

# Robot Navigation control through EEG Based Signals

*Kale Swapnil T, Mahajan Sadanand P, Rakshe Balu G, Prof. N.K.Bhandari*

Department Of Electronics Engineering Pravara Rural Engineering College, Loni.

## ABSTRACT:

*The Electroencephalogram (EEG) is a biological signal that represents the electrical activity of the brain. Brain potentials have been of scientific interest since the discovery of the Electroencephalogram (EEG). This project develops a brain-computer-interface (BCI) based manmade robot control system with help of MATLAB and FPGA KIT. The system consists of an electroencephalograph (EEG) database and a manmade robot. The control loop includes a brain signals stored database, a robot interface and fpga board. The goal of our study is to control navigation of robot through neural signals acquired by EEG database. When the database having signals of "turn right", "turn left", "move forward", "turn 45 degree", "pick up and pick down" Then the developed control system is a powerful tool to examine relationships between complex manmade robot behaviours and given database signals. Mapping brain activity patterns in external actions has been studied in recent decades and is the base of a brain-computer interface. This type of interface is extremely useful for people with ill health, where one can control robotic systems that support, or even replace, non-functional body members. Part of the studies in this area focuses on non-invasive interfaces, in order to increase the interface usage to a larger number of users without surgical risks. Our results demonstrate that an EEG- data based brain-computer interface can be used for refined robotic interaction with the environment, involving not only navigation But also perform some task.*

**Keyword:** EEG (Electroencephalogram), BCI (Brain computer interface).

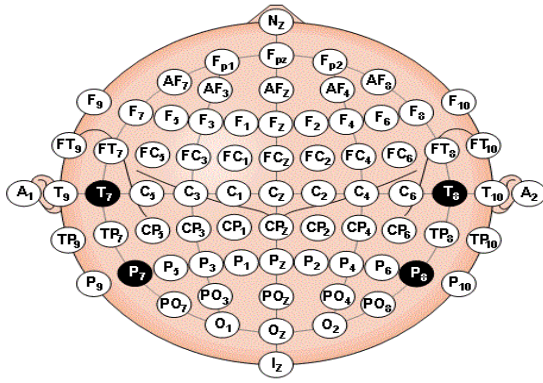
## I. Introduction:

The purpose of this work is to discover the methodology and uses of an expensive and non-invasive brain-computer interface for the control of robotic systems. Traditionally, brain computer interfaces was already discovered in the control of various electrical and mechanical devices, but the brain-computer interfaces that have been considered in the past are very rarely non-invasive. The only non-invasive option for interfacing a brain with a computer is the electroencephalogram, or EEG, which is usually large, and expensive. Additionally EEGs are difficult to find out side of research institutions and require a well-trained person to operate. For these reasons, this work explores the use of the Emotiv EPOC Electroencephalogram, which is a non-invasive brain-computer interface that is also in expensive and commercially available. Shortcomings in this solution of this system are made up for through a novel system of Artificial Intelligence, employing Linear Support Vector Machines to classify the data from the Emotiv EPOC into a set of outputs for a three degree of freedom robotic arm.

## II. EEG Technology:

Normal EEG signals are usually recorded from electrodes placed on the scalp and are often very small in amplitude of order 20  $\mu$ V. The electroencephalogram contains useful analytic information on a variety of neurological disorders. It is a non-invasive method used to measure the electrical activity of human brain. The EEG like all biomedical signals is very subject to a variety of large signal infection or artifacts (signals of other than brain activity) which reduce its usefulness [2]. The Electroencephalogram is a

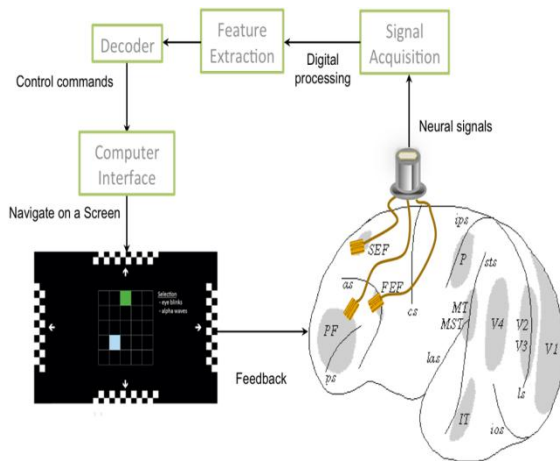
biological signal that represents the Electrical activity of the brain. Artifacts in EEG signals are produced by various factors, like line interference, EOG (electro-oculogram) and ECG (electrocardiogram). The deletion of artifact from scalp EEGs is of significant importance for analysis of basic brainwave activity. The presence of artifacts such as muscle activity, eye blinks, pulse signals and line noise in electroencephalographic recordings confuses the underlying processes. These artifacts sources increase the difficulty in analysing the EEG. For this reason, it is necessary to design a procedure to decrease such artifacts in EEG [4]. EEG signals can be developed using this portable system as well as clinical equipment. In both, scalp electrodes are referred to a linked-ear reference. The portable EEG system has eight scalp electrodes, whereas the clinical system supports 26 scalp electrodes and six non-EEG channels as shown in fig 1. In particular, EMG and EOG signals are measured to confirm the absence of electromyographic activity during the period imagination tasks and to detect ocular artifacts [10].



