2 A sample of the MATLAB GUI window

We have 32 signals in the database where, each signal is taken and computed on GUI. We determine whether the signal belongs to Class-1 and Class-2 and compute Energy, Entropy, Standard Deviation and Mean for each.

For example we are loading “S01” as Test signal, the signal is plotted, it’s energy, entropy, standard deviation and mean are calculated. The Test signal is compared with the trained database and is classified as “Belongs to Class1” as shown in Figure4.3. Then the LED bulb glows and Motor is in off state as shown in Figure4.4.

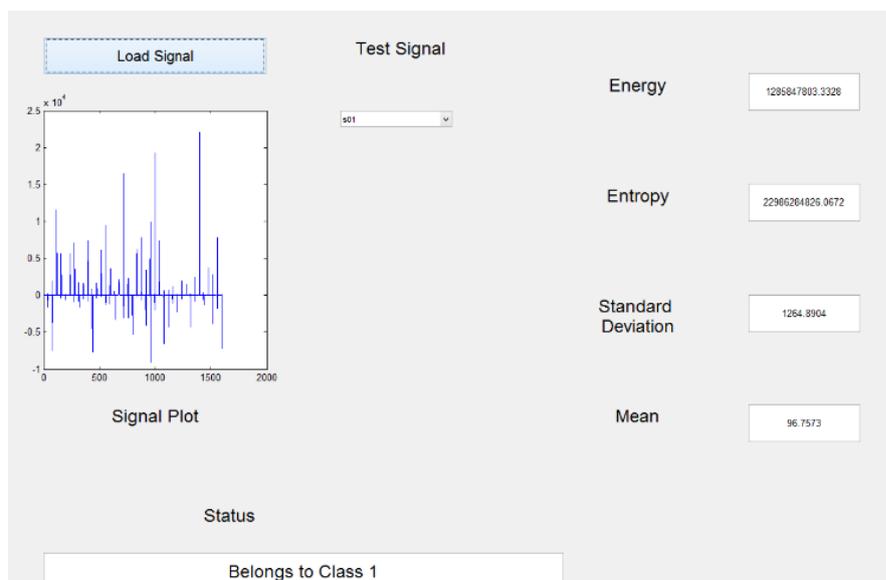


Figure 4.3 Signal “S01” Classified as Class-1

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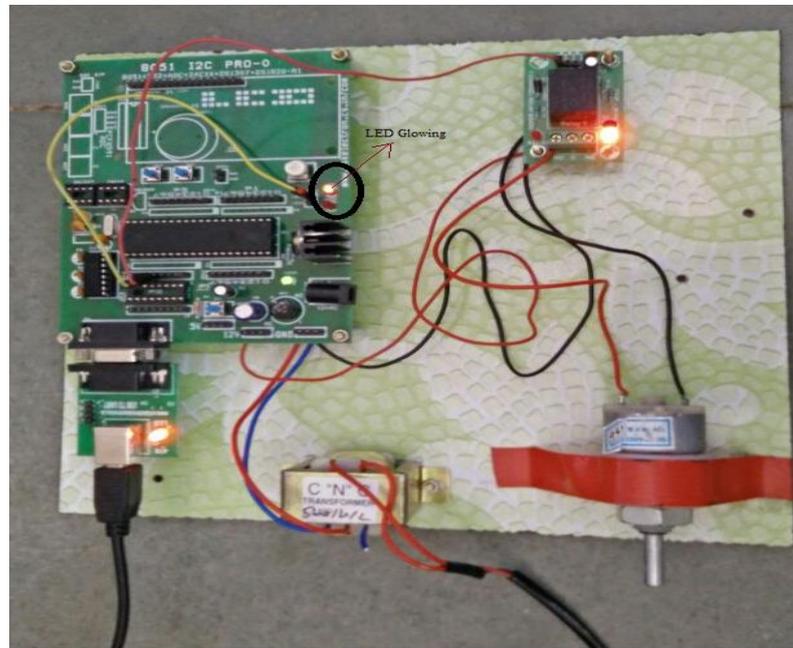


Figure 4.4 class-1: LED is ON and Motor is OFF

Next example we are loading “S16” as Test signal, the signal is plotted, it’s energy, entropy, standard deviation and mean are calculated. The Test signal is compared with the trained database and is classified as “Belongs to Class2” as shown in Figure4.5. Then the LED is switched OFF and Motor rotates as shown in Figure4.6.

