ISSN: 2277-9655
Impact Factor: 3.785

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

CLASSIFICATION OF EEG SIGNAL DATA USING HYBRID OF NEURO-FUZZY

Pratibha Rana*, Ms. Jyotsna Singh
Under the guidance of Ms. Jyotsna Singh Department of computer science engineering THE NORTHCAP UNIVERSITY, Sector 23A, Gurgaon, Haryana- 122017

DOI: 10.5281/zenodo.51017

ABSTRACT

Brain Computing interface technology represents a very highly growing field now-a-days for the research because of its unique applications system. In this paper we investigate classification methods of mental commands based on EEG data for BCI. The aim of this study is to present the work of training an artificial neural network (ANN) and Neuro-Fuzzy system provided with the data of a few healthy people who are in different mental states thinking about different activities like eating, walking or sleeping etc. It creates a mutual understanding between mind wave signals and the machine or surrounding system. In recent years' applications based on the brain computing interface have gained a rather huge popularity because of its benefits like providing disabled people with a communication and control environment along with different types of movement restorations. It is proving to be revolutionary in the fields of medical and robotics, mind reading and remote communication etc. This paper puts forward the idea of using a classification algorithm based on a new hybrid approach using neural networks and fuzzy logic that can collectively detect and recognize the state of mind. The EEG brain signals tend to change as our mind state changes because of the voltage fluctuations resulting from the ionic currents in the neurons of the Brain. Features are extracted from the raw electroencephalography (EEG) data using data processing technique PPCA (probabilistic principle component analysis) and are fed to the classifier. The features extracted have been used to train the neural network by using the MATLAB toolbox (Bronzino, J. D. 2010). The work carried out here is to be later on compared with the outputs generated by using just a neural networks based classification algorithm.

KEYWORD: Classification, EEG data, Brain Computing Interface, Feature Extraction (PPCA), FIS system, ANFIS toolbox.

INTRODUCTION

Brain Computer Interface (BCI) technology is strong communication tool between the users and electronic systems. It actually does not require anything like external hardware or muscle movement to issue commands and complete the interaction **(J.vanErp et al, 2012).** BCI is now-a-days a very rapidly growing and active field of research. It is becoming essential to understand brainwaves and analyze the EEG signals with the ongoing growth of the BCI applications in computerized tools. Instead of depending on the muscles, BCI directly measures the brain activities associated to the user's intent and translates the recorded activity into a control signal for the BCI application. This translation includes signal acquisition and features extraction. Most BCIs for human subjects usually rely on non-invasive electroencephalogram (EEG) signals; i.e., the electrical brain activity recorded by the electrodes placed on the scalp, user's EEG signals are captured and different signal processing algorithms are applied to translate them into the particular control command. The uses for BCI span various fields but these are primarily developed for severely disabled people to somewhat improve their quality of life. Also it is now finding place in a variety of other fields **(C. Anderson et. Al ,2013**) like robotics, video games, Neuro-marketing:- emotion recognition, computer games, psychology, machine learning and signal processing etc. Many researchers have proposed different systems that depict many emerging uses of BCI.

The increasing success of brain computing interface system is rapidly growing due to a better understanding of the dynamics of brain oscillations that generate EEG signals (**Begum, S. A., & Devi, O. M. 2011)**. In the proposed system supervised classification methods are used to recognize these class patterns of EEG activities. For example,

to learn the mapping of values of EEG data and classes associated to the mental task. From the data mining point of view this is a difficult task due to two main reasons. Firstly, the EEG data acquired is considered noisy and correlated as many electrodes need to be fixed and secondly because of the fact that activity of thousands of neurons generates various types of noise i.e., interference waveforms (artifacts) recorded along with the EEG signal during the recording session. The electrodes conduct voltage potentials as microvolt level signals, and carry them into amplifiers that magnify the signals ten thousand times.