**Fig.1 The standard electrode placement of an EEG according to the American EEG Society for use in the International 10-20system.**

### III. Brain Computer interface

A Brain Computer Interface (BCI) is a system that gets and examines Electroencephalogram (EEG) signals with the goal of producing a high bandwidth communications channel directly between the brain and the computer which is used to navigate mobile robots. It gives inactivated people a chance to communicate and navigate. BCI hurts with the problems related to modelling and acquisition of EEG signals. All this affects accuracy of the BCI system. Based on the Electro oculogram (EOG) signals, an eye control method serves the same purpose as the BCI. Compared to the EEG, modelling and recording of the EOG signals is far easier. The basic idea of BCI is to translate user made pattern of brain activity into corresponding commands. The basic structure of brain computer interface is shown in following fig.2.



**Fig.2 brain computer interface**

### V. SYSTEM FLOWCHART

A typical BCI is composed of signal acquisition and signal processing (including pre-processing, feature extraction and classification). Though some BCI systems do not include all mechanisms and others group two or three components into one algorithm, most systems can be abstractly divided into signal acquisition, pre-processing, feature extraction, and classification [7].

### IV. Robotic Arm

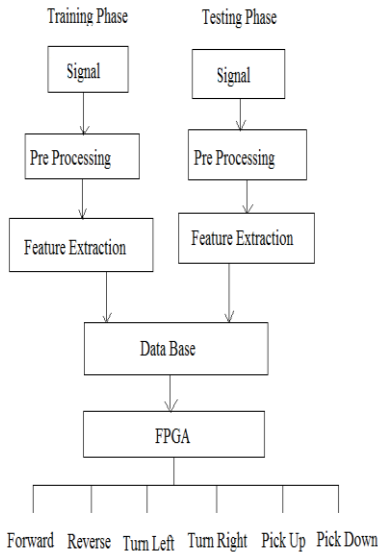
Robotic arm consist of some basic parts that are the arm, fore arm ,body arm and end effect manipulator. There are many different types of robotic arms but basically they are divided into four types these are revolute, polar, cylindrical and Cartesian coordinate. The degrees of freedom or the number of axis classify the type of robot. The area that a robot covers is called the work envelope [8]. The joints and movements of each arm create a different work packet. The number of axis is directly interconnected to the manoeuvrability of a robotic arm.

#### Revolute Coordinate Robot Arm:

The revolute coordinate robot arm is somewhat similar to the human arm and it is able to perform many task as a human arm. But the design of this type of robot is somewhat different from human arm due to the complication of the human shoulder joint. The shoulder of the revolute robot rotates by spinning the arm at its base. The association of the shoulder is done to move the upper arm member back and forth while the elbow joint moves the forearm up and down. This kind of robot is very springy and looks somewhat like a human arm.

#### Polar Coordinate Robot Arm:

The polar coordinate robot arm is very flexible and can comprehension different kinds of objects around the robot. The robot rotates by a phonograph base and the elbow joint is the second degree of freedom and moves the forearm up and down. This robot achieves the third degree of freedom by changing the reach of the forearm. The inner forearm has the job of bringing the gripper close or away from the robot.



**Fig.3 System flowchart**

**A. Signal Pre-processing:**

Signal pre-processing is a first step of given systems in which following two sub process are included which are as follows:

**1. Signal Acquisition**

Electrical activity of the brain is recorded by electrodes over the scalp. Electrodes begin connections between the scalp and EEG recording device by converting ionic current in to electrical current. Electrolytic gels applied between the scalp and the electrodes to stopreduction of the signal. An electrode placement system accepted as international standard called 10-20 System distributed to be able to compare the measurements taken [4].

**2. Filtering:**

Acquired signals are usually having somenoise. The filtering method depends on the type of noisein signal. Various types of interferences in biomedical signals are of different origin. Here we are using the IIR filtering technique for our proposed model or project work.

