Fetal ECG Extraction using LMS Filter

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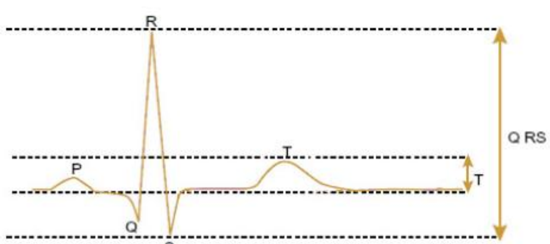
Abstract

In this project, proposed a new method for fetal ECG extraction based on wavelet analysis, the least mean square(LMS) adaptive filtering algorithm, and the spatially selective noise filtration (SSNF) algorithm. First, abdominal signal sand thoracic signals were processed by stationary wavelet transform (SWT),and the wavelet coefficients a teach scale were obtained. For each scale, the detail coefficients were processed by the LMS algorithm. The coefficient of the abdominal signal was taken as the original input of the LMS adaptive filtering system, and the coefficient of the thoracic signal as the reference input. Then, correlations of the processed wavelet coefficients were computed. The threshold was set and noise components were removed with the SSNF algorithm.

I. INTRODUCTION

Electrocardiogram (ECG) signals are widely used in health monitoring as a non-invasive way to establish clinical diagnosis of heart diseases. Conventional ECG monitoring systems are based on long-term recording (e.g., using Holter devices) that generate a vast amount of data requiring huge storage and transmission capacity. These devices record data during one to five days of a patient's normal daily life, and they are restricted by patient's mobility, transmission capacity and physical size Unfortunately, the fetal heartbeat signal yielded by this recording technique is quite weaker than the mother heartbeat signal, also due to the attenuation during the propagation caused by the tissues; moreover, many other signals are superimposed to the two heartbeats: artifacts such as mother breathing, uterine contractions, diaphragm, electrical line noise. Because of the low amplitude and the poor SNR, the fECG is hopelessly contaminated by the artifacts, therefore it is quite difficult to extract its shape, it is desirable to extract it and to trust a R-wave (see the Figure 1) extraction procedure as steady as possible towards the artifacts.



The fECG extraction is a typical blind source separation (BSS) problem and the first application of BSS techniques to fECG extraction was done by De Lathauwer etal.

[1], it is well accepted that Independent Component Analysis (ICA) is a suitable tool for separating the fECG "source" from the rest; some different ICA based procedures has been exploited so far: ICA estimated by INFOMAX algorithm [2] (applied to a dataset with eight sensors), ICA by JADE algorithm and a Wavelet-post processing consisting in baseline removal and denoising [3] (applied to five sensors), Singular Value Decomposition (SVD) and ICA by FastICA algorithm [4] (applied to a single channel recording), ICA by MERMAID algorithm [5] (applied to eight channels), a sensor array and electrode selection algorithm for fECG extraction by ICA proposed by F. Vrins et al. [6] (applied to one hundred sensors). we extract fetal ECG from abdominal signal using filtering techniques. Here, we use thoracic signal as reference signal for fetal ECG extraction. Fetal ECG extraction is done based on Stationary Wavelet Transform (SWT), the Least Mean Square (LMS) adaptive filtering algorithm and the Spatially Selective Noise Filtration (SSNF) algorithm related work

Dennis M.Healy, Jian Lu proposed Spatially Selective Noise Filtration technique for noise removal based on the direct spatial correlation of the wavelet transform at several different scales. The direct spatial correlation of wavelet transform contents at several adjacent scales enhanced major edges in the wavelet transform domain while the noise and small features were suppressed

Ali Khamene,presented a method for extraction of fetal ECG from the composite abdominal signal based on the detection of the singularities obtained from the composite abdominal signal using the modulus maxima locations of the abdominal signal are used to discriminate between maternal and fetal ECG signals. A reconstruction method is utilized to obtain fetal ECG signal from the detected fetal modulus maxima.

Jonathon A proposed an efficient method for extraction of fetal ECG based on sequential source separation in the wavelet domain. The distribution of the wavelet coefficients of the source signals is modeled by a generalized Gaussian probability density.

