

# A Review on Fetal ECG Extraction

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**Abstract**— In the modern electronic medical evaluation of foetus and mother, Fetal electrocardiography monitoring is the common activity. However, for accurate monitoring many challenges related with the Fetal electrocardiography quality must be solved such as abdominal muscles noise and attenuating, low signal-to-noise-ratio (SNR) and power line interference (PLI) noise. During the last many decades, many signal processing methods for noise reduction technique have been proposed which are available in the literature. This article aims to present different signal processing methods for Single and Multichannel Channel Signal Sources of Fetal electrocardiography.

**Keywords**— Fetal electrocardiography, power line interference, signal processing, noise reduction technique.

## Introduction

Foetal monitoring during pregnancy is very important for both foetus as well as mother and it becomes a routine part of medical evaluation. It helps to detect so many factors which negatively affect the health of the foetus and mother [1]. Some problems are like intrauterine death, hypoxia, pre mature birth affects both foetus and mother. The two most important Foetal monitoring methods are fetal heart rate and fetal electrocardiography (FECG) are used nowadays to examine the health state of foetus during pregnancy. The characteristic of fetal electrocardiography like S-T segment, heart rate, wave form and dynamic behaviour are helpful in predicting the foetal maturity and congenital heart disease [2-4]. The fetal electrocardiography data acquisition is achieved by invasively using scalp electrode and non-invasively by using skin electrode. Because of the direct contact, invasively method is more effective in term of quality recording. But there is also some disadvantage such as there is chance of getting infection of foetus from their mother.

The fetal electrocardiogram as a weak element of the abdominal signals mixture. The source of the signal, that is fetus heart is located in maternal abdomen so that the signal of interest is available with very poor signal-to-noise-ratio (SNR) during different data acquisition technique. The fetal electrocardiogram signal propagates to maternal abdomen belly surface undergoes through many attenuating media such as electromyogram(EMG) of the abdominal muscles. Apart from that there exist some other source of noise which is responsible for poor SNR of fetal electrocardiogram. Among them, the electrohysterogram, power line interference and respiration's baseline wander effects are important unwanted noise usually present. The power line interference noise amplitudes can cross the the abdominal fetal electrocardiogram signal, because of that the noise component at 50Hz/60Hz is the most difficult noise analysis in processing. Any parasitic capacitance between the maternal abdomen surface and the ground or a time-varying electromagnetic induction through power cables for power supply network typically direct the power line interference noise.

## Methods

This section deals many methods based on single and Multichannel channel signal sources will be discussed such as wavelet transform (WT), correlation technique (CT), filtering techniques (FT) such as FIR and IIR filtering, empirical mode decomposition (EMD), Independent component analysis (ICA), singular value decomposition (SVD), blind source extraction such as Barros's algorithm (BA). All of these technique have been used for extraction and pre-processing of Fetal electrocardiography from abdominal mother ECG as shown in figure 1.

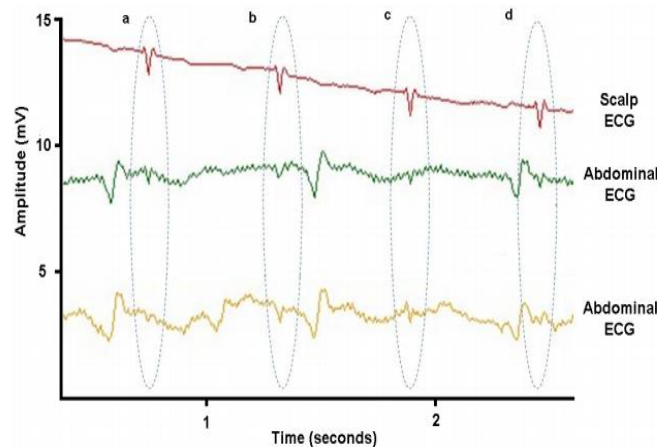


Fig. 1: Fetal heart beats (Circled) using invasively (upper trace) and non- invasively (lower two traces) [5]

### Single Channel Signal Sources

wavelet transform technique such as complex wavelet transform (CWT) and discrete wavelet transform (DWT) are very effective for non-stationary signals such as Fetal electrocardiography. Hassanpour et al. [6] used discrete wavelet transform for extracting of Fetal electrocardiography from abdominal mother ECG. They used heart beat waveform like wavelet.

Cross correlation and auto correlation method find the likenesses between Fetal electrocardiography and abdominal mother ECG at a particular time lag. Bommel [7] using this technique extracting a weak Fetal electrocardiography from abdominal mother ECG.

Filtering techniques is widely used in many problems for signal processing especially for removal of artifacts and noise. Power line interference (PLI) noise which is a type of narrow band interferences at 50Hz/60Hz can be removed by Notch filters [8-9]. Alcaraz et al. [10] removed the respiration's baseline wander effects by using an high pass filter at cut off frequency 0.5 Hz.

Principal component analysis (PCA) can be viewed as single channel blind source separation which is based on multi-algorithm fusion technique for fetal electrocardiography processing that was presented by He et al. [11].

Warbhe et al. [12] used Empirical mode decomposition technique that overcome the dependency on fixed pre-defined mother wavelet is totally data driven for non-stationary signals. They decompose the abdominal mother ECG into bandlimited functions called IMFs.

### Multichannel Signal Sources

Independent component analysis is used to extraction of fetal electrocardiography signal which is assumed to be statistically independent from abdominal mother ECG. This method needs minimum two electrodes. This approach consists of two steps in which the first involved the reduction of dimensionality followed using post processing stage that was showed by Ahuja et al. [13].

Singular Value Decomposition can be viewed as decomposition method which uses its basis functions for filtering the signal that was showed by De Lathauwer et al. [14].

Barros's algorithm is based on blind source extraction (BSE) algorithms which extracts desired signal from a noisy signal by using a priori knowledge. Zhang and Ye [15] used the autocorrelation function of the abdominal mother ECG and detected the fetal electrocardiography.

## Conclusion

In this paper different types of methods based on single and Multichannel channel signal sources is discussed regarding fetal electrocardiography extraction and pre-processing. The most common published technique are wavelet transform, Independent component analysis and Filtering techniques. A hybrid method based on the combination of two or more method discussed earlier passably give extension towards improve accuracy such as Independent component analysis together with ensemble Empirical mode decomposition that was showed by Liu and Luan [16]. These hybrid techniques provide accurate and extended analysis in clinical diagnosis and research.

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