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Electroencephalogram Signalling diagnosis using Softcomputing

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Abstract— The two most frightening things for the researchers in clinical signal processing and computer aided diagnosis are noise and relativity of human judgment. The researchers made effort to overcome these two challenges by using various soft computing approaches. In this article the present benefits of these approaches in the accomplishment of the analysis of electroencephalogram (EEG) is acknowledge. There is also the presentation of the significance of several trend and prospects of further softcomputing methods that can produce better results in signal processing of EEG. Medical experts apply the different softcomputing techniques for disease diagnoses and decision making systems performed on brain actions and modeling of neural impulses of the human encephalon.

Keywords*-Artificial Neural Network (ANN), electroencephalogram (EEG) and Adaptive Neurofuzzy Inference System (ANFIS).*

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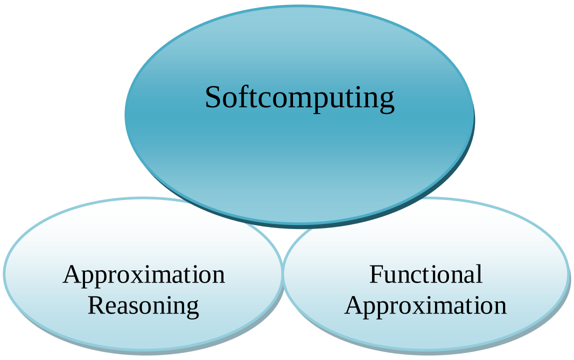
I. INTRODUCTION

1. Softcomputing

Softcomputing approaches based on the information processing of scientific systems. These are then enormous used in the field of making prediction and pattern matching. It uses different logics and methods which attempt to remove the problems which arise in real world problem when there is imprecision , uncertainity and difficult to categorize. Softcomputing is a wide range of approaches and treat as a family so that real practical problem can be solved in the same manner as solved by the human brain..

The advancement in the value of softcomputing is due to its features used in the different fields. Soft-computing could be described as a assemblage of computing approaches which performs collectively and determines, in one way or another, manageable information refinement efficiency for resolving any other way complicated actual life troubles The capacity of these approaches to largely reduce ambiquous actual life scenarios have been tested. Artificial Neural Network (ANN), which is a extensive association of artificial neurons operating jointly to imitate the information procedure of the human cerebral. It is treated as a problem resolution technique which consists of two parts i.e. approximation reasoning and functional approximation.



Fuzzy Inference Systems (FIS) which engages a logic without a crunchy limit and signifies variables in terms of apprehensible human acceptable terminologies, Genetic Algorithms (GA) Particle Swarm Optimization (PSO), Artificial Fish Swarm Optimization (AFSO), Adaptive Neurofuzzy Inference System (ANFIS) and flourishing variety of hybrid methods. These approaches attempt to tackle the capacity of parallel data processing and power to handle non-crisp logic to propose solution to a large range of daily problems and applications. The advantages of these softcomputing techniques are multitudious; efficient and best optimization procedures, non-continuous and parallel facts method, efficient input selection and feature extraction, cost-effectiveness, less difficult and precise modeling of large datasets and capacity to simultaneously handle sensation diagnosis . Other pros of softcomputing may inculcates the merging of large datasets with training network simultaneously over different computing nodes, precise predictive capacity and power to guide scientific decision making. Other merits of softcomputing techniques include their capacity to include human linguistic variables into mathematical, thereby making it best for developers .

Due to their plentiful advantages over traditional programming techniques and extensive variety of possible applications, softcomputing approach have found extensive series of applications in the medical domain.

In the vicinity of medical signal investigation, Artificial Neural Network has been applied for compression and filtering of biomedical signals with high precision. Hybrid softcomputing techniques merges the different techniques to get the purposeful output. These are on the top in medical applications. These techniques performs individually and gives best results, they have been analyse to achieve even hardly better when combined in some applications. The merging of techniques helps the developers to produce accurate results within their specific time period . For instance, in a Hybrid Expert System (HES) , employed in cardiology in which the hidden layers and different number of neurons of an Artificial

Neural Network were optimized by using Genetic Algorithm. In the same manner, with the use of hybrid systems, ECG signal was investigate for abnormalities detection using a combination of multi-resolution wavelet transform and Artificial Neural Network .

