Int J Pharm Bio Sci 2015 Oct; 6(4): (B) 943 - 950

Research Article **Biotechnology**

International Journal of Pharma and Bio Sciences **ISSN 0975-6299**

ENHANCEMENT OF FETAL ECG SIGNAL USING ADAPTIVE NOISE CANCELLATION

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ABSTRACT

Fetal heart rate monitoring yields vital information about the fetus health and can support medical decision making in critical situations. The Fetal Electro Cardio Gram (FECG) signal reflects the electrical activity of the fetal heart. It contains information about the health status of the fetus, so that an early diagnosis of any cardiac defects before delivery increases the effectiveness of the appropriate treatment. A compound signal is obtained non-invasively by placing electrodes on the abdominal area of the mother which comprises of both maternal as well as fetal ECG signals contaminated by various other signals from a the body and externally induced noises. This paper represents the enhancements achieved by the application of adaptive filtering technique using MATLAB. The characteristics of the FECG signal were shown and a relatively clean FECG signal is obtained.

KEYWORDS: Fetal Electro Cardiogram(FECG), Maternal's Electro Cardiogram (MECG), Fetal Heart rate (FHR), adaptive noise cancellation(ANC)

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INTRODUCTION

It is necessary to monitor the fetal heart activity during pregnancy and at childbirth. This monitoring is called electrocardiography which demonstrates the electrical activity of the heart; and in case of fetus, it is called fetal electrocardiography (FECG). Fetal electrocardiography provides information in both fetal heart rate and fetal heart condition. Alot of information on the normal and pathological physiology of heart can be obtained from these signals. However, such signals being non-stationary in nature, it is very difficult to visually analyze them. Thus there is need for computer based methods for FECG signal analysis. Transmission of ECG often results in the corruption of signal due to introduction of noise[1,2]. Various factors responsible for introduction of noise include poor channel condition, baseline wander (caused by respiration), 50 or 60 Hz power line interference etc. Analysing such a noisy signal is bond to give erroneous results. Thus the signal is first made free of noise , by a process called " denoising". A number of methods have been incorporated for extraction of fetal ECG signal such as filter banks, digital filters, neural network, adaptive filtering, wavelet domain, blind source separation, independent component analysis etc. A typical ECG signal consists of three waveforms, P-wave, QRS-complex and T-wave. Most of the clinically useful information in the FECG signal is found in the amplitude and duration of its waveforms.Approximately the number of fetal heart rate range is from 120 bpm to 160bpm[3, 4]. Changes in PR and PQ interval's , P-wave, T-wave and ST-segment and also in the width of QRS-Complex have been associated with the level of oxygenation.Lack of oxygen for a long period results in brain injuries for humans.In the case of fetus ,it may result in permanent damage to the fetus brain and nervous systems, so early diagnosis helps physicians to have an effective and appropriate intervention. The shape of the electrocardiogram signals for both the mother and fetus was simulated assuming that a mother's heart might produce a 4000 Hz sampling rate[5, 6]. The heart rate for this signal is approximately 89 beats per minute, and the peak voltage of the signal is 3.5 millivolts. The heart of a fetus beats noticeably faster than that of its mother, with rates ranging from 20 to 160 beats per minute. The amplitude of the fetal electrocardiogram is also much weaker than that of the maternal electrocardiogram. The heart rate for the fetal electrocardiogram signal corresponds to 139 beats per minute and a peak voltage of 0.25 millivolts. The measured fetal electrocardiogram signal from the abdomen of the mother is usually dominated by the maternal heartbeat signal that propagates from the chest cavity to the abdomen[10].The maternal electro cardiogram signal is obtained from the chest of the mother. The goal of the adaptive noise canceller in this task is to adaptively remove the maternal heartbeat signal from the fetal electrocardiogram signal. The noise canceller needs a reference signal generated from the maternal electrocardiogram to perform this task. Just like the fetal electrocardiogram signal, the maternal electrocardiogram signal will contain some additive broadband noise.

