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Efficient Removal of Artifacts from EEG SIGNAL Using Enhanced Hybrid Learning Method

B. Paulchamy

Department of Electronics and Communication Engineering, Hindusthan Institute of Technology, Coimbatore, Tamil Nadu, India

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ABSTRACT In this paper, the analysis and removal of artifacts is done by the proposed technique. Normally, ECG is one of the components of artifacts source and EEG is mixed by various artifacts and affects the electroencephalographic data. For further clinical analysis the data preparation is important to minimize the artifacts. In proposed method, Improved Adaptive Neuro-Fuzzy Inference System (IANFIS) and Improved ANFIS-Particle Swarm Optimization (IANFIS-PSO) algorithms are used to separate the signals of ECG and EEG for eliminating artifacts and to intensify the estimation of EEG signal quality. The pre-processing is done by ennobled quantum based genetic algorithm for fast process of optimization and removal of noise interference. The simulation result shows the improvement in Signal-to-Noise Ratio (SNR), minimum Mean-Square Error (MSE) along with the Power Spectrum Density (PSD) plot, which are used to measure the performance comparison of proposed with existing algorithm. The prospective method performs with more appropriate process of enhanced hybrid learning method and outperforms in minimizing the artifacts of ECG from the corrupted signals of EEG.

INTRODUCTION

In developing the environment, the advanced technology plays an important role in all fields. In medical line, recording of human body electric potentials and detecting the implantable system is done by using the advanced technology. Electrocardiogram or Electromyogram recording is used to monitor the activities of brain by detecting the location (Ravi and Suma 2016). The signal bandwidth is varied for both ECG and EMG from tens to hertz or kilo-hertz while the site of recording is small with amplitude voltage less or in mill-volts. The extracted signal magnitude is based on various factors like signal level activity, electrode type, contact impedance and electrode placement. These would vary as per time according to the patients. Generally high gain is required to ensure the signal-to-noise ratio throughout the cascade of signal processing management (Pavithra 2016). The automatic adjustment of gain in amplifier is necessary for condition matching during recording time. The conventional method is used to perform the variation process of gain.

In signal processing, the detection of disorder and status of sleep is obtained by the standard technique of Polysomnography (PSG) analysis (Princy 2015). In order to procure the knowledge of various functions of corporal, the performances of the biological signals are analyzed. By including the signals like electromyogram, electroencephalogram, abdominal and thoracic breathings, oronasal airflow, electrocardiogram, oxygen saturation, electro-oculogram, blood pressure and other biomedical records are used to analyze the signals to detect the status of health (Umera Banu et al. 2016). To observe the activity of brain, Electroencephalography (EEG) tool is used. By this tool the performance of detecting the localization and resolution of time are considered apparent, easy accessible, prostrate and prominent in performances. In clinical work this signal is used widely and have small signal-to-noise ratio. The normal signal waveform of EEG is shown in Figure 1.

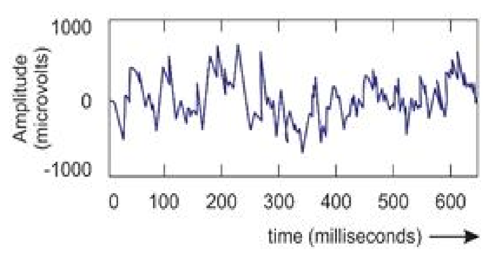

Fig. 1. EEG signal waveform
Source: Author

Usually EEG signal is used to detect the rhythms neural which are affected by the source of noise and biological signals. According to the process of EEG signal the sources are analyzed and the clinical information is obtained. The analysis will become difficult when the source of noise increases. In frequency and time domain the techniques are developed in order to remove artifacts. By filtering, the common noises are removed which are present in the recorded signal (Serteyn et al. 2015). Figure 2 shows the flow work of removing noise from the signal.