2. Electroencephalogram

Electroencephalogram is a device that represents the neural actions of the human brain electrically . EEG make it easier to govern , segregate and identify the problem of various brain conditions in a nondevastating, advanced manner with the help of electrodes attached to the scalp. It incorporates to identify the problem and monitoring of coma, epilepsy, brain-death, injuries or defects that affect the structure or function of the brain, and other diseases. EEG is also helpful in the examination of the level of mental attentiveness besides detecting brain tumour.

In the beginning of 19th century , the foremost outstanding electroencephalogram(EEG) signals was accounted for the human scalp by the German scientist Hans Berger while registering computable traces of the neural actions which took place in the human brain. The profound perception of the efficiency of the human brain helped in the enhancement of EEG signal processing.

The function of Brain hinged on the connections of brain neurons . These neurons are linked in divergent circuit as well as in convergent circuit. The divergent circuit comprises the presynthetic neuron whose axon is connected with the dendrite of postsynaptic Neuron. However in the convergent circuit various presynaptic neurons outcross the dendrite(s) of one postsynaptic neuron merely.

The production of Excitatory Post-Synaptic Potentials (EPSPs) at the apical dendrite trees of pyramidal neurons results in the development of human scalp electroencephalogram .These momentary depolarization takes place due to the potential which develops when the neurons are excited by the inputs at their apical dentrites. The subsequent current that runs across the volume conductor is attained due to the potential gradient from the neuron cell body membrane to the basal dendrites to the apical dendritic trees. The current is categorized into intracellular or extracellular . Current based on the current flow path which helps in the depiction of EEG.

This work therefore investigates the chief effect of several softcomputing techniques on the precision and enhancement of electroencephalogram and suggests workable adjustments to the prevailing systems for more desirable productivity. In the field of biomedical signal processing , the utility of softcomputing and expert system is recommended.

II. PRESENT DAY OBSTACLES IN EEG SIGNAL PROCESSING

To locate active neural signals by the processing of EEG data in a complicated endevour. It comprises various steps: refinement of signal-to-noise ratio; dividing several structures from anatomical MRIs; mathematical result of the electromagnetic forward problem; an explanation to the strenous electromagnetic inverse problem; and suitable management of multiple statistical corrections spanning space, time, and frequency over experimental essentials and associations groups of subjects . The most essential tool for diagnosis of various brain conditions is the EEG .But this tool also face the problems encountered by any typical electrical signal systems that is noise. The voltage variations of even in microvolt affects the working of EEG. That's why besides the voltages from the human scalp, signals produced by the activities of various body parts which are non-evidential of the brain conditions are also accomplished. These undesirable Electroencephalogram signals are called artifacts - ocular (EOG) or muscular (EMG) or a combination of both. These signals include the signal produce due to eye movement or movement of associated muscles. While the interpretation of signals or during computer analysis, These noises are the cause of miscalculations. There is a noteworthy spectral similarity between the artifacts which spread across the scalp with the pathological scalp EEG signals making traditional techniques appropriate (Figure 1 and Figure 2). This seriously poses significant challenge in the manner that precise analysis becomes troublesome.

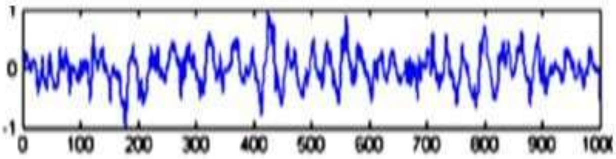


Figure 1 Standard EEG signal

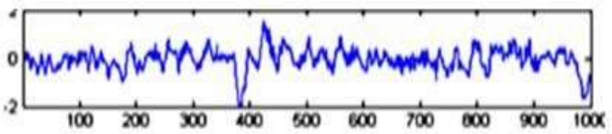


Figure 2 An EEG signal contaminated with artifacts

That's why elimination of these artifacts is essential in the search for strengthen signal depiction and upgraded pathological diagnosis of cerebral states and conditions.