Thus in this paper we also introduce a pre-processing and feature selection method that will be used to extract the features from the dataset. We used PPCA feature extraction which is used to reduce the dimensions of data but does not affect the classification accuracy. Feature selection is always a very important call for any research because it is used to make the project more efficient and fast(**Van Heertum, et. Al 2011).**Also a classifier based on ANN seems to be a very good approach for EEG classification but for the sake of better performance a hybridization of neural networks and fuzzy logic are applied.

- Supervised neural network training supplies the network with inputs and the desired outputs. Response to the input is measured and weights are modified to reduce the difference between actual and desired outputs.
- Including fuzzy logic will make the classification seem closer to the way our Brain thinks. The better the membership functions the better the outcome.

Thus, the contribution of my research can be summarized as mentioned below.

- Signal processing morphological operation used.
- Noise reduction using Gaussian noise.
- Use of PPCA(Probability based principle component analysis) for features selection.
- Two best classification techniques used 1) Neural Network 2) Neuro-Fuzzy Hybrid system (FIS).
- We used Tuebingen, Germany dataset for the research.

EEG DATASET DESCRIPTION

The dataset which is used to interpret our proposed approach is from the available data sets of BCI. The purpose of our BCI model is to evaluate the performance in different features selection and machine learning schemes. In the competition of several machines learning algorithm schemes there are several sites that provide BCI datasets of different types that are publicly available for analysis by research institute/groups worldwide. Each of the given dataset in the above given references is from leading laboratories and is typical in the field of BCI research **(Emanuel Morales-Flores et al (2014)).**

Data is taken from a single healthy subject at the University of Tuebingen, Germany, as described by (K.R. Muller et al, 1991). The given data has been divided into have 5 types of different classes as Eating, walking, sleeping, eyes movement and hand movement. As per the data description provided by the University of Tuebingen this data is recorded and the subject also received visual feedback of his slow potentials. The signal patterns of each movement were recorded by the researchers of the University and it also describes that during every trial, the task to produce cortical negative or positive was visually presented by a highlighted goal.

For Classification, All the provided EEG data is divide into three major parts, Training set (), Test set () and Validation data () in order to find the accuracy of the overall machine learning algorithm. For neural network and Neuro fuzzy system the purpose is to categorize the trials in the test set into the class "0" or class "1" which means Neuro-fuzzy accepts the target matrix as logical only.

METHODOLOGY

To investigate and implement the proposed method publicly available dataset used and MATLAB computing is used for implementation. Principal Component Analysis is used for feature reduction. Classification is carried out using multilayer perceptron with different learning rate and Momentum **(Jung, T. P ET. Al. 2001).**

A. Dataset

For this research we used Dataset of University of Tuebingen, Germany as described by **(KR Muller et al, 1991).** It contains data of 5 different classes **(Van Heertum, et. Al 2011).** Each subject corresponding represents a task, as we

already mentioned; when a person imagines such movements, there are associated changes in the EEG signal data which is event-related. EEG is basically the measurement of the currents that flow during synaptic excitations of dendrites of pyramidal neurons in the cerebral cortex. During different activities by the subject different signal patterns are recorded. Furthermore three dataset files are available for each subject: Training, testing and validation

B. Probability based Principal Component Analysis (PPCA)

Feature extraction and reduction is referring to reducing the multidimensional data spacing mapping into lower dimensional space which is actually required for efficient machine learning. These techniques are usually referred as pre-process to machine learning algorithms for pattern recognition and prediction **(G. Pfurtscheller, 2003)**. The feature data actually play a very important role for the classification, during feature extraction PPCA cuts pre-processing costs and lowers effects of the classification which is actually quite helpful in making good predictions.
Probability based Principal component analysis (PPCA) is an EEG data analyzing method which is used to compress high dimensional data vector sets into low dimensional ones and solve multiclass problems. PCA is derived from many starting points and optimization criteria in order to reduce the dimension of data, the most important data optimization is to them being minimization of mean-square error in data which is compressed, PCA locates the mutual orthogonal point directions in given EEG dataset with max variances as observed by the PCA, and data de-correlation is also done using orthogonal matrix transformations **(Al-Allaf, O. N. 2014).**