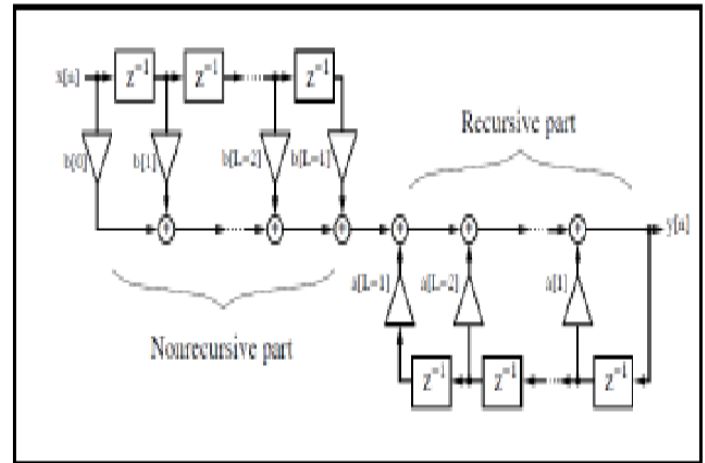
**IIR Filter:**

A non-recursive filter chains, as the name implies, nofeedback. The impulse response of such a filter is finite,

- When a and b are real, the magnitude response  $|H(e^{j\omega})|$  is an even function, and the phase response  $\theta(j\omega)$  is an odd function. Frequently It is suitable for computing and plotting the log magnitude of  $|H(e^{j\omega})|$  as

$$10 \log_{10} |H(e^{j\omega})|^2$$

i.e., it is an FIR filter. A recursive filter, is also having a feedback, and is projected, in general, to have an infinite impulse response, i.e., to be an IIR filter. Figure 4 shows filters with distinct recursive and non-recursive parts



**Fig.4 Recursive and non-recursive parts of filter**

- The transfer function of the IIR filter is given by:

$$H(z) = \frac{\sum_{k=0}^M b(k)z^{-k}}{\sum_{k=0}^N a(k)z^{-k}}; \quad a(0) = 1$$

- Its frequency responses are (where w is the regulated frequency ranging in  $[-\pi, \pi]$ ):

$$|H(e^{j\omega})| = \left\{ \frac{\left[ \sum_{k=0}^M b(k) \cos(k\omega) \right]^2 + \left[ \sum_{k=0}^M b(k) \sin(k\omega) \right]^2}{\left[ \sum_{k=0}^N a(k) \cos(k\omega) \right]^2 + \left[ \sum_{k=0}^N a(k) \sin(k\omega) \right]^2} \right\}^{1/2}$$

$$\theta(j\omega) = -\tan^{-1} \frac{\sum_{k=0}^M b(k) \sin(k\omega)}{\sum_{k=0}^M b(k) \cos(k\omega)} + \tan^{-1} \frac{\sum_{k=0}^N a(k) \sin(k\omega)}{\sum_{k=0}^N a(k) \cos(k\omega)}$$

This is measured in db.

**3. Feature Extraction:**

There are different feature extractions methods like principal component analysis, discrete derivatives, Wavelet Transform and FFT transform. Out of these we are using the principle component analysis method.

**PCA:**

PCA is the mostly used subspace projection technique for face recognition. PCA basis vectors are calculated from a set of training images I. As a first step, the average image in I is

calculated and subtracted from the training images, creating a set of data samples.  $i_1, i_2, \dots, i_n \in \mathbb{R}^1$ . These data samples are then arrayed in a matrix X, with one column per sample image

$$X = \begin{bmatrix} \vdots & & \vdots \\ i_1 & \dots & i_n \\ \vdots & & \vdots \end{bmatrix}$$

$XX^T$  is then the sample covariance matrix for the training images, and the principal components of the covariance matrix are computed by solving

$$R^T(XX^T)R = A,$$

Where A is the diagonal matrix of eigenvalues and R is the matrix of orthonormaleigenvectors. Geometrically, R is a rotation matrix<sup>2</sup> which rotating the original coordinate system onto the eigenvectors, where the eigenvector connected with the largest eigenvalue is the axis of maximum variance, the eigenvector associated with the second largest eigenvalue is the orthogonal axis with the second largest variance, etc. Typically, only the N eigenvectors connected with the largest eigenvalues are used to define the subspace, where N is the preferred subspace dimensionality. There are three related arguments for matching images in the subspace of N eigenvectors. The first is compression. It is computationally more efficient to compare images in subspaces with significantly reduced dimensions. For example, image vectors with 65,536 pixels (256\_256) might be projected into a subspace with only 100–300 dimensions. The second argument assumes that the data samples are drawn from a normal distribution. In this case, axes of large variance probably correspond to signal, while axes of small variance are probably noise. Eliminating these axes therefore improves the accuracy of matching. The third argument depends on a common pre-processing step, in which the mean value is subtracted from every image and the images are scaled to form unit vectors. This projects the images into a subspace where Euclidean distance is inversely proportional to correlation between the source images. As a result, nearest neighbour matching in Eigen space becomes an efficient approximation to image correlation [12].