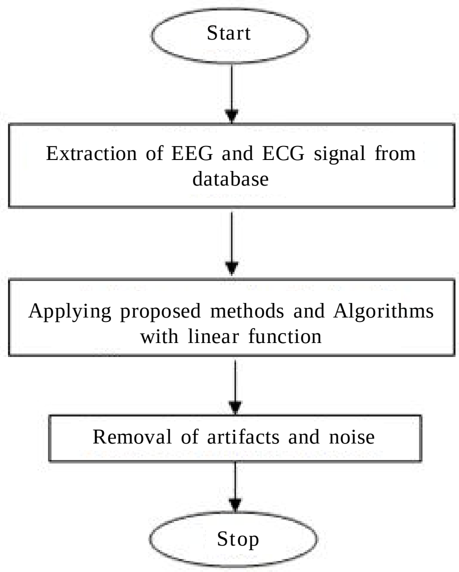

Fig. 2. Noise removal flow work
Source: Author

In this paper, the removal of artifacts is done by using the proposed method and algorithm. By the proposed method the EEG and ECG signals are separated. The functions are trained and initialized to extract the signals by using IANFIS-PSO algorithm. The rest of the paper is organized section wise. In section II the literature review of ECG and EEG extraction is discussed. In section III the explanation of proposed method and algorithm is presented. The simulation result of the proposed technique is illustrated in section IV. Finally the conclusion and future work are presented in section V.

MATERIAL AND METHODS

The removal of artifacts and the analysis of signals are discussed in this section. Electroencephalogram (EEG) is an electrical activity recording and improved to proceed with the cerebral signal recording. The unwanted signals, generated when recording activities are called artifacts. The analysis of signal is affected by artifacts and in order to reduce artifacts, hybrid learning algorithm is implemented based on Adaptive Neuro-Fuzzy Inference System (ANFIS). By Particle Swarm Optimization (PSO) algorithm the process of extracting is performed with the analysis of signal (Priyadharshini and Edward 2014). During the recording of EEG the sources of noise is reduced by those techniques (Reddy and Narava 2013). The structure of ANFIS is shown in Figure 3.

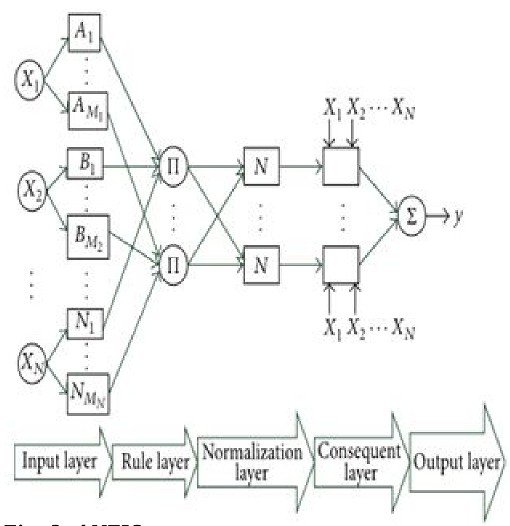

Fig. 3. ANFIS structure
Source: Author

The changes of activities with various parameters are recorded, based on signal EEG inside and outside the environment. Event related potential is used to generate the informative signals from the device and it is made more informative by using mathematical tool. Every change is based on the data of ERP. In order to generate signal processing the biomedical engineering ERP and EEG is used for analysis and pre-process by using soft computing tools (Tandle and Jog 2015).

Based on adaptive filter of cascade, the EEG signal artifact is removed by the Least Mean Square (LMS) algorithm. The filter function is used to cancel EOG spikes, line interference elimination and ECG artifacts removal. For reduction Finite Impulse Response (FIR) filter is presented in EEG signals (Roy and Shukla 2015). The reduction of noise factors is based on Adaptive Linear Neural Networks (ADALINE) and wavelet transformation in EEG signals (Zhang et al. 2015).

The efficiency of the ECG monitoring is significantly damaged by artifacts movement, which causes unsuitable treatment or false alarm triggers and misdiagnoses. However, noise separation from bio-signal is challenging because of overlapping frequency spectrum. As per the removal technique of artifacts, motion using accelerometer helps to monitor ECG and tele-homecare (Reyes et al. 2014; Al-Qazzaz et al. 2015).