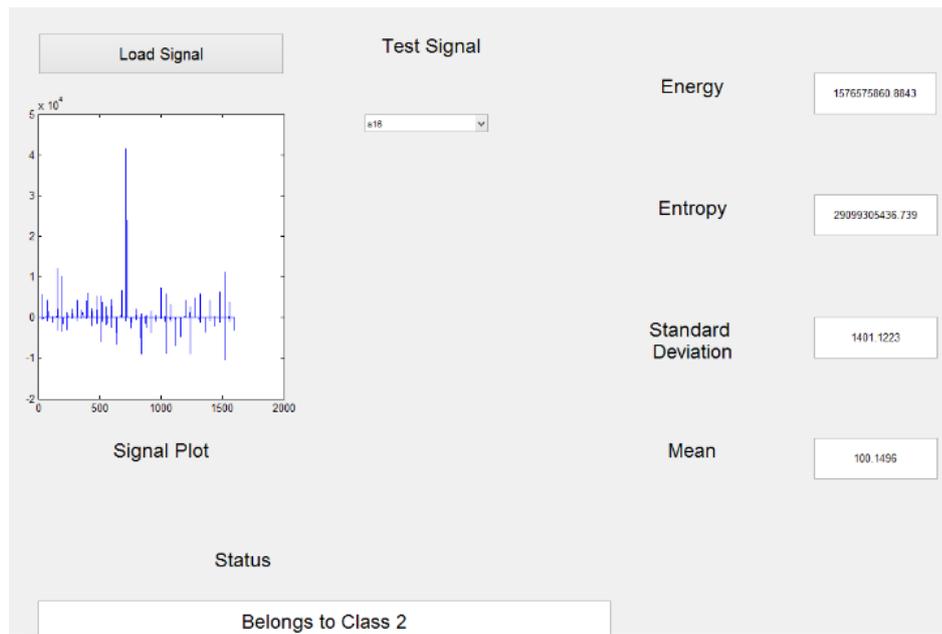


Figure 4.5 Signal “S16” Classified as Class-2

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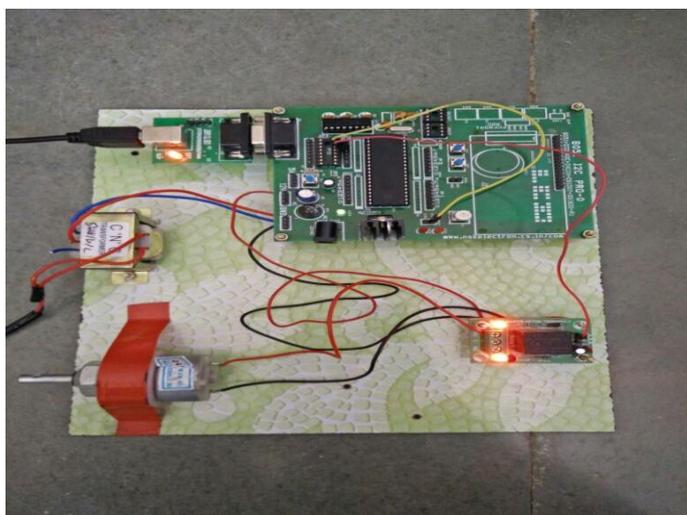


Figure 4.6 Class-2: LED is OFF & Motor is ON

V. CONCLUSION AND FUTURE WORK

BCI is used to assist abnormal patients. Hence in this paper we have implemented a prototype model which can classify into two classes using DWT and KNN classifier. Based on the classifier output, two applications are implemented as discussed in the results. Further, this project can be enhanced by using the real time signals acquired from patients. In this work, we have classified into only 2 classes. Further, more classes states can be classified and more applications can be incorporated.

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