PROPOSED SYSTEM

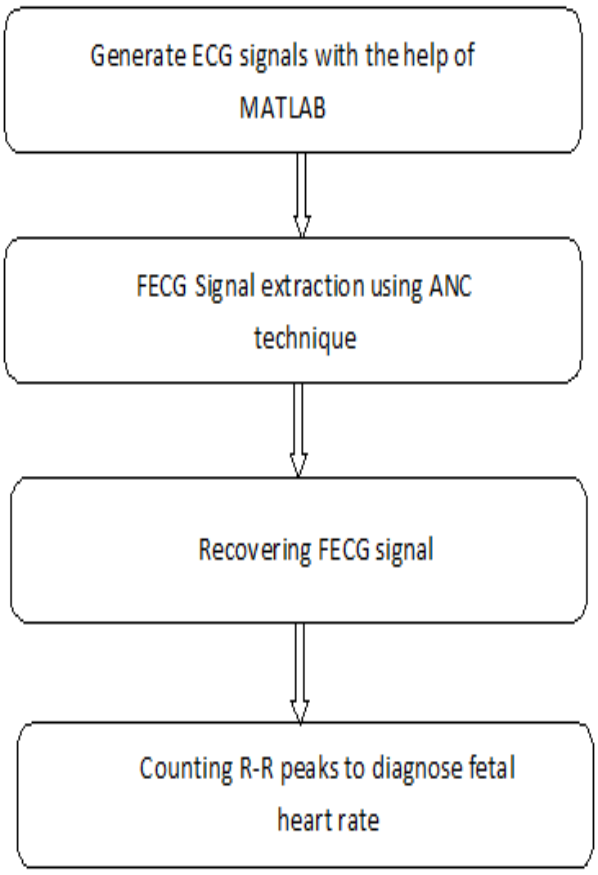

Figure 1
Algorithm for FECG Extraction

A. ECG signal generation in MATLAB

In this proposed system MATLAB tool is used for simulating ECG's of mother and fetus. The heart rate for this ECG signal is approximately 89 beats per minute, and the peak voltage of the signal is 3.5 millivolts. The heart of a fetus beats noticeably faster than that of its mother, with rates ranging from 120 to 160 beats per minute. The measured fetal electrocardiogram signal from the abdomen of the mother. It is usually dominated by the maternal heartbeat signal that propagates from the chest cavity to the abdomen.

