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FUZZY RULE SET BASED FETAL HEART RATE DETECTION AND SEPARATION USING WAVELET SIGNAL ANALYSIS UNDER VARIOUS PSYCHOLOGICAL MOMENTS

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ABSTRACT

The maternal heart rate detection becomes more important in medical solutions where the human ECG consists of different a component which represents different activity of heart rooms. The fetal heart rate has to be monitored at different situations of maternal activity. The human heart wave differs with different psychological and physical changes also affects the heart rate of the fetal also. We propose a heuristic approach which detects and separate the fetal heart rate from the mother using wavelet analysis and fuzzy rule set. The rules set consist of variety of rules for different psychological moments which represent the possible heart rate and values of different components of ECG. Using the rule set maintained, the fetal heart rate can be easily identified at different situations of the patient, which supports the medical practitioner to go through the medical procedures. The proposed method has produced higher rate of detection accuracy which makes the separation process an easier one.

Keywords: *Fuzzy Systems, Rule Sets, ECG, Wavelet Analysis.*

1. INTRODUCTION

The electrocardiogram (ECG) which represents the activity of the human heart, which is recorded by different electrodes, fixed on various part of the human body. The room of heart responds to the electric signal passed with the electrode fixed and recorded with the digital system. The ECG has different components like QRS, P-wave, Q-Wave, where each shows the electrical response of the particular auricle and ventricle rooms. . Any ECG gives two kinds of information, the duration of the electrical wave crossing the heart which in turn decides whether the electrical activity is normal or slow or irregular and the amount of electrical activity passing through the heart muscle which enables to find whether the parts of the heart are too large or overworked.

Wavelets transform a signal processing technique used in various applications to decompose, filter, feature extraction etc…. Wavelet transform has huge impact in biomedical systems for signal processing. For many signals, the low-frequency content is the most important part. It is what gives the signal its identity. The high-frequency content, on the other hand, imparts flavor or nuance. To gain a better appreciation of this process, it is performed a one-stage discrete wavelet transform of a signal. The decomposition process can be iterated, with successive approximations being decomposed in turn, so that one signal is broken down into many lower resolution components.

In wavelet analysis, a signal is split into an approximation and a detail. The approximation is then itself split into a second-level approximation and detail, and the process is repeated. The transformed signal provides information about the time and the frequency. Using this approximated information low frequency data could be identified, which is more important in cardiac disease prediction.

The fetal electrocardiogram (FECG) is used for the calculation of the fetal cardiac frequency and in the prediction of the fetal acidosis. An FECG provides information about the fetal well-being and the physiological state of the fetus.

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The fuzzy logic system which uses different rules to get a decision and acts according to the rule match. The rule has different attributes and values which will be mapped to find the matching rule. The fuzzy rule sets are mostly used where the condition will not be predictable and the values are not rounded. The fuzzy rule has attribute values in range and the system acts according to the rule set provided.

2. BACKGROUND

There exist many solutions to detect and separate the fetal heart rate with the support of wavelet analysis and we discuss few of them here:

In Fetal Electrocardiogram Extraction Using Adaptive Neuro-fuzzy Inference Systems and Un-decimated Wavelet Transform [1], FECG is extracted from the maternal electrocardiogram using adaptive neuro-fuzzy inference systems and un-decimated wavelet transform (UWT) is proposed. The performance of the proposed system is compared with the standard discrete wavelet transform (DWT). For numerical evaluation, the mean square error (MSE) between ¬de-noised FECG signal and original FECG signal is used.

Design Methodology of a New Wavelet Basis Function for Fetal Phonocardiography Signals [2] introduces a new mother wavelet basis function for denoising of fPCG signals. The performance of newly developed wavelet is found to be better when compared with the existing wavelets. For this purpose, a two-channel filter bank, based on characteristics of fPCG signal, is designed. The resultant denoised fPCG signals retain the important diagnostic information contained in the original fPCG signal.

Fast technique for non invasive fetal ECG extraction [3], describes a fast and very simple algorithm for estimating the fetal electrocardiogram (FECG). It is based on independent component analysis, but we substitute its computationally demanding calculations for a much simpler procedure. The resulting method consists of two steps: as a dimensionality reduction step and a computationally light post processing stage used to enhance the FECG signal.

