FATAL ECG MONITORING SYTEM

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Abstract- In this proposed system, we remove FECG from background noise and artifacts with the help of DSP application of Adaptive filter.

Keywords—FECG, MECG, MATLAB, Adaptive filter, Noise.

I. INTRODUCTION

With the help of Fetal electrocardiogram, we are able to monitor beat to beat variable. There is technical problem with non-invasive extraction of ECG. The fetal ECG signal gets corrupted by other sources like maternal ECG. The different type of signals , noise , overlapping frequencies and low amplitude signals make the extraction of FECG more critical. The main task of electronic fetal monitoring is to extraction and analysis of fetal ECG. The digital signal processing plays an important role in the extracting this signals. Abdominal ECG signal (AECG) is a non-linear combination of the maternal ECG, fetal ECG signal and other interference signal is the primary assumption. We record two signals form mother skin one is at thoric and second is abdominal area. The abdominal electrocardiogram is a mixing of both maternal and fetus ECG signal whereas the thoracic ECG (TECG)is considered as completely maternal signal. Suppression of maternal ECG in composite abdominal signal is required to extract the fetal ECG. MECG cancellation is a special case of optimal filtering which can be obtained when the information about the thoracic signal is available. Besides the problem of electrode placement, noise from electrography activity affects the signal due to the low amplitude signal of fetus. Another interfering signal is maternal ECG which has the intensity 5 to 10 times higher than the FECG. The maternal ECG affects all the electrodes which are placed on the chest (thoracic electrode) Fetal ECG Extraction using Adaptive Filter and those placed on the abdomen (abdominal electrode). Due to weak nature of the fetal ECG , the Because of the weak nature of the FECG, electrodes placed on the pregnant women will difficult record any FECG .If we are able to eliminate the maternal ECG from composite signal , the fetal signal can easily extract.

II. LITERATURE SURVEY

non-linearities and a flexible non-linear model are two models adopted by Yalan Ye et.al which are the switching technique of separating mixture of pure sub-Gaussian source signals and super-Gaussian source signals [1]. The shapes of the electrocardiogram signals for both the mother and fetus are simulated assuming that a mother's heart might produce a 4000 Hz sampling rate. The peak voltage of the signal is

3.5 millivolts and heart rate are 89 beats per minutes .About 20 to 160 beats per minute the fetus heart rate is beat which is faster than that of heart rate of mother. The amplitude of

Submitted: 21/10/2022 **Accepted**: 30/11/2022

maternal signal is much greater than that of the fetus. The heart rate for the fetal electrocardiogram signal corresponds to 139 beats per minute and a peak voltage of 0.25 millivolts[2]. The signal which is propagate from the chest cavity of the mother is highly dominated by the maternal signal measured fetal electrocardiogram. Linear FIR filter with 10 randomize coefficient can describe the adaptive f propagation . To stimulate any broadband noise source can be added with small amount of uncorrelated Gaussian noise. Through the chest of the mother maternal signal can be obtained. The prime purpose of the adaptive noise canceller is to extract maternal heartbeats from the fetus heartbeats. Maternal ECG is required as a reference to the noise canceller to perform this action. Like fetus electrocardiogram maternal electrocardiogram also contain the adaptive broadband noise. As the fetal electrocardiogram signal, the maternal electrocardiogram signal also contains some additive broadband noise[3].

About 77.9% of the time fetal heart rate pattern is the most similar during labour .The category II and category III pattern occurred 22% of the time during labour, and only 0.004% of the time during labour respectively. [4].

III. IMPORTANT TERMS

1. Fetal:

The fetal heart monitoring using external equipment is performed using attaching the external transducer to the mother‶s abdomen with the help of elastic straps. With the help of Doppler ultrasound, we can detect the fetal heart movement and that information is sent for the monitoring which calculate and record the fetal heart on continuous strip of paper. In the modern era fetal heart monitors using microprocessors along with mathematical procedure to improve the fetal rate accuracy recording.

