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Detection of Neurological Disorders Using Soft Computing Technique

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***Abstract*— EEG (Electroencephalogram) is recorded and used for detection of neurological disorders. In this paper we proposed soft computing technique for detection of the neurological disorder using feature extraction process, the ANN i.e. artificial neural network and Fuzzy Logic. ICA (Independent Component Analysis) is used as feature extraction technique. The important factor of this whole paper is Real Time EEG signals. The Signals which we have used are recorded in real time from different patients. Then those are used in processing techniques. Real time EEG signals are tough to handle while applying soft computing techniques on then. So it's a bit challenging for detection of neurological disorder.**

KEYWORDS- ICA (INDEPENDENT COMPONENT ANALYSIS), RMS MACHINE AND SOFTWARE, EEG SIGNALS, REAL TIME DATA,BACK PROPAGATION NEURAL NETWORK, FUZZY LOGIC(SUGENO)

I. INTRODUCTION

Now-a-days EEG is the trusted way of detection or acquisition of the brain activity signal, as those are in the form of electrical signals the special type of electrodes are used for detection of these signals. These signals are detected using 32 electrodes which placed on the head of the patient. All these signals are acquired using RMS Machine and RMS software. Here for our research work we used Real Time Acquired data from different patients. The acquisition is done up to 30-35 minutes for getting the more clarification data signals from the patient because there are the possibilities of getting the artifacts within those signals such as movement of leg, hand fingers, etching somewhere while recording the EEG signal, etc. that's the reason that half an hour is the preferred acquisition time by Neuro Physicians.

In this paper we have discussed about the detection process or a system which will detect the neurological disorder. The reason behind making the system is to reduce the load of doctors of detection of disease and giving the report about it. As doctors need to study the 30-35 min recording and then write a report of it.

In the detection process the most important we need to know the features of each disease or disorder we are going to detect. That's the reason we need a feature extractor. Then there may be possible that for same disease some of the features in some patients are different, then those features are also taken into consideration. But just from using the feature extraction process the system will not able to decide that what type of disease it is as there are about 8 types of disorders. For our process we are considering Brain Death, Epileptic Seizure and Normal signals. Capturing all these signals from patients, extracting all the features we need to train them in Artificial Neural Network i.e. ANN. By training the Artificial Neural Network (ANN) will help us to use a learned file which having all the references of the features of the diseases. And hence, as we appear an EEG signal against it, it will give us the name of detected disease by comparing the features detected I the appeared signal and the reference signal.

This is the obvious process of detection of the neurological disorders but as the EEG signals are non-linear there may me some different features may also present which may not detected by the ANN, thus the Fuzzy Logic comes in to picture. Here just for giving more precession to the detection process of the neurological disorders Fuzzy Logic is used.

Let us discuss about all the three processes in detail which are used for making an independent system for getting the best results of Neurological disorders out of it.

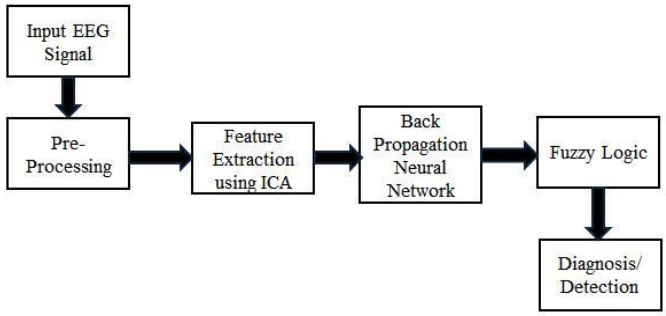


Fig. 1

Above figure shows the proposed block diagram of the complete system. It consist of the pre-processing, then feature extraction, Artificial Neural Network (ANN) and Fuzzy Logic.

II. ACQUISITION AND PRE-PROCESSING

For proper and correct EEG Signal acquisition, the most important thing is the placement of electrodes on the head. The position of electrodes is in 10% - 20 % system between Nasion-Inion points. All these Signals are captures using the RMS Machine and RMS software.