A method of extracting fetal ECG based on adaptive linear neural network is proposed in [9] . It can be realized by training a small quantity of data. A lightweight algorithm, which extracts the fetal ECG with a pre-knowledge about its skewness is presented in [10]. By using the skewness, a cost function is defined by which Weight vector is updated and through this desired fetal ECG signal is extracted.

A technique based on the fetal ECG extraction algorithm OL-JADE [11], which tries to invert the whole blind extraction process only for the FECG, estimated sources in order to estimate the FECG power at the electrodes. Due to the recursive sample-by-sample nature of the whitening stage of OL-JADE, an approximated Least Squares solution has been introduced in the back projection scheme revealing adequate performance.

ECG Arrhythmia Recognition using ArtificialNeural Network with S-transform based Effective Features [27], proposes a potential application of Stockewelltransforms (S-transform) to classify theECG beats of the MIT-BIH database arrhythmias. Featureextraction is the important component of designing the systembased on pattern recognition since even the best classifier willnot perform better if the good features are not chosen properly.In this study, S-transform is used to extract the eight featureswhich are appended with four temporal features. The first approach uses temporaland S-transform based feature set, whereas the secondapproach uses the wavelet transform based features. Thesefeatures from two approaches are independently classifiedusing feed forward neural network (NN). Performance isevaluated on several normal and abnormal ECG signals ofthe MIT-BIH arrhythmia database using two techniques suchas temporal and S-transform with NN classifier (TST-NN)and other wavelet transform with NN classifier (WT-NN).

A PC-aided optical foetal heart rate detection system [28] consists of a photo plethysmography (PPG) circuit, abdomen circuit and a personal computer equipped with MATLAB. A near IR beam having awave length of 880nm is transmitted through the mother's abdomen and foetal tissue. The received

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abdominal signal that conveys information pertaining to the mother and foetal heart rate is sensed by a low noise photo detector. The PC receives the signal through the National Instrumentation Data Acquisition Card (NIDAQ). After synchronous detection of the abdominal and finger PPG signals, the designed MATLAB-based software saves, analyses and extracts information related to the foetal heart rate. Extraction is carried out using recursive least squares adaptive filtration. Measurements on eight pregnant women with gestational periods ranging from 35–39 weeks were performed using the proposed system and CTG.

3. PROPOSED METHOD

The presented Fuzzy Ruleset Based Fetal Heart rate detection and separation consists of following stages namely: Preprocessing, Rule Based Fetal Heart signal Identification and separation. Each of the functional models will be discussed later in this chapter.

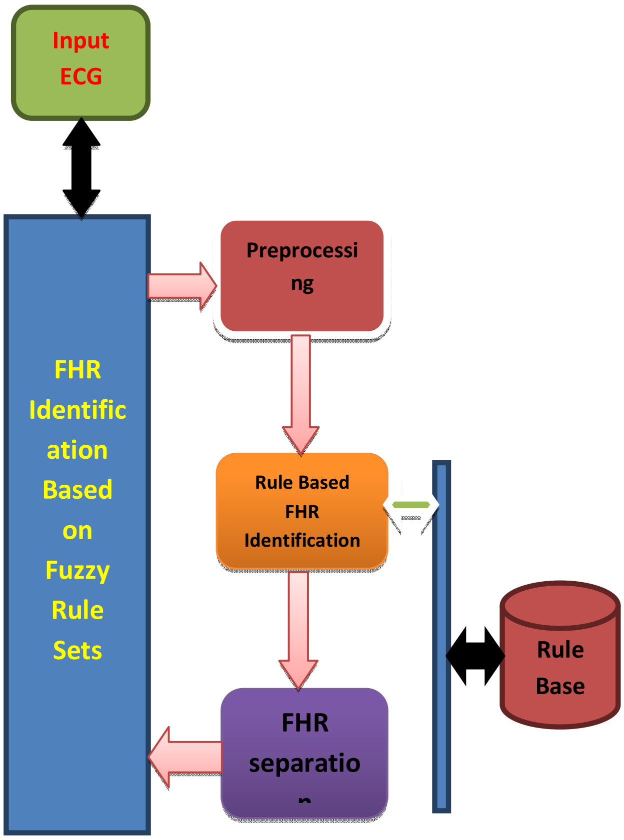

Figure1: Proposed System Architecture.

