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EXTRACTION, NOISE CANCELLATION AND MONITORING OF FETAL ELECTROCARDIOGRAM

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The Fetal Electrocardiogram (FECG) signal reflects the electrical activity of the fetal heart. It contains information about the health status of the Fetus and therefore, an early diagnosis of any cardiac defects before delivery increases the effectiveness of the appropriate treatment. This paper proposes the use of Adaptive Neuro Fuzzy Inference Systems (ANFIS) for Fetal Electrocardiogram (FECG) extraction from two ECG signals recorded at the Thoracic and Abdominal areas of the mother's skin. Wavelet transform is performed on ANFIS output to extract pure FECG with high Signal to Noise Ratio (SNR) and low error rate. The effectiveness of this technique is underlined in this paper.

Index Terms: FECG, MECG, ANFIS.

1. INTRODUCTION

The Fetal Electrocardiogram (FECG) reflects the electrical activity of fetal heart which contains information on the health status of fetus. The FECG reflects the health

of fetus. There are several technical associated with the noninvasive extraction of FECG from Electrocardiogram (ECG) signals recorded at the abdominal surface. These problems are mainly due to the low power of the FECG signal which is contaminated by various sources of interference. These sources include the maternal ECG (MECG), the Maternal Electromyogram (EMG), 50 Hz power line interference, baseline wander and random electronic noise [2],[3]. By using low noise electronic amplifiers with high common mode rejection ratio, the effect of the 50 Hz interference and electronic random noise can be eliminated. The EMG noise can also be reduced but not necessarily eliminated with the use of classical low pass filtering techniques. Therefore, it is safe to say that if one is able to eliminate the Maternal ECG component in the composite signal, a reasonable estimate of the FECG signal can be obtained. To further enhance this FECG estimate, especially its P and T waves, one needs to apply post filtering techniques.

2. OBJECTIVE

In this paper we propose to detect heart problem of Fetus before delivery. We extract Fetal ECG from abdominal ECG by using different extraction techniques and compare the different techniques to extract Fetal ECG. The optimized technique is selected to detect the heart problem of Fetus. Finally the optimized technique is implemented in Field Programmable Gate Array (FPGA).

3. EXTRACTION AND MONITORING OF FETAL ECG

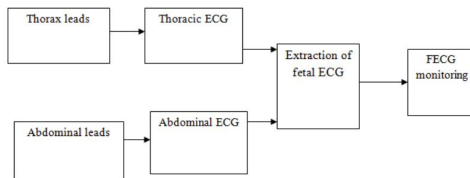


Fig. 1 Block Diagram of Extraction and Monitoring of Fetal ECG

Different filtering techniques like Adaptive Filtering techniques, Tapped Delay Line Adaptive Linear Network, Adaptive Neuro Fuzzy Interference System (ANFIS) were applied for the extraction of FECG.

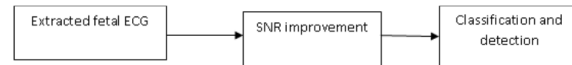


Fig. 2 Block Diagram of Monitoring Fetal ECG

Fetal ECG monitoring is divided in to two parts first one is SNR improvement and second one is Classification and detection. After the Fetal ECG was extracted, monitoring of the same was implemented to study conditions like- Fetus is alive or not, twins are present or not, find Arrhythmia like Tachycardia, Bradicardya. To further enhance this FECG estimate especially its T and P waves one needs to perform Signal to Noise Ratio (SNR) improvement [5]. Here we perform SNR improvement by using Wavelet Denoising.

4. RESULTS AND SIMULATION

Extraction of Fetal ECG from Abdominal ECG by using different techniques like LMS adaptive filter, Sign Sign adaptive filter, Sign Data adaptive filter, RLS adaptive filter, Kalman Filter, Tapped Delay Line Adaptive Linear Network, ANFIS, Wavelet transform after and before ANFIS were implemented using MATLAB® and their results were compared. The following

figures show the extracted ECG signal from the abdominal ECG by different techniques