To reduce interference common mode, the microcontroller operates the automatic gain control circuit (AGC) and setup of recording Double-Differential (DD) to provide tunable gain. The imbalance network is reduced by generating the signal clock by using custom-designed variable gain amplifiers (ASIC) based on microcontroller (Rieger and Deng 2013).

The physiological parameters of the ECG signals are tested and optimized based on Block-Based Neural Network (BBNN) algorithm. The structure of model, parameters and weight are performed by optimizing with wavelet mutation, searches through information element over a space search (San et al. 2013). The data of ECG is accomplished in an unrestricted manner by developing the technique by detecting and analysis of obstructive apnea with quality (Lee et al. 2013).

The application of portable ECG monitoring, the mixed-signal ECG System-on-Chip (SoC) is operative with low-power consumption for high quality signal. By custom digital signal processor the detection of peak and removal of artifacts motion is performed (Kim et al. 2014). Figure 4 shows the mixed signal of ECG and EEG with interference of line in recording.

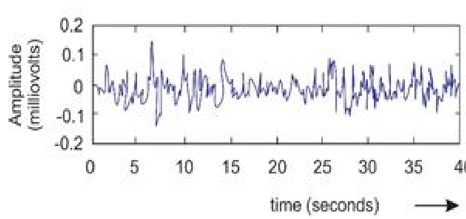

Fig. 4. EEG signal recording with ECG signal and interference
Source: Author

Proposed Work

In this section, the proposed algorithm technique of removing artifacts is explained with application. By the proposed method the input source is trained and initialized to extract the signal from the MIT-BIH database. By the analysis and implementation of proposed enhanced hybrid learning method, the ECG and EEG signals are separated with artifacts minimization.

EEG signal is affected by the artifacts of ECG. In order to avoid the artifacts the signals are separated for better quality of signal to analyze the EEG signal. It records the electrical activity of the brain. When recording the signal the cerebral origin is also included, this is mentioned as ECG artifacts. In the designed method Improved Adaptive Neuro-Fuzzy Inference System (IANFIS) and Improved ANFIS-Particle Swarm Optimization (IANFIS-PSO) algorithm, are used to remove artifacts from the signal and the flow of proposed system implementation is shown in Figure 5.

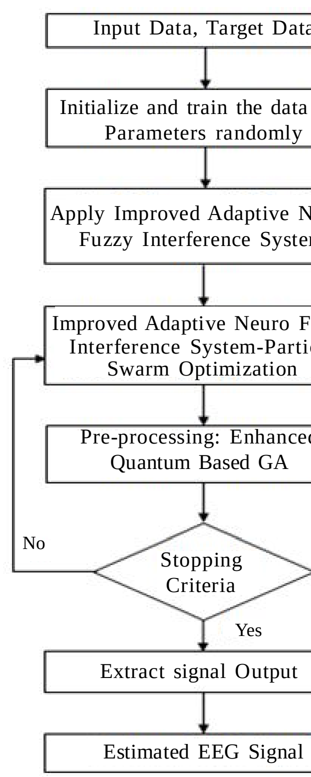

Fig. 5. Proposed system Flow work
Source: Author

The optimized parameter is applied to the structure of IANFIS for separating the signals with removal of artifacts. By optimization algorithm the membership function is initialized and the input and the parameters are trained randomly using Improved ANFIS-Particle Swarm Optimization (IANFIS-PSO). The membership function of the proposed algorithm is given below:

$$\mu_X(a_1) = \frac{1}{1+\left|\frac{a_1-z_i}{x_i}\right|^{2y}} \qquad (1)$$

The parametric representation of IANFIS, back propagation function and updating functions of parameter is given below:

$$S1=\{\{x_{11},y_{11},z_{11}\},\{x_{12},y_{12},z_{12}\},\ldots..,\{x_{1p},y_{1p},z_{1p}\},\ \ldots.,\{x_{np},y_{np},z_{np}\}\} \qquad (2)$$

Back propagation:

$$E=\sum_{k=1}^{K} E_k \qquad (3)$$

Parameter Updating

$$\Delta\propto_n = -\eta\frac{\partial+E}{\partial\alpha_n} \qquad (4)$$

Pre-processing of the system is used to filter the noise from the signal extraction. It is processed in the system until it satisfies the stopping criteria of finding minimum particles of error, using the step based enhanced quantum based genetic algorithm. It provides fast process and removal of noise interferences (Singh and Sharma 2015). The flow work or the procedure of pre-processing is implemented as shown in Figure 6 and learning process procedure is given below.