Nurse evaluates the strip door continuity and the accuracy for interpretation at the time of monitoring, to get an idea of the baseline fetal heart rate and presence of variability. To understand whether there are accelerations or decelerations from the baseline that could be identified using patterns of uterine contraction, and it correlate with the accelerations and decelerations with the uterine contractions. This is useful to the nurse to predict whether the fetal heart rate recording is reassuring, no reassuring, or ominous. This can help to deliver baby in best situation.

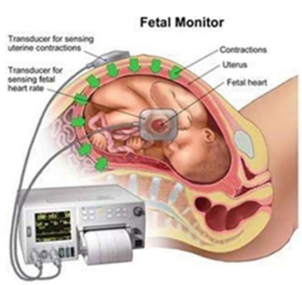


Figure 2. Fetal heart system

The range of fetal rate varies in the range of 120 to 160 beats per minute. A continues deflection from the baseline (variability) shows a healthy nervous system, chemoreceptors, baroreceptors and cardiac responsiveness. Beat-to-beat, or short-term, variability is a Indicator. Loss of this deflection may indicate an ominous condition; however, it can also indicate healthy rest-activity in the fetus or depression of the central nervous system due to medication. In the increasing in the deflection ,will result in the acute hypoxia or mechanical compression of umbilical cord.

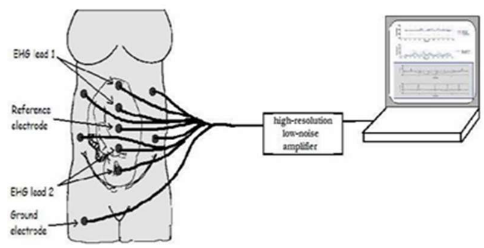


Figure 3. Extracting Fetal ECG signal

2. Classification of fetal heart

About 77.9% of the time fetus heart rate pattern to be the most similar during labour .The category II and category III pattern occurred 22% of the time during labour, and 0.004% only at the time of labour respectively.

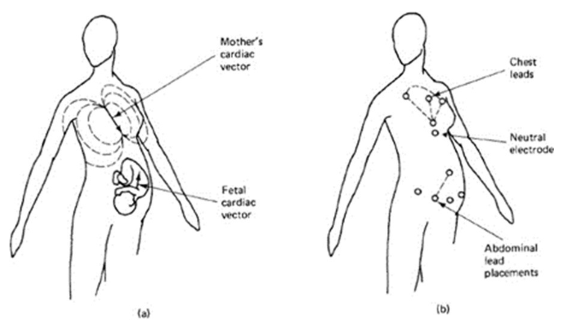
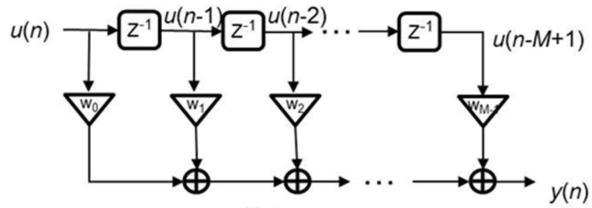


Figure 3. Fsield vectors of mother and fetus and Placement of leads

LMS filter :

Widor and Hoff developed LMS algorithm in the year 1959. Which is widely used in various application in adaptive filter. The main features of LMS algorithm is that it has Low computational complexity, stable behaviour and proof of convergence in the stationary environment.



$$y(n) = \sum_{k=0}^{M-1} w_k u(n-k)$$

Figure 4. LMS filter

An easy convergence and simple implementation is the LMS algorithm where convergence is dependent upon the size of the step. Figure 4 shows the block diagram of Least Mean Square Algorithm.

w is the filter coefficients (weight), k represents the order of the filter. In this design we implement Finite Impulse Response FIR filter and made it adaptive in nature. FIR filter is most stable than that of the IIR Filter [5].The LMS filter mimics the mother‟s body from the chest to the stomach. The Adaptive LMS filter used has 8 as the order of the filter and w coefficient is initialized.