Hossein Hassain proposed a new algorithm for extracting and separating the mother heart signal, the fetal heart signal and the noise component from the combined ECG using Multivariate Singular Spectrum Analysis (MSSA)

II. PROPOSED WORK

In this project , we extract fetal ECG from abdominal signal using filtering techniques. Here, we use thoracic signal as reference signal for fetal ECG extraction. Fetal ECG extraction is done based on Stationary Wavelet Transform (SWT), the Least Mean Square (LMS) adaptive filtering algorithm and the Spatially Selective Noise Filtration (SSNF) algorithm. First, the abdominal signal and the thoracic signal are processed by Stationary Wavelet Transform.For each scale, the detail coefficients are processed by Least Mean Square algorithm. Then, the noise components are removed by Spatially Selective Noise Filtration algorithm **.**

In the block diagram (Figure 3.1), the abdominal signal and the thoracic signal were processed by Stationary

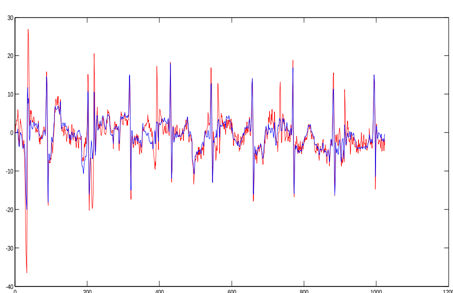


Fig. 3.1 Block Diagram of Fetal ECG Extraction From Abdominal Signal Using Filtering Techniques

Wavelet Transform and the wavelet coefficients at each scale were obtained. In wavelet decomposition , the bior1.5 wavelet was chosen from matlab wavelet toolbox after comparison from various families and the decomposition scale was set to 5. At each scale, the detail coefficients are processed by Least Mean Square algorithm.

The coefficients of the abdominal signal was taken as the original input and the coefficients of the thoracic signal was taken as the reference input of the adaptive filtering system. The correlation of the wavelet coefficients were computed. The threshold was set and the noise components were removed by Spatially Selective Noise Filtration algorithm. The processed wavelet coefficients were reconstructed by inverse SWT to obtain fetal ECG.

III. RESULTS AND DISCUSSION

The simulation result of separated maternal ECg and fetal ECG using the Least Mean Square algorithm and Recursive-Least-Squares (RLS) with the abdominal signal as desired input and thoracic signal and reference input is shown in figure 4.1.

The result obtained after applying SWT and LMS at 5 different scales are shown in Figures 4.2,

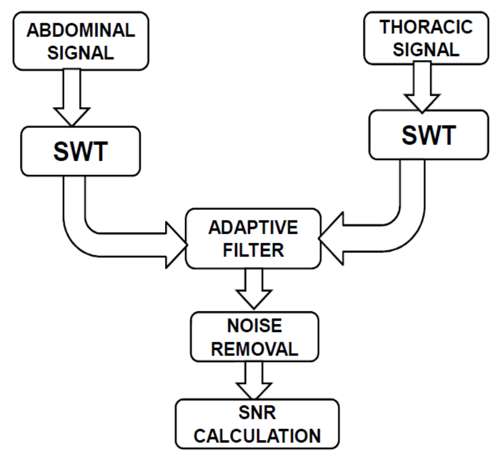


Fig 4.2 Maternal and Fetal ECG at 1st level Decomposition

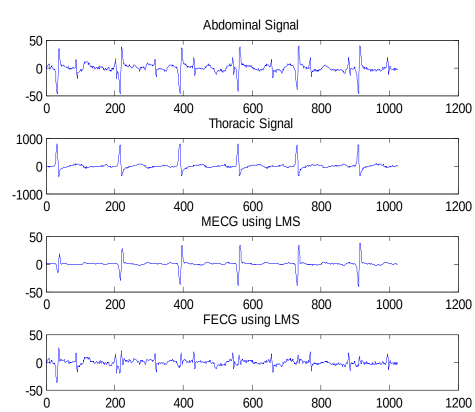


Fig 4.3 Maternal and Fetal ECG At 2nd Level Decomposition

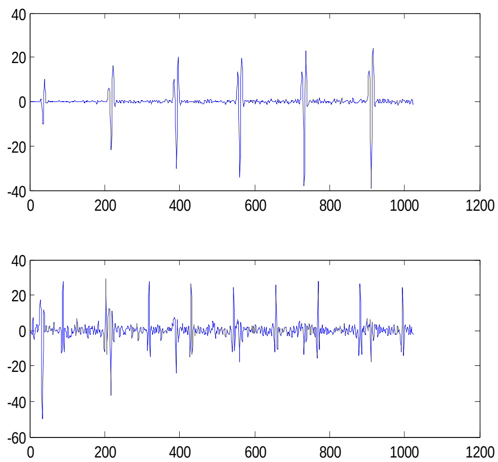


Fig 4.4 Comparison of LMS and RLS+SSNF Algorithm

The results obtained after the comparison of LMS alone with that of our algorithm is shown in Figure 4.4

IV. CONCLUSION

The proposed method outperforms the LMS adaptive filtering algorithm by showing improvement in case of superimposition R-peaks of Maternal and Fetal ECG.The noise disturbance is eliminated by incorporating the SSNF algorithm and the extracted waveform is more stable. The performance has been proven by SNR calculation quantitatively.

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