Furthermore, maximum recorded predictive works on biological signal are based on the execution of logistic regression or discriminate function that categories individuals into exclusive groups based on linear aggregations of the absolute variables that enhance the possibility of maximal difference of subjects into groups. In scientific studies several variables may be mutually dependent and the alternative process employed in logistic regression and discriminate function analyses generally forces some variables out of the equation. This process may compromise the revealing dynamism of the analysis and bring to less authentic case ordering. To date, no one at all of the published models have accomplished the high degree of a precision important for this utility. Thus, the multivariate statistical models usually deficient the specificity required for application in scientific decision making (luki *et al*., 2012). The necessity for the making of further capable predictive models in biomedical signal analysis and computer supported diagnosis consequently remains crucial.

III. ARTIFICIAL NEURAL NETWORKS FOR ARTIFACT REMOVAL

An artificial neural network also called a "neural network" is an interconnected group of artificial neurons that uses a computational model for information processing which are based on a connectionist approach to computation. It is a computational model based on the structure and functions of biological neural networks. Artificial Neural Networks (ANN) works as an alternative technique to classical statistical techniques, an example of such application is the design and implementation of an ANN-based event classifier to classify different neural events in the collected EEG signals. Neural networks are parallel, dispersed, adaptive information-processing systems that develop their performance in response to disclosure of data. ANN models use artificial intelligent networks solve different types of problems. Their classification, pattern recognition, and prediction capabilities allowed to solve problems that are very difficult and impossible to solve by standard and classical methods. ANNs is used in wide range of applications in numerous fields due to its different capabilities.

ANN is interconnected by nodes and these nodes have some weights. The weights which are associated with nodes specify the strength and weakness of the connection. Complexity of the interconnections of neurons determine the effective computational power of the network.

Artificial Neural Networks (ANNs) have strong prediction effectiveness because of their best pattern matching ability. Generally, ANNs operates by creating connections between many different processing elements, Each analogous to single neuron in a biological brain. These neurons may be physically constructed or simulated by digital computer. Each neuron takes many input signals then based on their weights, produces a single output signal that's typically send as input to another neuron. ANNs includes neurons which are connected through adaptable weights .These weights are adjusted repeatedly during the training phase in order to take a set of network weights which help the models the problem at hand. The neurons are tightly interconnected and organized in different layers .the input layer receives the input and output layers produces the final output. There are some hidden layers which are sandwiched in between the two layers. The predictive power of these networks has been inspected using a feed forward ANN and backpropagation learning algorithm

Different types of algorithms were discovered over the last decade. These algorithms have their own advantages as well as disadvantages but all were developed for the improvement of the performance of the artificial neural networks. The best results are produced by the resilient backpropagation algorithm(RP). It includes RP function which analyze weight and bias values. RP algorithm can be applied successfully when the network must fulfill all the requirements like having a transfer function that has derivative functions. RP algorithm has many advantages over other algorithms. It is faster and requires modest amount of memory than the Gradient Descent Algorithm (GDA). This algorithm includes a direct adaptation of weights as suggested by the local gradient trend. The characterize advantage of the RP algorithm is its capacity to remove the pitfall of being trapped by the gradient behaviour because it deals only with the direction of the partial derivative and not the size.

In the resilient backpropagation algorithm, the adaptation procedure works as follows: if there is a change in the sign of the partial derivative of a weight , it denotes that latest update has been too large and that the algorithm has arise over a local minimum, If the sign of the derivative remains the same then the weight-update is little bit increment so as to speed up convergence of the algorithm over shallow regions. After the determination of weight- update value , updating the weight follows the following rule: there is decrement by weight-update if there is a positive error (that is, a positive derivative) and there is increment by weight-update if the error is negative

These advancements have been distinct in the aspect of optimized architecture, optimized training epoch less training time, enhancement in sensitivity as well as overall achievement of the networks. Cerebral palsy in infants with central coordination disturbance can be predicted with the help of artificial neural networks (ANNs)

In other research like ANNs, artifact detection was enhanced significantly when radial basis function network (RBFN) was trained with various artifacts features as training data.