3. Adaptive Filter

Most of the used adaptive procedure to perform its task is done by adaptive noise canceller. For our simplicity purpose we use (LMS)adaptive filter with 15 coefficient and a step size of 0.0007.With the help of these, the adaptive noise canceller converges reasonably well after a few seconds of adaptation-certainly a reasonable period to wait given this particular diagnostic application, as shown in fig.2e.

FECG s(nT)

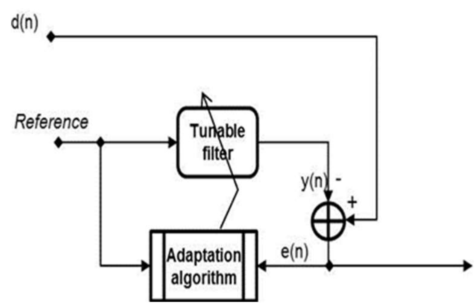


Fig. 5: Block diagram of adaptive filter

„h‟ represents changing path of signal x. At the beginning stage transfer function didn‟t know. To estimate the transfer function LMS algorithm perform the main task. With the help of convolution, we can calculate the signal distortion which we represent by „d‟. Here „d‟ is the echo and h are the transfer function of the hybrid. We are terrifying to create „w‟ using adaptive filter. The transfer function is used for calculating an approximate of the echo. The estimate echo is represented by y.

To get the output signal from algorithm we need to add those signals

S (n) represents the coefficients of the adaptive FIR filter tap weight vector at time n. The step size represents by „µ
„which is a small positive constant. This step size parameter used to the influence of the updating factor. Selection of a particular value for µ is imperative to the performance of the LMS algorithm, if the value is too small the time the adaptive filter takes to converge on the optimal solution will be too long; if µ is too large the adaptive filter becomes unstable and its output
diverges.

IV. CALCULATIONS AND RESULTS

In our LMS Adaptive Filter the algorithm follows below 5 steps and is also shown in figure 4 as a block diagram

1. Set the order of the filter to 8 and initialize the w
coefficient.
2. Compute the predicative output y(n) which is the filtered output signal.

$$y(3)=\sum_{k=0}^{2} w_k u(3-k) = w_0 u(3) + w_1 u(2) + w_2 u(1)$$

e=d-y (1)

Here, „e" represents error signal.
The input signal x and error signal is used for calculating the filter coefficient vector „w". the main issue is to selecting filter weight is that the path is not stationary. Hence, the weight of the filter must updated so that the adjustment to the variation person smoothly. The filter used is an FIR filter with the form

W= W0 (n)+W1 (n) Z-1+….+WN-1 (n)Z- (N-1) (2)

The LMS algorithm is a type of adaptive filter known as stochastic gradient which is based on an algorithm as
it utilizes the gradient vector of the filter tap weights to converge on the optimal Weiner solution.
With each iteration of the LMS algorithm, the filter tap weights of the adaptive filter are updated according to the following formula

W (n+1)=w (n)+2µe (n)x (n) (3)

Here x (n) is the input vector of time delayed input values,
X (n) = [x (n) x (n-1) x (n-2) …..x (n-N+1) T .

The vector w (n) = [w0 (n) w1 (n) w2 (n) .. wN-1 s(n)] T

TABLE I
VARIABLE USED AND THEIR DEFINITIONS

Symbol	Definitions
λ	Maximum of Eigen values
$d(n)$	Measured Fetal Electrocardiogram
$u(n)$	Measured Maternal Electrocardiogram
w	Filter Coefficients
k	Filter Order
μ	Condition for Convergence
$e(n)$	Error Signal
y(n)	Filtered Output

Fig 6. Step wise algorithm

3. **Calculate the estimation error**

$e(3) = d(3) - y(3)$

4. Compute the new w coefficients as the adaptive new weights

$w(n+1) = w(n) + \mu u(n)e(n)$

5. These weights by circulate computing new filtered output signal until the total input MECG signal is filtered.

Figure 6 is the step wise algorithm implementation with Filter Order of 3 for demonstration purpose. The filtered Measured Maternal Electrocardiogram MECG signal is the heart beat signal of mother transmitted to the stomach. Measured Fetal Electrocardiogram MECG+FECG cancels the filtered MECG. The cancellation error is the baby‟s heartbeat. The error signal is about 0.26 mV level which is the babies.