3.1 Preprocessing:-

At the first stage the input ECG signal wave will be processed to validate the signal values. The signal values and the components must be in satisfactory level to get selected for further processing. The wavelet signal analysis is performed on the submitted wave forms. Each component in the wave form mustbe having different values but should be in certain level. The ECG waveform also must contain values for various components and we identify the values and select them for further processing. The noisy and irrelevant signal values are removed from this and given for the next level.

Algorithm:

Step1: start

Step2: initialize signal pattern E.

Step3: read input signal IE.

Step4: for each signal E_i at time T_i from IE

$E_i = DWT(E_i)$

If E_i>minTh then

Add to the signal pattern E.

$E=\sum(E+E_i)$.

End

Step5: stop.

3.2 Feature Extraction:-

The preprocessed ECG waveform will be used for further processing and it has many components namely P, Q, R, S, T waves. Also the combinations of the components represent the activity of heart at different time frames. Theelectrocardiogram contains various time domain and space domain values; they are amplitudes and intervals of various sectors. We extract P-R interval, R-R interval, Q-T interval, S-T interval, P-wave interval, QRS interval and the amplitude values of P, R, S, Q, T, U waves. Each features extracted is stored in the data base for further manipulation.

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Algorithm:

Step1: read transformed ECG signal Ds.

Step2: Extract the following features.

Pr=P-R interval

Rr = R-R interval.

Qt = Q-T interval.

St = S-T interval

P= P wave interval.

Qrs = QRS interval.

PA- P wave Amplitude.

QA – Q wave Amplitude.

RA – R wave Amplitude.

TA - T wave Amplitude.

SA – Synus Amplitude

UA- U wave Amplitude.

Construct vector Vi and add to ector set Vs.

Vs = ∑Vi(Pr,Rr,Qt,St,P,Qrs,PA,QA,RA,SA,TA,UA).

End.

Step3: stop.

3.3 Rule Based FHR Identification and separation

The fuzzy rule sets are selected for processing and the extracted feature values are used for rule mapping. The preprocessed signals are converted into processing pattern and each of the items present in the pattern shows the value of signal value of the components present in ECG signal. The converted pattern is mapped with each rule from the rule set RS and we compute the FHR score which shows the relevancy of the pattern towards the rule. Finally a single rule will be selected based on the FHR score. The proposed method maintains different rules for each psychological changes of the mother like happy, lazy, sadness, surprise and etc. For each of the role the proposed method has rules present in the rule set.

Algorithm:

Step1: start

Step2: initialize FHR score Fs, distance D, flag W, Waveset FWS .

Step3: read rule set Rs.

Step4: for each rule R_i from rule set Rs.

For each attribute A_i from R_i

$D_i = D_i+|A_{i(}R_{i)} - A_{i(}R_{i)}|$.

If $\Omega(A_{i(}R_{i)})$ then // within the range

W =1;

Else

$FWS_i = FWS_i+A_{i(}R_{i)}$.

End.

End

End.

Step5: Sort the weight and assign class.

Step6: construct ECG wave form from FWS.

Step7: stop.

4. RESULTS AND DISCUSSION

To examine the efficacy of the proposed system in separating the preferred FECG signal from the MECG signals, experiments were conducted on the simulated signals. The ECG for both the mother and fetus has been simulated assuming sampling rate of 4 000 Hz.

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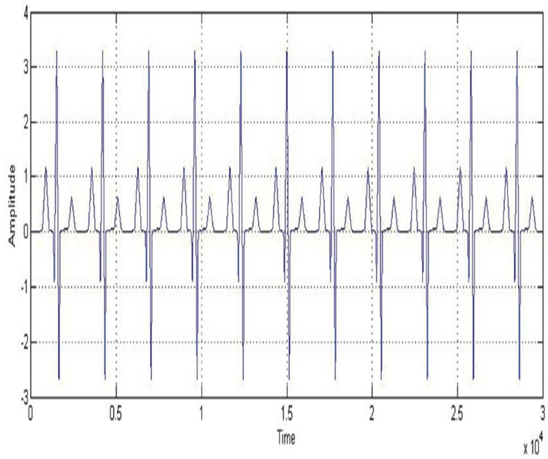

Figure2: shows the MECG as input ECG

The figure 1 shows the electrocardiogram wave form of the mother.