Procedure of learning the process and GA is performed for finding the fitness function and sorting the chromosomes in ascending order. Then the maximum generation is obtained to find probabilities of mutation and crossover.

Procedure Begin
Initialize t !0 and P (t);
While (t<maximum generation) do
Increment t !t+1;
Evaluate sorting-fitness (P (t-1));
Find P (t) and P (t-1);
Complete P (t) by mutation and crossover;
End while
End

To maximize the iteration of the process, stopping criteria is used and by fitness function the Mean Square Error is considered (Ashfanoor and Cellia 2012). At the end of iteration the best

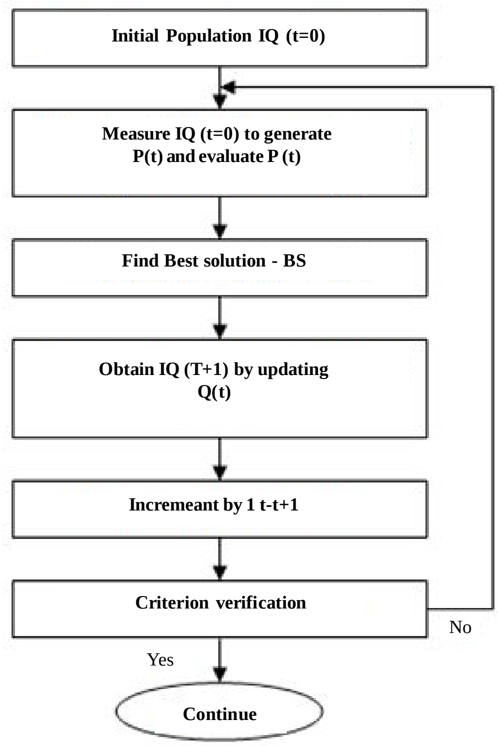

Fig. 6. Flow work of Enhanced quantum based GA
Source: Author

solution is obtained by finding the Minimum Mean Square Error particle and the solution is submitted to ANFIS structure. To extract signal the optimized parameters is implemented by using proposed algorithm and obtain EEG signals with minimized artifacts and estimation.

RESULTS AND DISCUSSION

In this section, the simulation results of the proposed system is evaluated and analyzed to show better performance than the existing system. The proposed algorithm is executed to simulate the real data set from the MIT-BIH database to extract the EEG signal. Figure 7 shows the input sources of mixed standard signal of EEG and ECG.

From the source signal the separation of signals are EEG and ECG is performed by using proposed method. EEG signal is to be found along with noise. So, by using proposed algorithm IANFIS-PSO the EEG signal is extracted by reducing noise. Figure 8 shows the extrac-

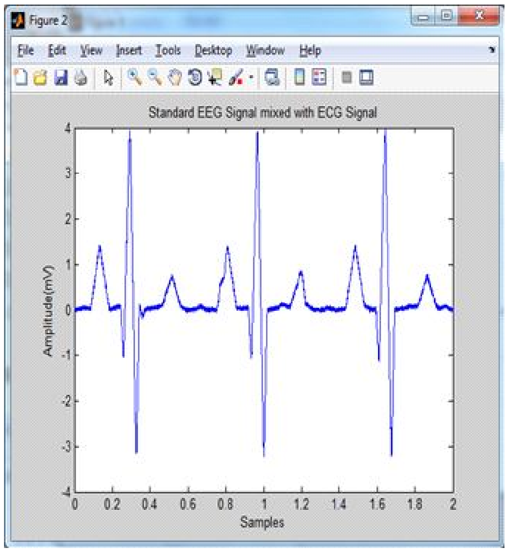

Fig. 7. Standard EEG signal mixed with ECG signal
Source: Author

tion of EEG signal from the input source signal. It clearly shows the proposed technique removes only the noise from the EEG signal without affecting the information content. And Figure 9 shows the extraction of non-linear ECG signal from the source input (Khatwani and Tiwari 2013). The source input is original EEG signal with Noise (ECG) Signal. From the original input through the proposed technique the non-