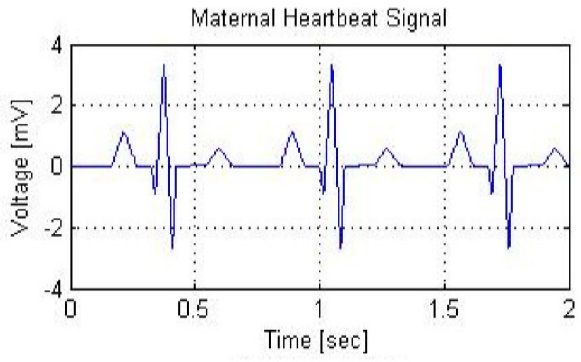

Figure 2
Maternal's ECG

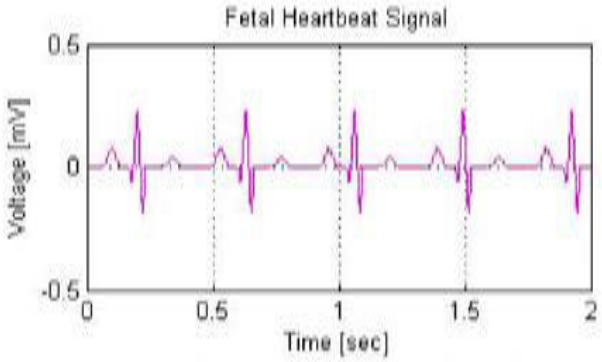

Figure 3
FECG ECG

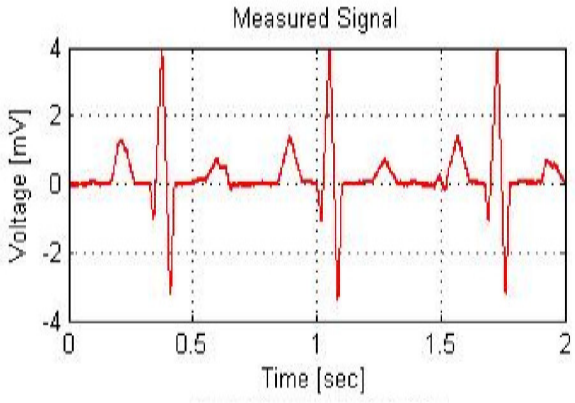

Figure 4
Measured FECG from abdomen

B.FECG Signal Extraction using ANC technique

Removal of background noise and artifacts from FECG signals using adaptive filters necessitates the application of two input signals; The primary signal is FECG signal added with MECG signal and the secondary signal is the reference signal which is the noise to be cancelled i.e., MECG signal. The secondary noise signal must be well correlated with the noise in the primary signal. Adaptive filters were used in fetal electro cardiography, in which a maternal heartbeat signal is adaptively removed from a fetal heartbeat signal. An adaptive filter operating in a stationary environment, the error-performance surface has a constant shape as well as orientation. When the adaptive filter operates in a non-stationary environment, the bottom of the error performance surface continually moves while the orientation and curvature of the surface may be changing too. Therefore, when the inputs are non-stationary, the adaptive filter has the task of not only seeking the bottom of the error performance surface, but also continually tracking it. The adaptive noise canceller can use almost any adaptive procedure to perform its task. For simplicity, we shall use the least-mean-square (lms) adaptive filter with 15 coefficients and a step size of 0.00007[7]. With these settings, the adaptive noise canceller converges reasonably well after a few seconds of adaptation, certainly a reasonable period to wait under this particular diagnostic application.

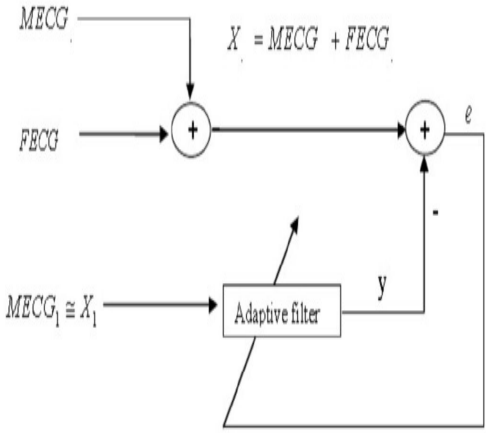

Figure 5
ANC

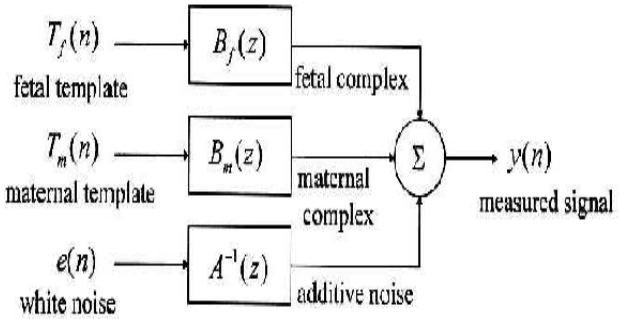

Figure 6
signal extraction through ANC

C.Digital filter for removal of signal interference

FIR filters are one of two primary types of digital filters used in Digital Signal Processing (DSP) applications, the other type being IIR. FIR filters can easily be designed to be "linear phase" without any phase distortion. They are suited to multirate applications like "decimation" (reducing the sampling rate) or "interpolation" (increasing the sampling rate), or both. Whether decimating or interpolating, the use of FIR filters allows some of the calculations to be omitted, thus providing an important computational efficiency. In order to fetal heart rate are the peaks corresponding R wave of the FECG need to be extracted. To achieve this in first stage an FIR filter is used with appropriate filter coefficients to remove high frequency. The peak corresponding to the R wave of the FECG are extracted by fixing the threshold value slightly around than the normal level. From the R-R interval the FETAL heart rate can be obtained. Extracted by fixing the threshold value slightly around than the normal level. From the R-R interval the FETAL heart rate can be obtained.