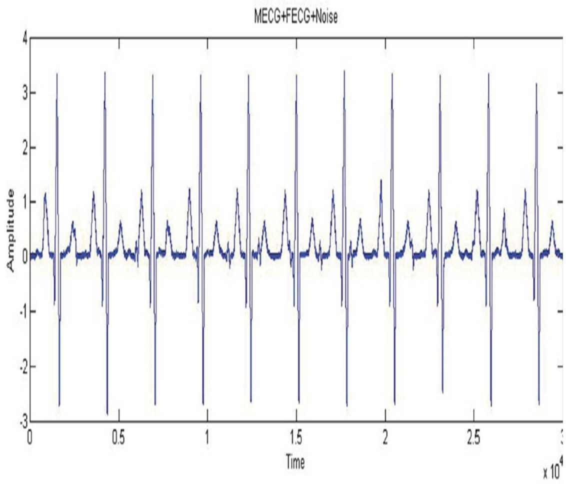

Figure3: shows both mother+ fetal+ noise ECG

Figure 3 shows the wave form which contains the electrocardiogram signal of both mother, fetal with noise signals.

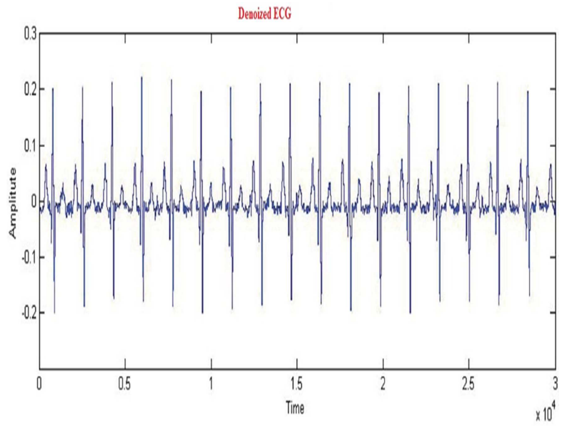

Figure4: shows the Noise removed ECG.

The figure 4 shows the ECG wave form of both mother and fetal with noise been removed.

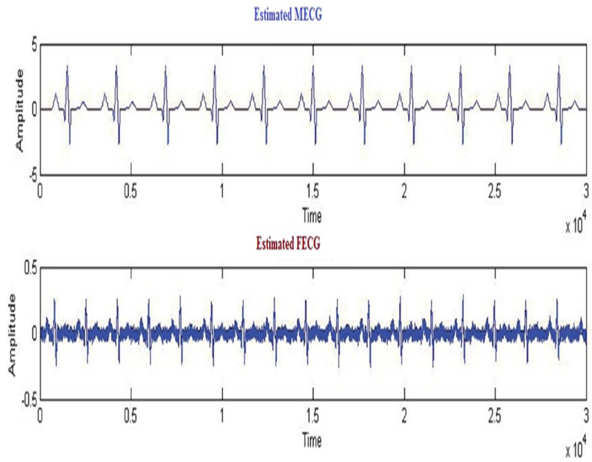

Figure 5: shows the separated FECG.

The figure shows the separated fetal electrocardiogram from the mothers ECG.

For numerical evaluation, the mean square error (MSE) between the de-noised FECG signal and the original FECG is used. The performance of the proposed system is compared with DWT.

5. CONCLUSION

We present a heuristic fuzzy rule based approach to detect and separate FHR with the support of wavelet analysis. We have used wavelet transform to obtain the missing values of signals which are very low belongs to the fetal and boost using the wavelet transform. The fuzzy

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rule based approach has been used to evaluate the fitness of the sample towards each category of emotion and to deviate the signal from fetal ECG wave. The proposed method has produced efficient results and the real time recording and separation of long time ECG with comparison to other methods also shows the efficiency of the proposed method.

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