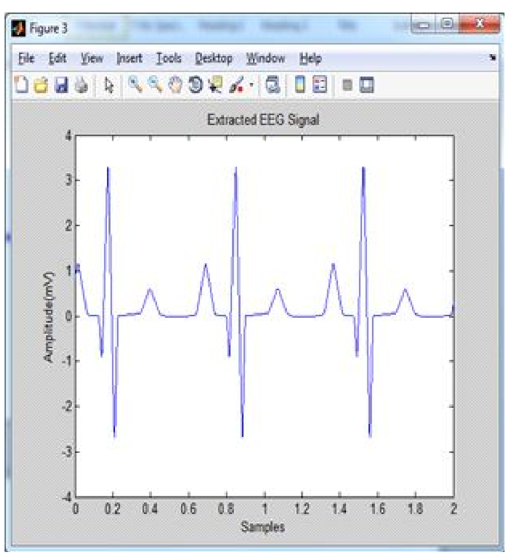

Fig. 8. Extracted EEG signal
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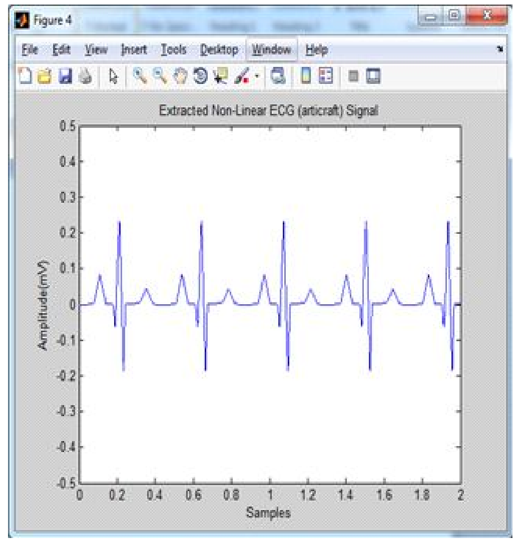

Fig. 9. Extracted Non-linear ECG (artifacts) signal
Source: Author

linear ECG Artifacts signal only removed. The power spectral density of the proposed system is shown in Figure 10.This power spectral plot shows the each trial of noisy EEG signal and artifacts Signal by the proposed method.

Table 1 performance analysis of proposed system with existing system, it summarizes the comparison of performance analysis of proposed and existing algorithms with the results of pa-

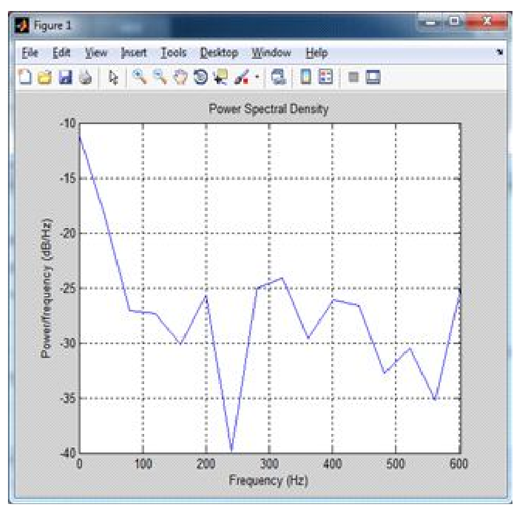

Fig. 10. Analysis of proposed system power spectral density
Source: Author

Table 1: Performance analysis of proposed system with existing system

Methods	*PSNR (dB)*	*SNR (dB)*	*MSE*	*Entropy*	*Execution time*
Existing method	27.45	15.0245	5.1424e-004	3.0859	6.543258
ANFIS	29.57	10.0423	0.0015	5.3323	4.157356
IANFIS-PSO	31.63	9.4858	0.0011	8.3348	3.033725