Results:

An adaptive noise canceller based fetal electrocardiogram extraction method is proposed and implemented. The FECG signals can be extracted from the abdominal electrocardiogram signals using LMS algorithm for changing tap-weight vector. Software implementation of LMS algorithm is presented to implement the ANC system. Fetal heart rate signals are extracted from the peaks of R-R interval.

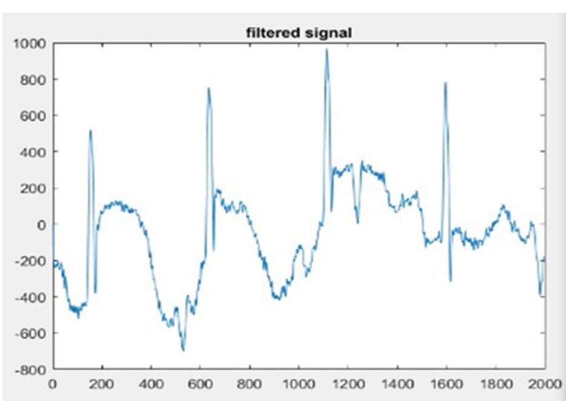


Fig 7: LMS filter output

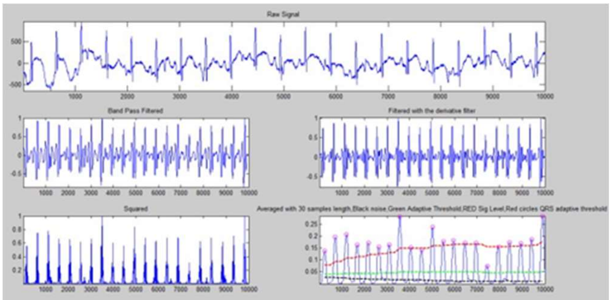


Fig. 8: Derivative filter output

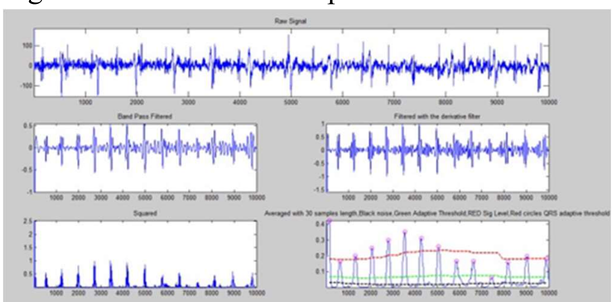


Fig 9 Square Output

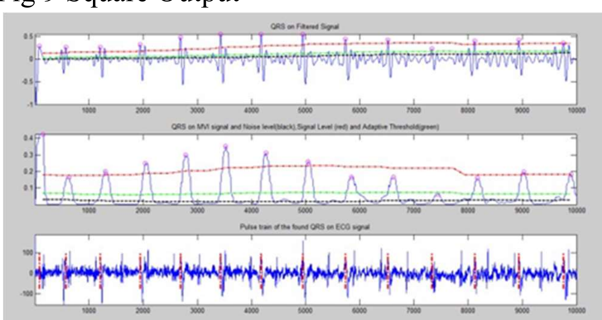


Fig10. QRS detection

Results of Fetal ECG Extraction on different ECG's

Sr. No.	Input ECG	Materna l Heart Beat(BP M)	Fetal Heart Beat (BP M)	Conditi on
1.	r01	93.8443	128.3 285	Normal
2.	r04	80.5868	123.9 285	Normal
3.	r07	112.864 5	126.7 293	Normal

4.	r08	7.9271	128.2 462	Normal

ACKNOWLEDGMENT
We would like to express gratitude towards Prof. Nilima Warade All India Shree Shivaji memorial institute of information technology, Shivajinagar, pune for guiding throughout the adaptive filter.

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