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Research Article

SPIKE DETECTION FROM EEG SIGNAL USING PARTICLE SWARM OPTIMIZATION

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ABSTRACT

The abnormality spikes detect from the Electroencephalogram (EEG) signal. The recorded EEG signals contains large amount of artifacts like spike whose detection is a technically challenged one. Chebyshev filters are used to separate one band of frequencies from another. Chebyshev filter was primarily used for its speed. Chebyshev filters are fast because they are carried out by recursion rather than convolution [8]. The design of these filters is based on the z-transform. In this paper, we proposed an optimization technique along with a spike detection method using Chebyshev filter**.** In this method, initially the noise within EEG signals is removed by the wavelet technique and the preprocessed EEG signals are given to the classification algorithm. In the proposed method, Particle Swarm Optimization (PSO) is used for the computation of optimal structuring elements in the Chebyshev filter used for the spike detection. From the EEG signal, the spikes can be detected more effectively by attaining correctly detected spikes with the help of conventional spike detection methods.

Keywords: Electroencephalogram (EEG), Chebyshev Filter, Particle Swarm Optimization (PSO), Spike Detection, Wavelets.

INTRODUCTION

The electrical activity of active nerve cells within the brain produces currents spreading through the top. These currents conjointly reach the scalp surface and ensuing voltage variations on the scalp is recorded because the EEG [1]. The graph is one among the helpful bio-signals to sight the human emotions. It's a time variable electrical signal recorded from the electrodes connected to the scalp of human subject. The signal arises from the potential short lasting changes in potential drop among the neural cells of brain as such is measure of brain activity. The analysis of electroencephalogram recording is that the first technique of diagnosing of brain disorder. The foremost necessary non-invasive diagnosing tool used at encephalopathy surgery centers is electroencephalography (EEG). To search out the brain sources, that is typically sculptured as current dipoles that are liable for the measured potentials at the encephalogram electrodes on the scalp is an inverse problem [6]. The automated spike detection downside may be merely transferred to the detection of the presence of inter-ictal spikes within the multichannel encephalogram recording with high sensitivity and property. This means that top proportion of true events should be detected with a minimum variety of false detections [7].

Electroencephalogram (EEG) is a measurement technique to record the neural activity in our brain. It's applied in several researches, notably in feeling prediction. There are 5 major brain waves: delta (0.5-4 Hz), theta (4-7.5 Hz), alpha (8-13 Hz), beta (14-26 Hz), and gamma (30+ Hz) Note that every work might outline these brain wave ranges otherwise. The effective information measure for graph signals is more or less up to 100 cycles. However, it's possible to receive graph signals with the varying bandwidth between two hundred and 300 cycles. Within the feeling prediction task, researchers typically think about solely signals with the frequency vary between 0.5 and 50 cycle. The optimization plays an important role in the process. The most probably used techniques for optimization are ACO, PSO, GA and ANFIS[13-15].

EEG shows an honest correlation with the mental stress in terms of suppression of alpha waves and improvement of letter of the alphabet waves. Alpha waves theta active in bone and frontal regions of the brain. These waves are related to idleness of the brain. So, in no stress condition, once the brain is doing no activity, alpha waves area unit dominant whereas in disagreeable things, the ability of alpha waves falls down

showing the modification in response below stress. Beta waves show variable behavior in numerous frequencies in numerous components of the brain and power in theta waves will increase below stress or mental tasks. The correct classification of electrical activity in a very explicit state of human brain helps in medicine diagnosing and conjointly for establishing standards for instrumentation development. This classification conjointly helps within the brain laptop interfacing that has been gaining wide attraction within the analysis trade[11-12].