rameters PSNR, SNR, MSE, entropy and execution time. Concluded that in ANFIS method PSNR value is higher than existing method. IANFIS-PSO method PSNR value is higher than in ANFIS method. Finally IANFIS-PSO method achieves high PSNR value compared to existing and ANFIS method. Similarly IANFIS-PSO method outperformed existing and ANFIS method as far as SNR, MSE, entropy and execution time Figure 11 shows the performance evaluation of the proposed system X-axis epochs, Y –axis Root Mean Square Error and Figure 12 shows the PSNR and SNR performance of proposed system with existing system (Sabarimalai and Suman 2012; Kaur and Malhotra 2014). This comparative analysis clearly shows that the proposed technique gives better PSNR and SNR values compared to existing method. And Figure 13 shows the analysis of Entropy and processing time of proposed method with existing method. It clearly shows that, IANFIS-PSO method outperformed when

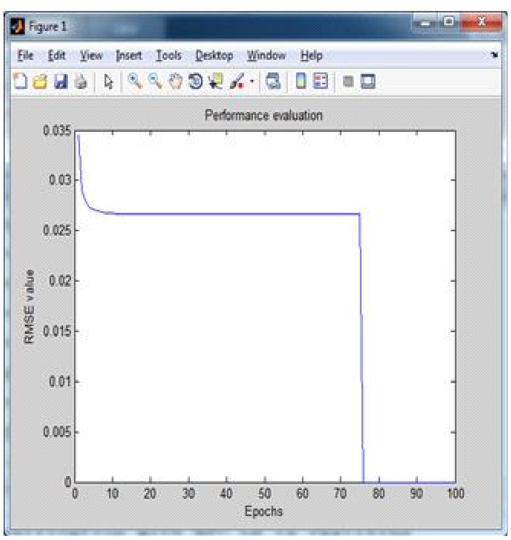

Fig. 11. Analysis of proposed system performances evaluation
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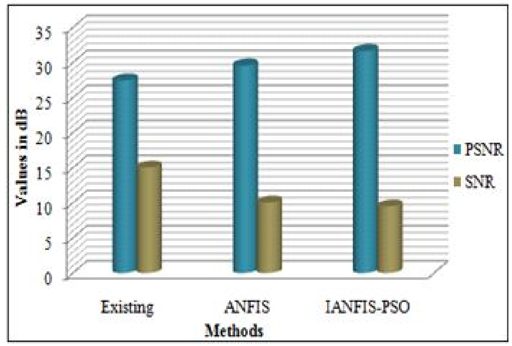

Fig. 12. Performance analysis of PSNR and SNR values
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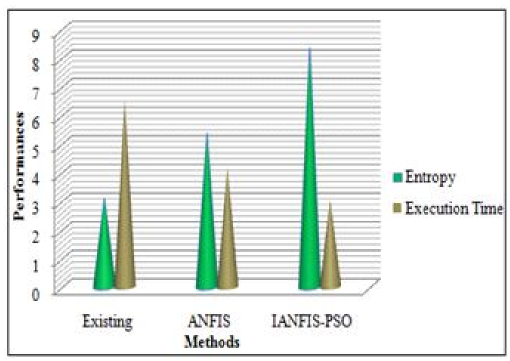

Fig. 13. Performance analysis of entropy and execution time
Source: Author

compared to existing and ANFIS method as far as entropy and execution time are concerned.

CONCLUSION

In this paper, the IANFIS is applied to the model to train and initialize the data from the MIT-BIH database to extract the signal for better performance for reducing the artifacts in the signal. The efficient process of identifying the parameters is based on the enhanced hybrid learning algorithm. The experimental and simulation results of our system shows better performance than existing, without performance degradation for same data; also reduced noise or artifacts in the signal. The RMSE result is based on member function inputs. From the experiment results finally the researcher concludes that the proposed method provides improvement in power spectral density of de-noised signal high signal to noise ratio value, reduction in the time in removal process, Entropy achievement and improvement of information content in the signal.

RECOMMENDATIONS

Future work is to further improve the performance of reducing the artifacts in EEG signal. Consider more data sets with some more parameters to provide analysis with high quality of solution and performances. Multidirectional transforms like curvelet and contourlet transform can be investigated to denoise the EEG signal.

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