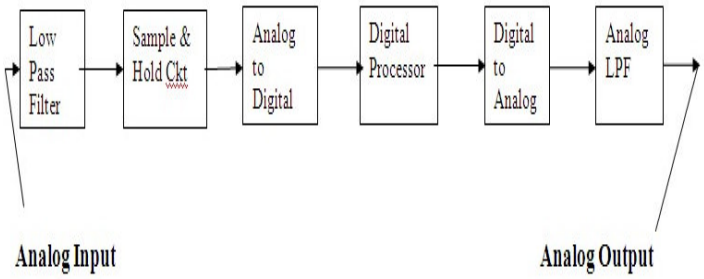

Figure 7
Block diagram of Digital filter

D. R-R peak detection

The idea is to clean up the signal, and then set some dynamic threshold, so that any signal crossing the threshold is considered a peak[1]. The peaks can be counted per time window. Fig. 9 shows the peaks that can be counted per time window and Fig. 10 shows the graph of FECG heart rate.

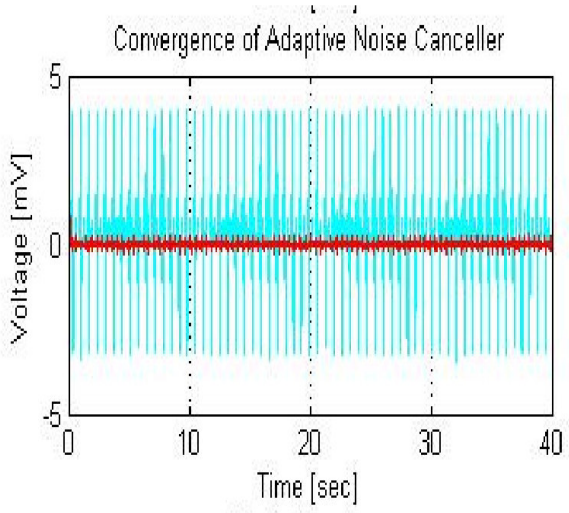

Figure 8
ANC output

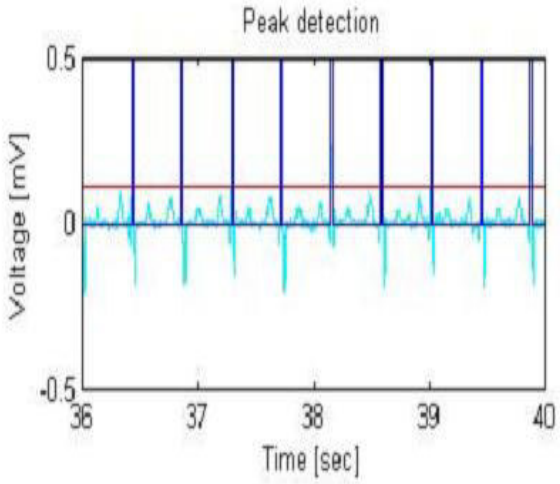

Figure 9
FECG peak detection

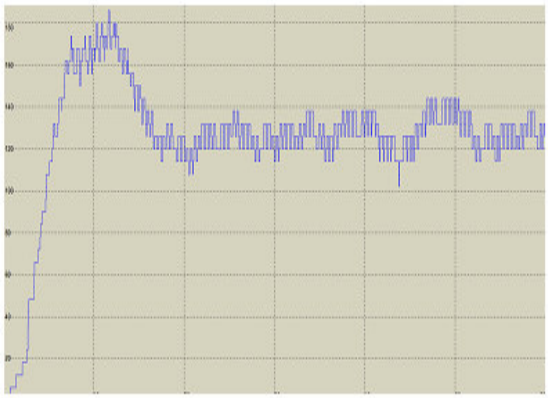

Figure 10
Fetal Heart rate signal

CONCLUSION

In a real biomedical signal analysis we deal with a noise. In case of the electrocardiography signal, the noise amplitude is relatively high. The impulsive noise decreases the signal quality and makes it difficult to analyze the signal without filtering. The result obtained through the proposed technique is shown. The various artifacts mixed in the ECG signal cannot be filtered directly because they pass through the human body. The FECG signal can be extracted from the maternal's ECG using filtering process. In this project, the filtering process is carried out by digital high pass filters. The FECG signal is filtered from interferences of internal organs and disturbances produced by power supplies during interpretation of ECG. Both fetal and maternal ECG signals are synthesized using different parameters for different shapes and beat rates of the two signals. The extracted signal is free from noise which provides the effective signal foranalyzing the condition of the fetus.

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