ANNs is a process information to presenting way of human brains, does the network is composed of large number of highly interconnected processing elements working in product to solve a specific problem and difficult task. Biomedical signals are analyzed and processed parallel with the help of ANNs. Features of interest in such signals could be extracted (Figure 3) and give as inputs into the input layer of an ANN, depending on the weights, threshold and firing strength, these signals are propagated as inputs to other layers and the training could be repeated until the signal feature selection have been satisfactorily modeled with the help of the selected algorithm.

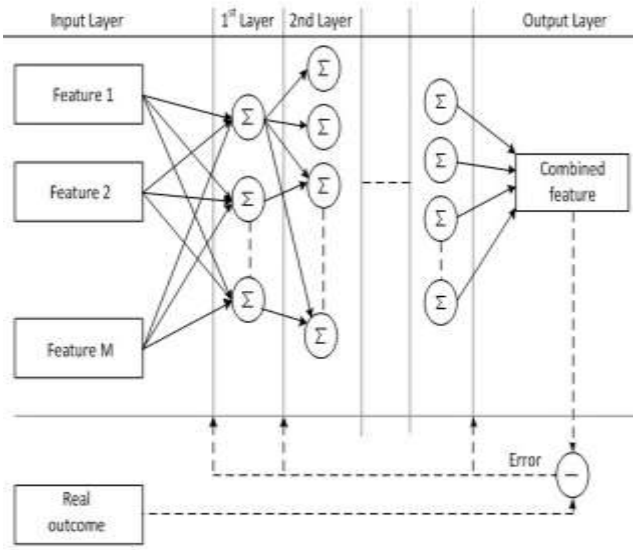


Figure 3 The Artificial Neural Network framework for feature selection of biomedical signals (Neurauter *et al.*, 2007)

The study of extensive literature review and deep analysis of the abilities of ANNs, the ANN framework of Figure 4 has been designed for the analysis of electroencephalogram signal. The entire acquired database is segmented into training and testing database.

Pre-processed EEG training dataset is used for required features.The Layer Sensitivity Based (LSB) algorithm is used for the desighning of feedforward ANN. The pros of LSB ANN algorithm are

- less calculation overhead
- reduction in network training time
- layer-by-layer sensitivity analysis of the network.

The achievement of the deployed network is then checked using appropriate performance index with respect to the separated testing dataset.

IV. FUZZY LOGIC BASED SYSTEMS FOR ARTIFACTS REMOVAL

The critical task is to design and implementation of competent and adequate computerized processes for most medical systems. The unexpected results occur from the existence of uncertainties in modeling, measurement and instrumentation. There exist some techniques which are used for tackling these challenges are the Fuzzy Inference Systems (FIS) and other fuzzy-based hybrid systems. Researchers take full advantage of the techniques provided by these systems in the field medical systems. Fuzzy inference system is including satisfying the requirements of some objects, medical systems, signals without any other operands of mathematical relationship between variables.

Artifact from EEG signals can be removed from a new technique called Adaptive Noise Cancellation (ANC). This approach merges ANC with ANFIS. Adaptive Neurofuzzy Inference System is a hybrid soft computing technique which merges ANC and ANFIS. It combines the excellent pattern matching and learning capability of ANNs with Fuzzy Logic and also divides its functions into five major levels. ANFIS could be readily programmed from MATLAB command prompt. Different Available soft computing techniques are not only used in ANN and Fuzzy systems but also used in different levels of signal processing task but not limited to Particle Swarm Optimization (PSO), Artificial Fish Swarm Optimization (AFSO) (Neshat *et al.*, 2012), and Artificial Bee Colony (ABC) (Yaghini, 2012), (Chen, *et al.*, 2011) optimization. These are processes which provide solutions to difficult and optimized problems by applying the natural principle of organism survival. Genetic Algorithm (GA) and its hybrid techniques which employ the biological principles of generational offspring's and mutation are also applicable (Mitra *et al.,* 2006; Dhiman & Saini, 2014; Furtado et al., 2014; Gil, 2012).