PPCA is a common and effective technique for locating or finding patterns in very high dimensional data. According to some of the researches this is the best feature extraction algorithm. The Statistics of a subject which is based on actually how much that you have to analyze with this algorithm the set terms of relationships between individual points in data in the given set. **(E. E. Sutter, 1992)**PCA's goal is data dimensionality reduction while fetching much of variation available in the original data set. PCA is the method of identifying data patterns of high dimension data and expressing it in a way that to highlight both similarities and differences of the given dataset.

C. Classification (Neuro-Fuzzy hybrid approach)

Neuro-Fuzzy hybrid algorithm is a powerful new method for machine learning. This algorithm is powerful because of the fact that two best classification algorithms solve each other's problems in combined hybrid approach **(Lin, C. J et. al 2009).** ANFIS (Adaptive Neural Fuzzy System toolbox) is already available in the MATLAB for such implementations. For Classification we have already divided data into 3 major partsas Training, Testing and validation. We also have to provide a target logical matrix to the system to understand the class group. In case of Hybrid Neuro-Fuzzy we have created appropriate membership function which is nothing but just the conditions which actually give a graphical view of the satisfaction of the user. Multilayer perceptron has been trained in the supervised fashion for correct class classification.**(S. Gao and M. Cheng1992)** Similarly Fuzzy rules (If-Then rules) are also a condition which actually helps the machine to understand the identification of the object for which we are classifying.

RESULT AND DISCUSSION

The multivariate technique Principle Component Analysis (PCA) is applied to samples, and so component scores are subjected to sampling variability (**Kwan, H. K., &Cai, Y. 1994).** It extracts data features through variance maximization. Fig.1 shows the EEG data when PPCA is applied on the selected samples.

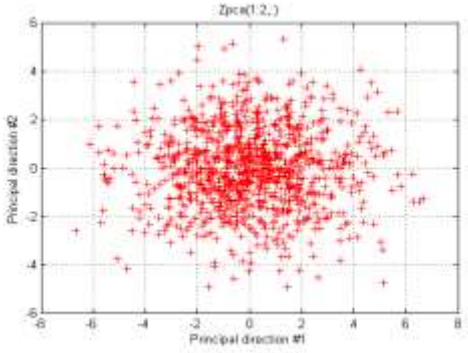

Figure 1: Plot EEG signal data after applying PPCA algorithms

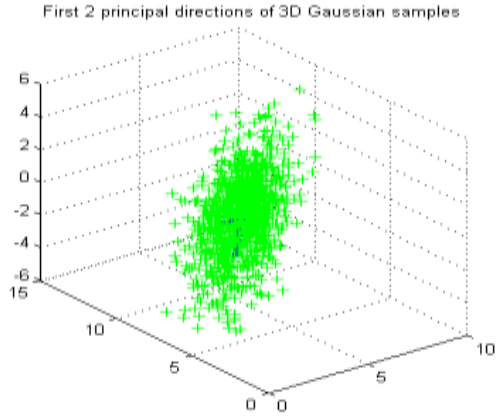

Figure 2: Principal direction of 3D Gaussian Sample

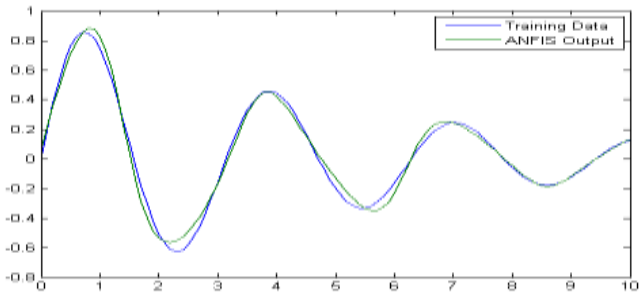

Figure 3: ANFIS data training VS ANFIS output graph

As the comparison graph in Fig.3 depicts the test data or the output data (GREEN) of ANFIS resembles a lot with the training data of ANFIS (BLUE).

