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An Algorithm for Fetal ECG Extraction from the Composite Abdominal Signal

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***Abstract*— The electrical activity of the fetus heart is basically the fetal electrocardiogram.FECG is a weak signal which is measured indirectly by placing the electrode on the surface abdomen of the mother. The Fetal signals contains many other interfering signal. Extraction of the fetal ECG parameters from the abdominal signal has an important value in clinical application and also enables continuous monitoring of the fetus status by means of analyzing its cardiac activity. This paper proposes a non-invasive method for the FECG extraction by using a template for the cancellation of maternal QRS complex. The final results specify that the fetal R peaks can be easily detected under various circumstances without using the reference maternal thoracic signal.**

IndexTerms—**AECG(AbdominalElectrocardiogram), FECG(Fetal Electrocardiogram), FHR(Fetal Heart Rate), MECG (Mother's Electrocardiogram).**

I. Introduction

The electrocardiogram is basically a non-invasive test that is used to detect the electrical activity of the heart. The heart's rhythmic contraction is due to the depolarization and re-polarization phenomenon which results in generation of the ECG waveform. The ECG signal travels over the conducting medium of the human body and can be measured by a group of electrodes placed at various locations. But in the case of fetus, the FECG is not easily available. Invasive techniques for monitoring the fetal ECG involve diffusion of tissue which are highly sensitive to infection in the intra-uterine environment [1]. As a result, there is an increasing demand for non-invasive techniques to measure the fetal electrocardiogram. Monitoring the fetal ECG permits the determination of cardiac parameters as well as the cardiac diseases such as cardiac arrhythmia and uterine contraction information [2] [3]. Although alternative techniques such as the echocardiogram and the Doppler ultrasound have been used for diagnostic purpose but for monitoring, fetal ECG would allow a harmless long-term monitoring of the fetal heart rate [4][8]. The measured FECG is largely distorted by various types of noise, among which the Maternal Electrocardiogram (MECG) is the most important interference [4]. However, in spite of various recent advances in the extraction of fetal ECG, there are still intrinsic technical restrictions due to high order statistics as a result such technique are not suited for the real time applications[6] [7]. To cope with this limitations a customized FECG extraction method is proposed in the paper using various signal processing techniques.

II. Proposed System

The proposed system for fetal ECG extraction from the composite abdominal signal consisted of 3 major steps: step 1, Preprocessing of abdominal signal; step 2, Extraction of fetal ECG from composite abdominal signal; step 3, Detection of fetal R peaks.

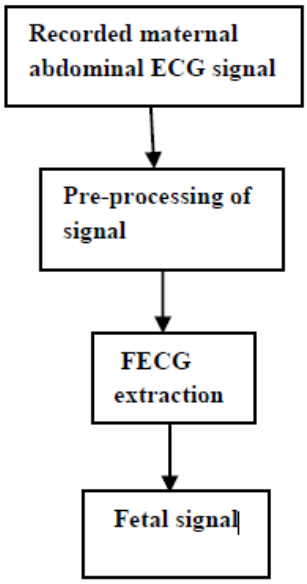

Figure.1 Block diagram of the proposed system.

A. Database

The abdominal signal were taken from the PhysioNet Non-invasive fetal ECG database [9].The database contains a series of 55 multichannel abdominal non-invasive fetal electrocardiogram (FECG) recordings, taken from a single subject between 21 to 40 weeks of pregnancy. The database consists of 2 thoracic signals and 3 abdominal signals. The transducer used is Ag-AgCl where electrode positions are varied in order to improve the SNR value. The recorded signals have the bandwidth of 0.01Hz-100Hz with a sampling rate of 1 kHz and resolution of 16 bits. The duration of each signal is 10 seconds. This database is introduced into MATLAB in order to separate the maternal and fetal ECG signal.

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B. Pre-processing of the Signal

Signal Averaging:
In which multiple abdominal signals are averaged to remove the disturbance and disclose small dissimilarities in the QRS complex.

Removal of Baseline Drift:
The baseline drift is a low-frequency activity in the AECG signal which may affect the signal analysis. It is mainly due to the respiration, artefacts and electrical noise. It is eliminated by subtracting the mean value of the signal from the signal itself.
Removal of Powerline Interference:
A notch filter with 50 Hz frequency is applied to attenuate the coupling with the mains.

Butterworth Bandpass Filtering:
4-100Hz filter is applied to attenuate the low and high frequency noises.

C. FECG Extraction

Maternal QRS Complex Detection:
In the proposed system a discrete wavelet transform is used to decompose the recorded AECG signal. The signal is decomposed by using Daubechie wavelet which is analogous in shape to heart beat. The AECG signal is decomposed by applying a high and low pass filter followed by down sampling operation. The data is down sampled in order to reduce the data rate. The output of this provides the detail as well as approximate values. The approximate values of the decomposed signal is used to detect the maternal QRS complex.

Maternal ECG Cancellation:
Once the maternal QRS complex is been detected the signal is divided into frames which are individually analyzed in order to know the exact positions of the QRS complexes. The positions are then used to generate the maternal template. The generated template is correlated with the maternal signal and the one with the highest correlation is used. Before subtraction of the template with the signal proper aligning of the template to each of the maternal QRS complex is done. For proper alignment the template is scaled with respect to amplitude and width. The subtraction of the best correlating template allows the suppression of the maternal QRS complexes. The output obtained after the maternal ECG subtraction is fetal ECG signal.