## VI. Experimental Result:

The following figs shows the experimental result of our work.

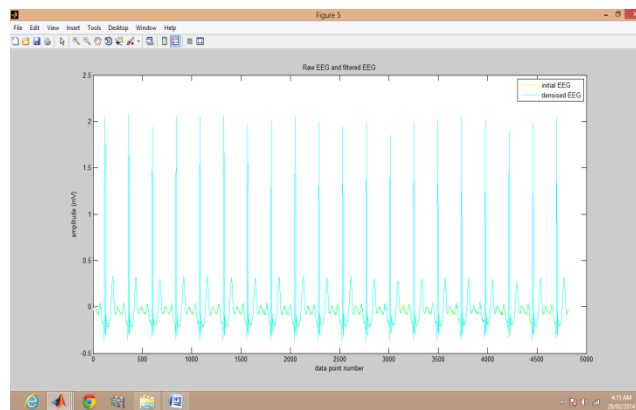


Fig.A

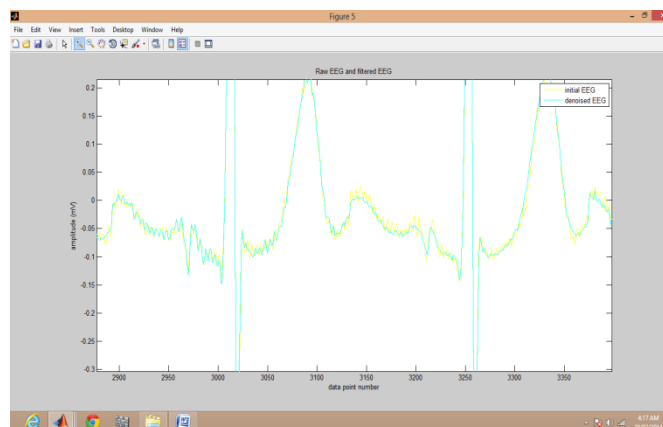


Fig. B

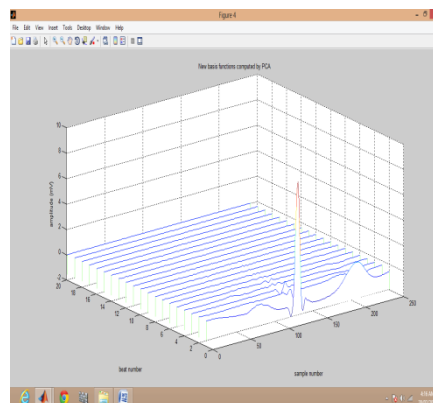


Fig. c

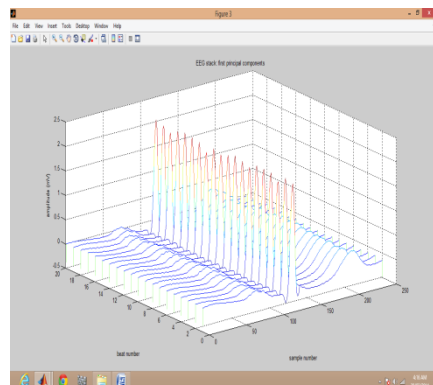


Fig. D

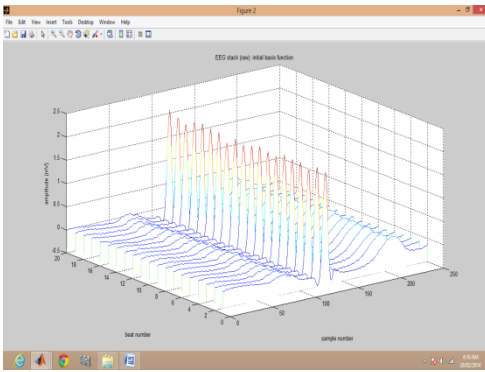


Fig. E

## VII. Conclusion:

Thus we have studied the control of robot navigation through EEG signal database which having signals like turning right, turning left, walking forward, pick up and pick down using the principal component analysis method and it is found that this gives us more accurate result for feature extraction of brain signals. Also it is observed that the accuracy of system model is increased using this PCA technique. To avoid noise in system we have used IIR filter, it eliminates the noise from brain signal and gives us original EEG signals

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Mr. Sadanand P. Mahajan B.E. student, Department of Electronics Engineering, P.R.E.C. LONI, MAHARASHTRA, INDIA.

Prof. N.K. Bhandari, Department of Electronics Engineering, P.R.E.C. LONI, MAHARASHTRA, INDIA.