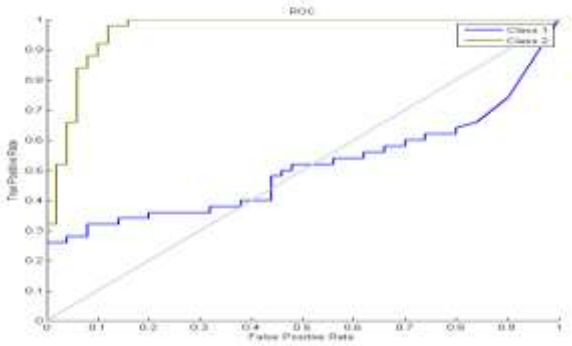

Figure 4: ROC graphical representation of True positive and false positive rate

Receiver operating characteristic (ROC) analysis is an established method of measuring diagnostic performance in medical imaging studies. Traditionally, artificial neural networks (ANN's) have been applied as a classifier to find "best" detection rate.

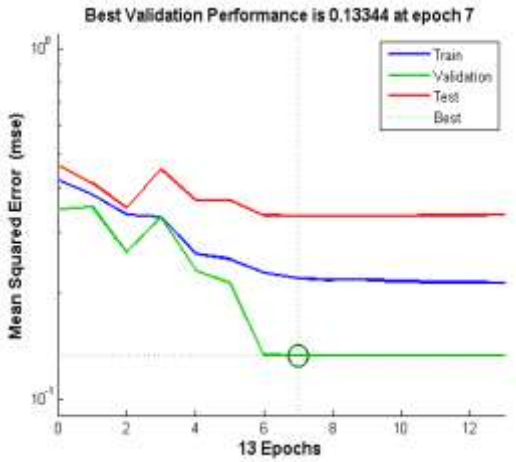

Figure 5: Graph plot between Training, Test, and validation data

In the graph in Fig.5 we try to find the best validation performance which is 0.13444 at epoch 7 represented as (---- green). This graph is explaining how efficiently we have trained our machine.

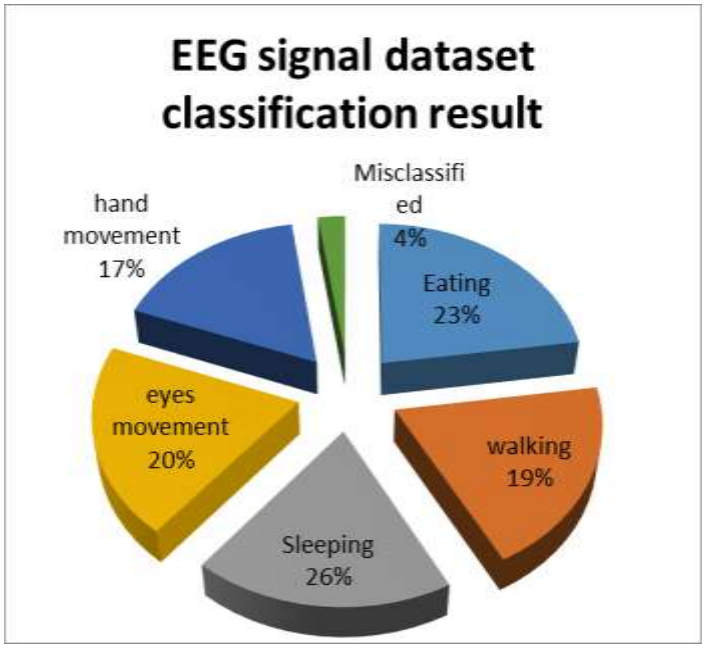

Figure 6: EEG Signal's result after classification

Above graphical representation demonstrates the total classification rate of dataset. In above graph we can observe that hand movement detection is not up to mark as compared to other movements and misclassified data is 2 % which can be solved if we have pure dataset of EEG.