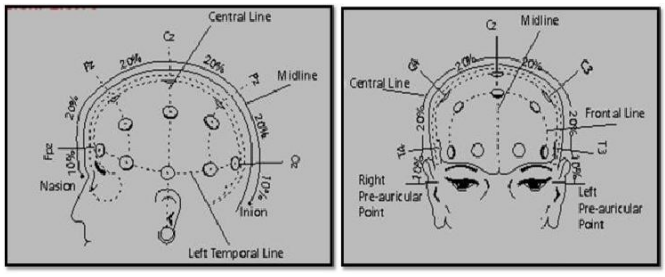


Fig.1

Above image shows that the placement of the Electrodes through which EEG signals are captures from the patients.

For our soft computing technique it is important to do some pre-processes that we have to convert the acquired EEG signal in the format which will be suitable for processing. As we have using the MATLAB as praltform for soft computing that's the reason the signals which are acquires in the RMS maschine has

to be converted into .m files. Then only the further process will be done by using those EEG signals.

III. Feature Extraction

Here we used ICA i.e. Independent Component Analysis for feature extraction process. As already discussed in the paper Feature Extraction process using ICA[13] we are using The basic Bell-Sejnowski ICA algorithm [2] which we feels the best algorithm for feature extraction as Oja & Hyvarinen [3] are also considers ICA as latent variable model.

ICA defined as, method of decomposition it is also known as the Bind-Signal Separation Technique. Basically in the paper[] it was thoroughly discussed about it, that it's a kind of mask for separating the two mixed signals, and the iteration are taken up till the cocktail of the two signals get separated. In each single iteration, some of the features of the signals are extracted and the signals are separated by considering those features.

The Bell-Sejnowski gives the simplest algorithm for extraction of features. As ICA will separate the mixture of the signals in this algorithm, we have decided to mix our EEG signals with a random but known signal. As our EEG signal having 16 channels data, therefore we have to take random signal of 16x16 matrixes. The combination or mixture of these two signals are given to the ICA and it will extract our EEG signals along with that it will provide us the mask using which the EEG signal is separated from our known random signal. This mask we call it as stack of Features of the EEG signal.

ICA has the concept of Blind Signal Separation Technique. To explain this term, here we have an example of cocktail drink. Let's consider that we have a cocktail of two drinks, we want to separate them from each other but we did have the information of the drinks. In such a case we need a standard or any random mask or filter. After first filtration, we've got a bit information about the drinks, the as per the result we need to do some updates or changes in the filter, again after filtration we got some more features again we need to update or do the changes in filter and again do filtration till we get the two drinks separated completely. At the end of all this, we've got the perfect filter or mask which definitely separate those two drinks in future. All the points or components of this mask are known as the Features.

$$\mathbf{W}_{new} = \mathbf{W}_{old} + \eta \left(\mathbf{W}^{-T} - \frac{2}{N} \sum_{t=1}^{N} \tanh(\mathbf{y}^t) \, [\mathbf{x}^t]^T \right)$$

Where,
N - Number of Data points per
Signal 2 – Two Source Signals
x – Mixture of two source signals
y – Estimated Source signal

W*old* – considered as identity matrix for 1st iteration and from 2nd iteration W*new* will be W*old.*

Above formula is working in the background for extracting the features of the EEG signal, which we will further used for the classification and detection of the neurological disorders.

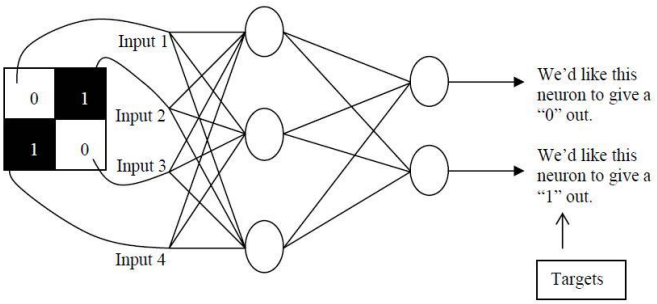
IV. Back-Propagation Neural Network

Back Propagation is the learning and the training algorithm; it will learn itself by examples. You have to give the example to the BPNN of what you want to learn or train, and with the help of that it will update the weights as far as training is concerned. We have selected BPNN as Artificial neural network because BPNN is best for pattern recognition and mapping tasks To train the network we just need to give the examples to the neural network and it will be ready to find out the output we want i.e. we can call it as TARGET pattern or result.

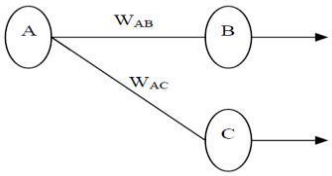
As soon as the training of the ANN is done, then it will be ready for giving the desired output as we train it to give Targeted Output.