PROBLEM STATEMENT

Different rippling, thresholding and filter primarily based ways applied for acting spike detection and denoising method were used in the existing methodologies. The thresholding and rippling ways are wide used for spike detection. In thresholding primarily based ways, the edges are often set manually or mechanically in step with the statistical characteristics of spike trains. However, it fails to discriminate spikes with completely different morphologies however with similar amplitude. Within the rippling based mostly spike detection techniques, initially the coefficients are determined and so a threshold-based operation is performed to get the spikes from the signals. In such works, there's a scarcity of research in choosing the acceptable threshold price. In filter primarily based ways, Chebyshev filters are most generally used technique within the spike detection method. The Chebyshev filters accomplish the spike detection method by mistreatment the best structuring parts and adaptation amplitude thresholding method. This morphological primarily based technique attains the high exactitude rate once the amplitude of signal is high. However during this technique, the performance is insufficient as a result of the choice of best structuring parts. Because, there's no normal improvement techniques exists in choosing the best structuring parts. So, these ways degrade the spike detection performance. to beat the drawbacks in these existing ways, the rippling technique is employed to cut back the ground noise from graphical record recordings and therefore the Particle Swarm improvement is projected for the computation of best structuring parts within the Morphological filter used for the spike detection.

METHODOLOGY

In this work, the EEG signals that were obtained from the benchmark dataset were first pre-processed using DWT, to remove noise from the given input EEG signal. Using this preprocessed technique the noise present in the signal can be removed and the output received from the preprocessing technique is now a noise free signal. After the noise removal, the noise free signal is then passed through a Chebyshev filter for dimensionality reduction of the pre-processed signal and the optimal structuring elements in morphological filter can be evaluated by using PSO (Particle Swarm Optimization) technique, the PSO classify the EEG signal. An adaptive amplitude threshold should be set to detect the occurrence of individual spikes [8]. Finally, performance evaluation was reported using three statistical measures, namely sensitivity, specificity, and overall classification accuracy. The flow diagram for proposed system for spike detection method using PSO is shown in Figure 1.

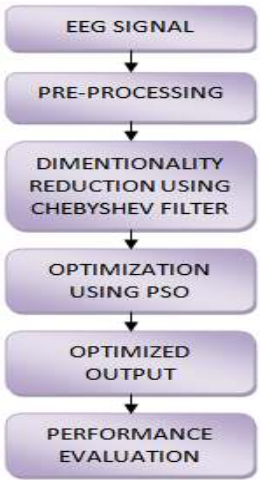

Figure 1: Proposed Spike detection using PSO method

SPIKE DETECTION METHOD

Nowadays electroencephalogram recordings became customary techniques for investigation individual or ensemble neural responses to physical stimulation or knowledge in varied analysis fields. The background signal within the graph signal which provides the poor quality of the graph recording result. Spikes could type teams in graph signal with some amount on a similar conductor. As spikes are short-time broadband events, their energy patterns are diagrammatical as ridges within the time frequency domain. During this domain, the high fast energy of the spikes makes them a lot of distinguishable from the background. The graph consists an underlying background method with superimposed transient non stationarities like spikes. The detection of spikes within the graph is of explicit importance within the diagnosing of encephalopathy. Spike detection will any cut back the info rate if spike counts are transmitted rather than spike waveforms. Within the projected work, the effective spike detection principally comprised of 4 stages particularly,

- Preprocessing
- Chebyshev filter for spike detection
- Constructing an optimal structuring elements by PSO
- Adaptive amplitude Thresholding