The output of some capable techniques, including some of the ones analyzed thus far for artifact removal in relation of Signal-to-Noise Ratio (SNR) and EEG signal analysis are shown in Figure 5 and Figure 6. These consists Recursive Least Square (RLS) Wavelet transform, Adaptive Linear Neuron(ADALINE) and ANFIS.

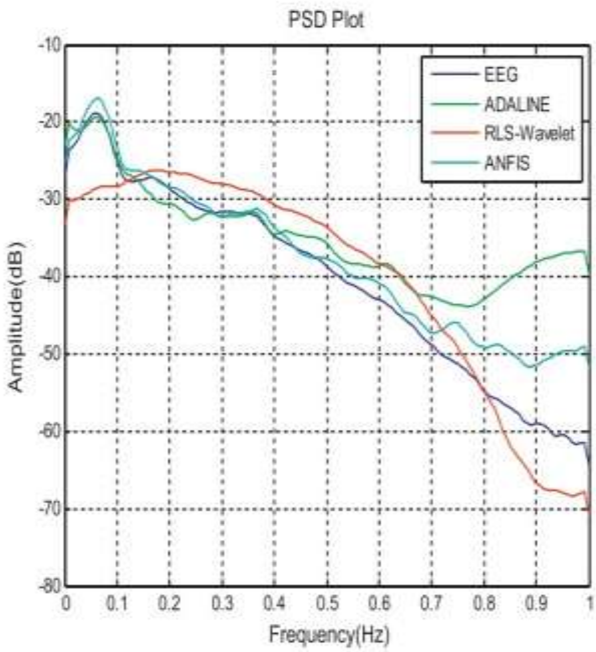


Figure 5 A comparisons of the performances of the techniques for EOG artifact removal (Priyadharsini & Rajan, 2012)

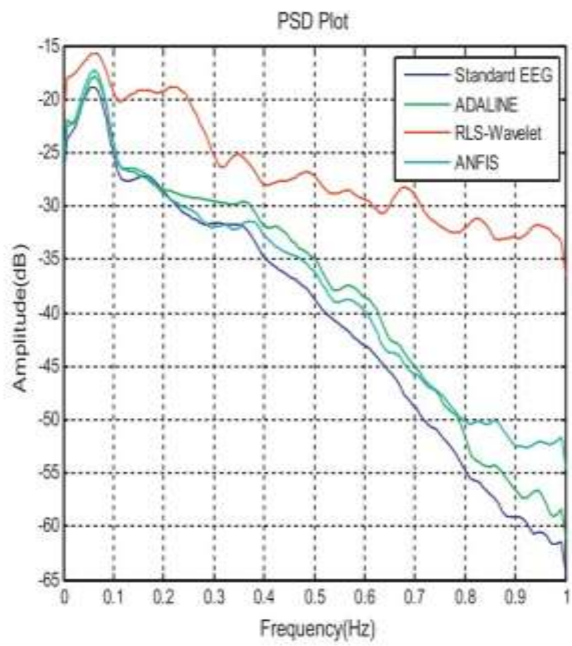


Figure 6 Comparison of the performances of different techniques for EOG and EMG artifact removal (Priyadharsini & Rajan, 2012)

Different types of artifacts can be removed by the best pattern matching ability of the ADALINE and Adaptive Inference System(ANFIS).ADALINE and ANFIS techniques performs best as compare to the RLS-Wavelet.

The advantages of these systems make sure they remain of good interest to researchers. They help in eliminating several human factors in interpretation of results, in addition to the relative ease of re-trainability of many of these softcomputing techniques.

V. CONCLUSION

The examined challenges in the diagnosis of electrical signal, there have been comprehensive reports on the developing impacts of softcomputing techniques in signal clarifying, designing and investigation. Analysis of electroencephalogram is not an exclusion to this direction and in this effort, we have been able to calculate several of these techniques and modeling different levels of a proposed neural network for removal of EEG artifact. Even though it is distinct that soft computing approaches still have a wide concept to go markedly in the aspect of EEG signal analysis and removal of undesirable signals, the positive anticipation that these advents offer remain fascinating

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