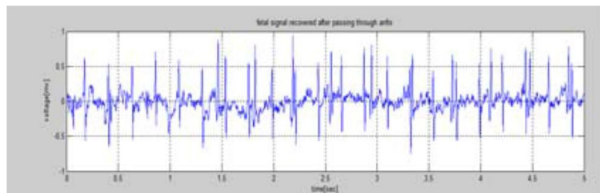


Fig. 3 Extracted Fetal ECG using ANFIS

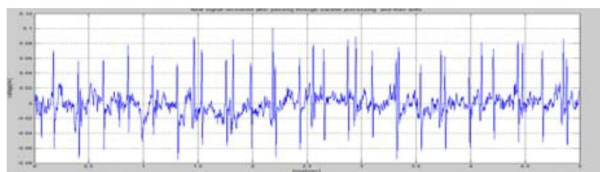


Fig. 4 Extracted Fetal ECG using Wavelet Denoising followed by ANFIS

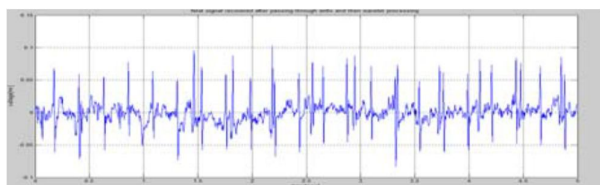


Fig. 5 Extracted Fetal ECG ANFIS followed by Wavelet Transform

It was found that ANFIS followed by Wavelet Denoising gave more accurate result.

The table below shows the comparison of the heart beat of Fetal by using different filtering techniques. It shows that ANFIS then Wavelet show a result of 97.13% correct.

Table 1: Comparing the Heart Beat of Fetal by using all Filtering Techniques

Filtering algorithm	Actual heart beat measured of fetal	Error in %	Correctness of result in %
LMS	208	49.6	50.4
Sign sign	280	87.05	12.95
Sign error	168	20.8	79.2
Sign data	224	61.15	38.85
RLS	88	36.6	63.4
Kalman	96	30.9	69.1
Tapped delay line	80	42.4	57.6
ANFIS	150	7.9	92.1
Wavelet ANFIS	+160	15.1	84.9
ANFIS wavelet	+135	2.87	97.13

5. FPGA IMPLEMENTATION OF PROPOSED SYSTEM

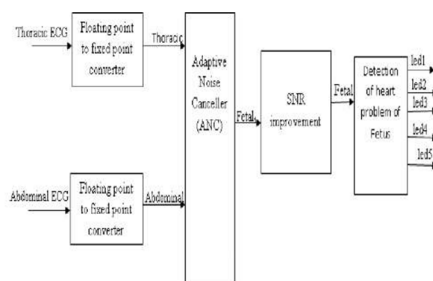


Fig. 6 Layout of Proposed System

The FPGA implementation of proposed system contains a Floating Point to Fixed

Point Converter, an Adaptive Noise

Canceller (ANC) with Adaptive Neuro Fuzzy interference System, a Signal to Noise Ratio (SNR) improvement and a detection unit. The Simulation results of different blocks can be seen in the following figures.

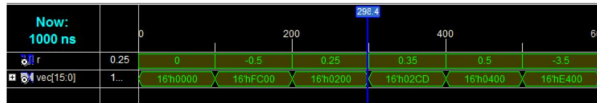


Fig. 7 Test Bench of Floating Point to Fixed Point Conversion

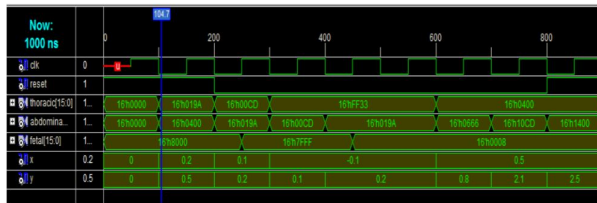


Fig. 8 Test Bench Waveform of ANFIS

The figure below shows the FPGA implementation of detection of heart problem of Fetus when reset='0'. Figure show Led1 glows indicating Fetus is alive.



Fig. 9 FPGA Implementation of Detection of Heart Problem of Fetus.

6. CONCLUSIONS

The ANFIS techniques of extraction of Fetal ECG by using Abdominal ECG and Thoracic ECG and the SNR improvement using wavelet transform were found to be promising. The Adaptive Noise Canceller with ANFIS was implemented in FPGA and the actual result was compared with Test Bench result and we got both results as nearly equal. A Detection Block was implemented and verified using Xilinx FPGA. Better technique than ANFIS should be studied and implemented. For SNR improvement measure other techniques should be studied to get more processing result.

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