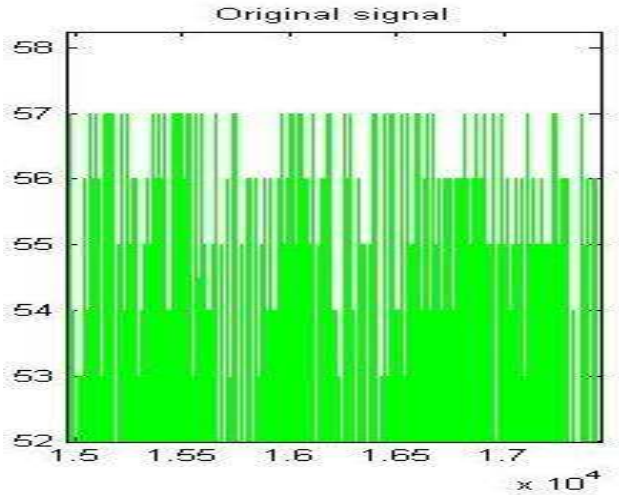

Figure 2: (i) Input Signal

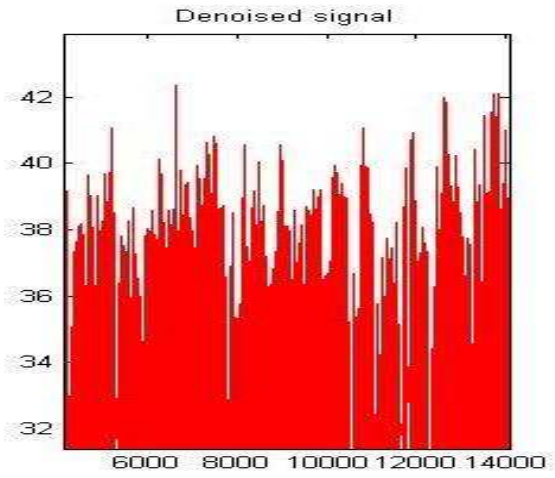

Figure 2: (ii) Denoised Signal

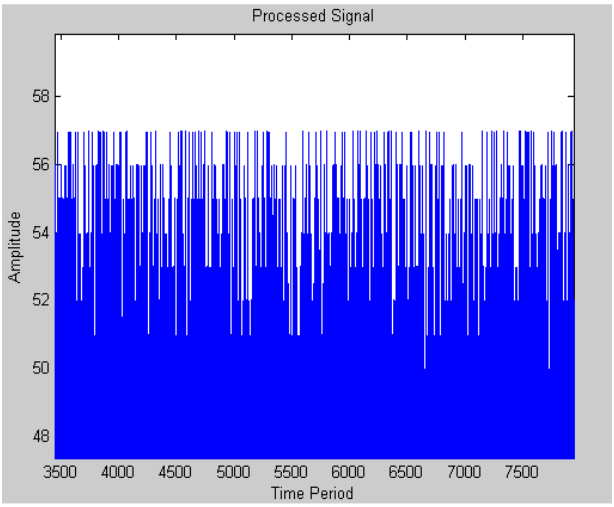

Figure 3: Processed Signal

A. Preprocessing

The preprocessing step is used to enhance the input signal to get a better output at the final stage. There are several methods that have been developed for EEG signal conditioning. Wavelet technique has been widely used in signal processing for its ability to separate the signal and noise. The output from the preprocessing signal is known as a noise free signal.

B. Dimensionality reduction by Chebyshev Filter:

Chebyshev filters are used to separate one band of frequencies from another. The EEG energy was computed in the 5-15 Hz region to primarily capture the Beta waves in the EEG signal which is closely linked to system behavior and is generally attenuated during active movements. Chebyshev filter was primarily used for its speed.

Chebyshev filters are fast because they are carried out by recursion rather than convolution. The design of these filters is based on the z-transform. Chebyshev filter reduces the dimension of the pre-processed signal [10].

PARTICLE SWARM OPTIMIZATION

The PSO (Particle Swarm Optimization) is an improvement technique projected by James Kennedy and Russell Eberhart in 1995 [1-4]. The strategy was created by simulating a simplified social model like model faculty of fish or flock of birds yearning for food. In PSO, the population is termed swarm. A swarm could be an amount of particles getting an n-dimensional area among a mathematical space of search. There's a conception of neighborhood for every particle that is the set of all neighboring particles. Every particle during a given iteration incorporates a speed and position in house. The particle additionally incorporates a little memory that stores the simplest position to this point achieved (best place), and therefore the best position ever reached by the known particle (best global), or, the best of all particles happiness to the neighborhood. It's like genetic algorithms and organic process algorithms, however needs less process memory and fewer lines of code take into account an improvement drawback that needs the co-occurring improvement of variables [5]. To verify if an answer is best than another if it utilizes fitness perform that determines however sensible the solution to the drawback is. As every particle's position represents a candidate answer to the matter, the fitness of a particle could be a perform of the position of the particle. Every particle modifies its rate taking under consideration the simplest position itself and the best position of the cluster and over time the cluster has reached the very best position within the house [1].