The ANN is initiated by setting up all the weights to be random numbers may be between –1 to +1. Then input patterns are applied & output will be calculated. This is called Forward Pass. The calculation of Forward Pass i.e. an output which will be completely different than what we want i.e. Target as the weights are in random manner. Then the ANN calculates the Error given or calculated by each neuron as compared to the desired target which is our Actual Output. This error will used to calculate mathematically to change the weights in such a way that the error will get reduced. In other words, the Output of neuron will reach closer and closer to its Target. This is called the reverse pass. The complete process will be repeated till the error gets minimized.

Hence, the process of Neural Network is known as Back Propagation.



The above figure gives the brief idea about the working of the back propagation neural network. The inputs are connected with the hidden layer neurons and they are further connected with the output i.e. target, and the paths are the paths through they start weight updating and comparing in the forward pass and reverse pass direction.



The above figure shows the weight updates in the back propagation neural network. The Connections we are interested in between neuron A and B and their weight updation procedures which is shon in the diagram is exactly the way it is just discussed above.

V. SUGENO FUZZY MODEL

There are two fuzzy models are present i.e. Mamdani & Sugeno, but we are considering the [11] Sugeno fuzzy model for our work. As the Mamdani model is based on the MAX values of the assigned inputs as in that it won't consider the value or the input having the MIN value and directly gives the result. Hence, we are using the Sugeno Fuzzy Model.

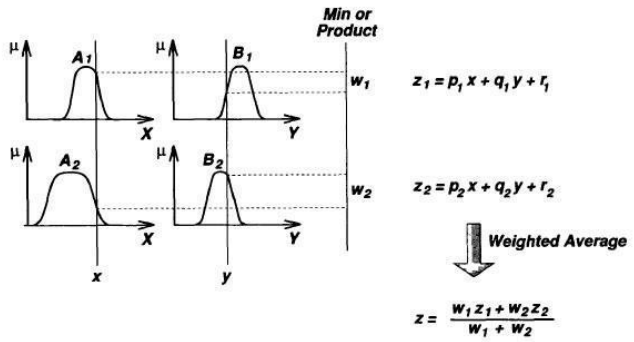
Sugeno Fuzzy Model has developed for systematic approach to generate fuzzy rule based resuts from a given inputs and expected output datasets. A typical Fuzzy Rule in Sugeno Fuzzy Model is given by –

$$if\ x\ is\ A\ and\ y\ is\ B\ then\ z = f(x,y)$$

Where A & B are Fuzzy sets.

While z = f(x,y)- is acrisp function, usually it is a polynomial using the input variables. It may any fuction as far as it should properly described. The output of the Sugeno fuzzy model is completely based on the disrobed or predefined rule sets. This we can called as First order Fuzzy Model. When F is constant then it is called as Zero orcer Fuzzy Model. This is called as the special case function in which reach rule's is specified by a Membership Function. Moreover the zero order Sufeno fuzzy model is also can call or equivalent to the radial baisi function.

The output of zero order models is smooth function of input variables as far as the neighboring Membership Functions in the antecedents have enough overlaps. In other words the overlap the membership functions in the Mamdani Model does not have a decisive effect on the smoothness. It is the overlap of the antecedents of membership functions depending upon the input and the output behavior.



The figure shows the reasoning procedure for the first order fuzzy model. Since, each rule has a crisp output, the overall output is obtained using weighted averaging, just for avoiding the time consumption of defuzzification which required in the Mamdani Model.

In actual practice, the weighted average is replaced by the weighted sum of the operators i.e.

$$z = w1z1+w2z2$$

To reduce the computational error especially for the training of fuzzy system. This simplification can lead to the loss of Membership functions linguistic meanings unless the sum of the firing strengths will close to unity and the fuzzy part of the Sugeno is only depends upon the antecedents, which is easy to demonstrate and the sitting between the set of fuzzy rules set up for the inputs given.

VI. CONCLUSION

Thus in this way, we have constructed an algorithm for for detection of neurological disorders. It's Also observed that the efficiency depends upon fuzzy outputs, as the neural network gives importance to the highest features only but the fuzzy will fives the equal value using the comparisons and the rule based model. As we found that the ICA is one or the good ways to find out or extraction of features as the EG signals are nonlinear and uncertain.

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