CONCLUSION

In this paper we are trying to implement ANFIS (Adaptive Neural Fuzzy system) which is considered as one of the best classification algorithms. But during our research we observed that not much research has been carried out on this hybrid algorithm with EEG datasets. Neural network is also a very good classification approach in taking decisions while Fuzzy logic is source of knowledge which works on the level of approximation. On combining these two different techniques i.e., human like reasoning style of fuzzy with connectionist structure of neural networks

better outcomes can be achieved. As our project is based on multiclass problem according to this research neural network should not be the only method to solve this practical problem, on the other hand fuzzy logic itself is also not sufficient as it is based on the level of approximation and the membership functions may not always be robust. Such problems in these two classification algorithms put forward the idea to implement a hybrid solution having the power of both these techniques. After using ANFIS hybrid tool on our project we observe that our result is better as compare to any other single algorithm based classification. In this paper we stated that the accuracy to identify multiple class system using Neuro-fuzzy system is 88%. .

REFERENCE

[1] C. Anderson et. Al ,2013 "the fourteen original reports on the human encephalogram"
[2] Bronzino, J. D. 2010, Electroencephalography: Basic Principles, Clinical Applications and Related Fields
[3] Van Heertum, et. Al 2011, "The Principles of Electroencephalography." The biomedical engineering handbook. IEEE transaction.
[4] Nunez, P. L. et. Al 1995." Neocortical dynamics and human EEG rhythms.". (1995). New York;Oxford: Oxford University Press.
[5] Emanuel Morales-Flores et al (2014)"Brain Computing interface development on recurrent neural, Springer international journal
[6] Jung, T. P et. Al."Analysis and visualization of single-trial event-related potentials." Human Brain Mapping, Vol. 14, Iss. 3, pp. 166-185. (2001).
[7] G. Pfurtscheller, " state of the art and clinical applications." Vol. 11, pp. 177-180. (2003).
[8] E. E. Sutter"The brain response interface: Communication through visually-induced electrical brain response." Journal of Microcomputer Applications, Vol. 15,(1992).
[9] B .Graimann,. "Detection of ERP and ERD/ERS patterns in single ECoG channels." IEEE Conference (2003).
[10] S. Gao and M .Cheng "An EEG-based cursor control system." IEEE Conference Proceeding, Vol. 1, pp. 669. (1999).
[11] Zhenjiang, M., &Baozong, Y. (1993). A new analytical method for AM neural networks and its application to pattern recognition. In *Neural Networks, 1993., IEEE International Conference on* (pp. 1570-1575). IEEE.
[12] Lin, C. J., Wang, J. G., & Lee, C. Y. (2009). Pattern recognition using neural-fuzzy networks based on improved particle swam optimization. *Expert Systems with Applications*, *36*(3), 5402-5410.
[13] Zhao, W., Chellappa, R., Phillips, P. J., & Rosenfeld, A. (2003). Face recognition: A literature survey. *ACM computing surveys (CSUR)*, *35*(4), 399-458.
[14] Darwish, S. M., & Mohammed, A. H. (2014). Interval Type-2 Fuzzy Logic to the Treatment of Uncertainty in 2D Face Recognition Systems. *International Journal of Machine Learning and Computing*, *4*(1), 24-30
[15] Begum, S. A., & Devi, O. M. (2011). Fuzzy algorithms for pattern recognition in medical diagnosis. *Assam University Journal of Science and Technology*, *7*(2), 1-12.
[16] Al-Allaf, O. N. (2014). Review of face detection systems based artificial neural networks algorithms. *arXiv preprint arXiv:1404.1292*.
[17] Kwan, H. K., &Cai, Y. (1994). A fuzzy neural network and its application to pattern recognition. *Fuzzy Systems, IEEE Transactions on*, *2*(3), 185-193.