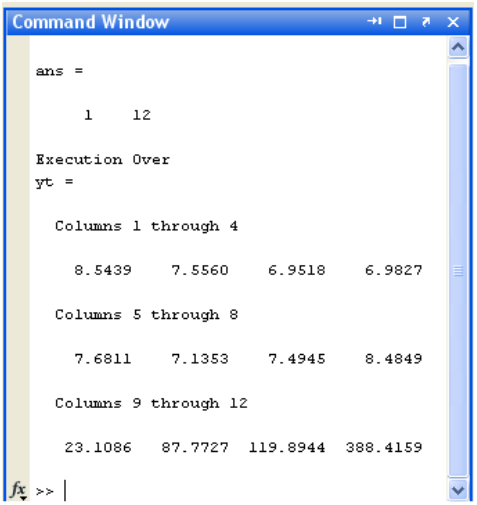

Figure 3: Dimensionality reduction of the Processed Signal

Particle swarm improvement (PSO) could be a process methodology that optimizes a haul by iteratively attempting to improve a candidate answer with regard to a given live of quality. every particle's movement is influenced by its native best known position and is additionally radio-controlled toward the simplest known positions within the search-space, that area unit updated as higher positions area unit found by different particles. This can be expected to maneuver the swarm toward the simplest solutions. PSO is initialized with a bunch of random particles (solutions) and so searches for optima by change generations. All particles are updated by following 2 "best" values. The primary one is that the best answer (fitness) it's achieved to this point. This value is termed pbest. Another "best" price that's tracked by the particle swarm optimizer is the best price, obtained thus so

much by any particle in the population. This best price could be a world best and known as gbest [2], [8].

In particle swarm improvement, all people within the swarm have identical behaviors and characteristics. It's assumed that data on the position and performance of particles are often changed throughout social interaction among particles within the neighborhood. Significantly, the particle swarm improvement depends on social interaction among particles through exchanging elaborate data on position and performance. Performance index is given as [3],

$$PI = \frac{PC - MC - FA}{PC} \times 100$$

Where,

PC (Perfect Classification): agrees the risk level output.

MC (Missed Classification): assumes high risk level as low risk level

FA (False Alarm): assumes low risk level as high risk level

Spike detection by PSO

Individuals in particle swarm follow a very easy behavior: to emulate the success of neighboring people and their own successes. The collective behavior that emerges from this easy behavior is that of discovering optimum regions of a high dimensional search area. A PSO algorithmic program maintains a swarm of particles, wherever every particle represents a possible resolution. In analogy with biological process computation paradigms, a swarm is comparable to a population, whereas a particle is comparable to a personal. The particles through a two-dimensional search area, wherever the position of every particle is adjusted per its own expertise which of its neighbors. The experiential data of a particle is mostly spoken because the psychological feature part, that is proportional to the space of the particle from its own best position (referred to because the particle's personal best position) found since the primary time step. The socially changed info is spoken because the social part of the rate equation. An adaptation amplitude threshold ought to be set to find the prevalence of individual spikes.

Performance evaluation

In practice, it's hard to judge the performance of a replacement algorithmic program with real recorded neural knowledge as a result of the knowledge, like the amount of spikes, the spike timings, the spike form, and therefore the amplitude and then on, is unknown. A wide used framework to judge the performance of an algorithmic program is to match the algorithmic program outcome of artificial knowledge with the first spike labels. Since the target for spike detection is to reduce the amount of incorrectly detected spike events (false positive) and maximize the amount of properly detected spike events (true positive), each hit rate and exactness are used to value the performance of the algorithm.

CONCLUSION

The EEG signals are non-stationary; the conventional method of frequency analysis is not highly successful in diagnostic classification. In this project we have presented a novel approach to detect spikes based on a set of diverse feature, which capture energy of the EEG signal using DWT, and using PSO (Particle Swarm Optimization) technique, the EEG signals got classified. An adaptive amplitude threshold should be set to detect the occurrence of individual spikes. The results showed that the proposed classifier has the ability of recognizing and classifying EEG signals efficiently. The most important advantage of the proposed method is the reduction of data size as well indicating and recognizing the main characteristics of signal.

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Biography:

Parthiban K G received his ME in Process Control & Instrumentation from Annamalai University (2005) and persuing his PhD degree in Computer Science Engineering from Anna University, Chennai (Jan 2009). He is currently serving as Associate Professor in MPNMJ Engineering College, Chennimalai, Erode. He has 11years of teaching experience. He has published more than 25 research papers in various National and International conference proceedings. Also he published One books on "Electric Circuits and Electron Devices" from Sri Krishna publishers, Chennai. Also he published two national journals in Bio Medical field. His area of interest includes Soft Computing techniques and Bio medical signal processing.

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