D. *Fetal Signal*

The peak detection algorithm is then applied to detect fetal R peak in order to calculate the RR interval. This RR interval is used to calculate the fetal heart rate (FHR).

III. Results

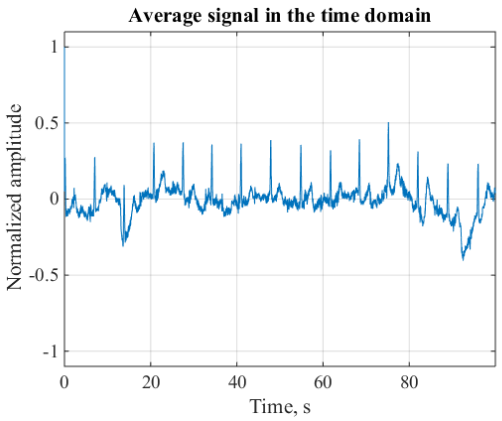

Figure. 2 Average of the AECG signal

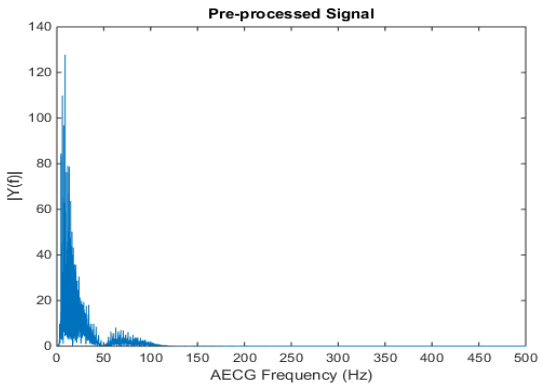

Figure.3 Pre-processed AECG signal in frequency domain

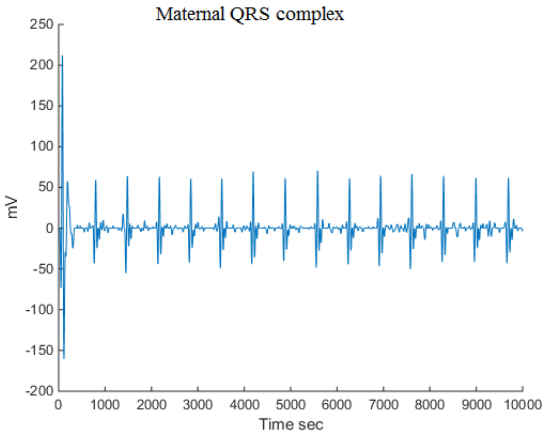

Figure.4 Detected maternal QRS complex after DWT

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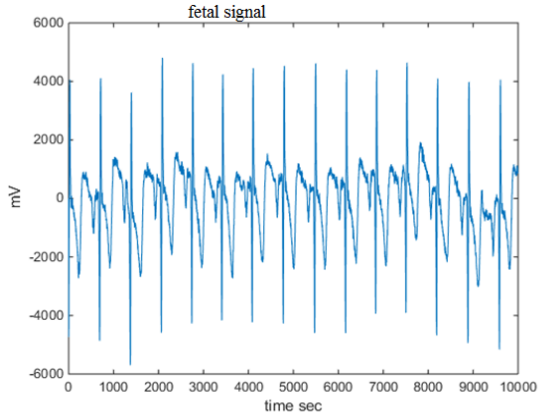

Figure.5 FECG signal

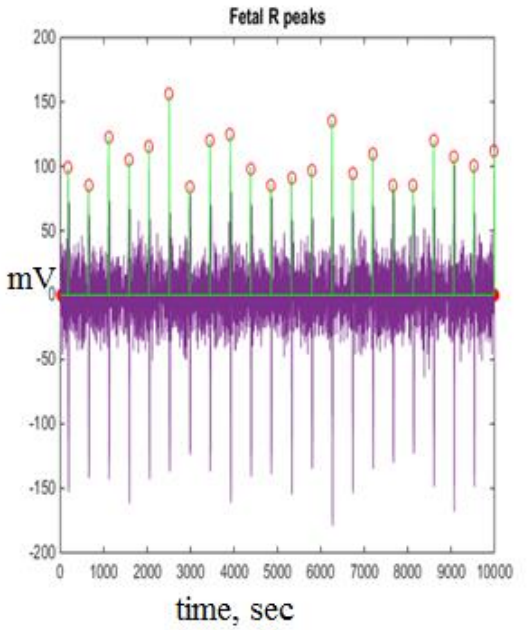

Figure.6 Detected fetal R peaks

III. Conclusions

The proposed system is developed to extract the FECG from the maternal abdominal ECG signal. The system is based on the identification of the maternal QRS complex by using the discrete wavelet transform. The identified maternal QRS complex is been subtracted by template generation and matching. On the obtained signal the fetal R peaks are been detected. The procedure is implemented on MATLAB platform with the intension to extract the fetal ECG in best possible way.

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