International Journal on Recent and Innovation Trends in Computing and Communication ISSN: 2321-8169
Volume: 4 Issue: 4 427 - 430

Fetal Electrocardiography Using Efficient Adaptive Algorithm

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***Abstract*:-**This paper presents a proficient least mean square algorithm for removal of noise. A measured cardiacsignal contains an unknown signal and interference signal. The aim is to design a LMS based noise cancellers. Adaptive algorithms used in many applications like identification, channel equalization, additive feedback cancellation in hearing aids, fetal monitoring, electroencephalogram filtering. We will focus on fetal monitoring that adaptively removes the maternal heartbeat signal from the electrocardiogram signal of fetus.

***Keywords*—** *Adaptive filtering, Least mean square,MME, MFE*

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I. INTRODUCTION

Adaptive filter [1] is a computational device that attempts to model the relationship between two signals in an iterative manner practically. Adaptive filters are self-learning or self-adjusting filters. As the noise signal pass through the filter continues, theself-adjustingadaptive filter coefficients get the desired result, such as recognizing an unknown filter or cancelling unwanted noise signal from input signal. Most adaptive filters are digital filters that perform digital signal processing due to the complexity of the optimizing algorithms. To obtain the best performance of an adaptive filter needs usage of the best adaptive algorithm with low computational complexity and a fast convergence rate.Adaptive algorithm is a process of adjusting the parameters of an adaptive filter to minimize a cost function chosen for present task The LMS algorithm [2] is the most popular and frequently used adaptive algorithm. This section describes LMS algorithm and their development process to gain a better understanding of adaptive filtering techniques. In many practical application LMS algorithm is used. Fetal electrocardiogram monitoring [3] is one of the good example of LMS adaptive filter. Fetal electrocardiography [4] is a technique for obtaining important information about the condition of the fetus during pregnancy, in which the electrical signals generated from fetal heart, is measured by multi-channel electrodes placed on the mother's body surface. The recording method of the fetal ECG from the mother's body, not in contact with the fetus (which is highly advantageous) is called non-invasive method. The Least Mean Square Algorithm will use two measured cardiac signals i.e. Measured Maternal Electrocardiogram (MME) and Measured Fetal Electrocardiogram (MFG) to perform the adaptive filtering in fetal electrocardiography [5-6].

II. ADAPTIVE FILTER

Filters used for noise cancellation purpose can be adaptive or fixed. The design of fixed filters is based on prior knowledge of both the speech signal and the noise signal. Other side, adaptive filters have the ability to adjust their own parameters themselves, and their design needs too little or no prior knowledge of signal or noise characteristics of speech signals. Adaptive filtering is a process in which the parameters used for the processing of signals changes according to some criteria. Usually the criterion is the estimated mean or the correlation.The adaptive filters are time varying because their parameters are continually changing in order to meet a performance requirement. Adaptive filter can be considered as a filter that performs the approximation step on line. Usually the definition of the performance criteria needs the reference signal existence that is usually hidden in the approximation step of fixed filter design. Adaptive filtering algorithms which have the adjusting mechanism for the filter coefficients are firmly related to classical optimization techniques, all calculations are carried out in an off-line manner. Adaptive filter is sometimes trace the optimum behavior of a slowly varying environment due to its real time self-adjusting characteristics.

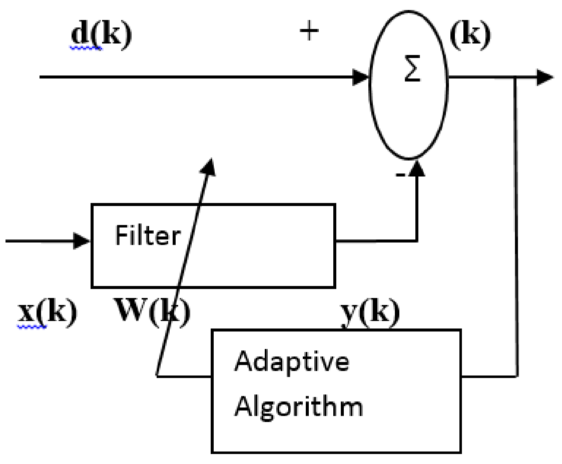

Fig 1: General set up of adaptive filter

III. LMS ALGORITHM

The Least Mean Squarealgorithmwas developed by Bernard Widrow. It was the first widely used adaptive algorithm. It was still popularly used in adaptive digital signal processing and adaptive antenna arrays, primarily due to its simplicity, easy implementation and better convergence properties.The LMS Algorithm is successful algorithms due to its efficient storage requirement and computational complexity. LMS algorithm is based upon the steepest descent approach. Basic LMS algorithm updates the filter coefficients after each and every sample of speech sample. An LMS algorithm is the best choice for many real-time systems. There are many types of LMS based algorithms, which include the Normalized LMS, Variable step size LMS, complex LMS, block LMS algorithm and the Time sequenced LMS algorithm.LMS adjusts the adaptive filter taps. LMS is improving them by an amount proportional to the instantaneous estimate of the error surface gradient. After few seconds of adaptation of the filter.There is no need of correlation function calculation or matrix inversions. Due to this it is very simple and easier algorithm examines and compares to different another algorithm. Adaptive filter based on least mean square will remove the interference signal from measured signal by using a reference signal. The filtration of signal is obtained by designing a least mean square adaptive filter with step size and a specific order that will confirm the adaptation to converge after few seconds of adaptation of the filter.

A.Operation of the least mean square algorithm:

LMS algorithm involves two basic processes.

1. Filtering process 2.Adaptive process
A filtering process which involves two steps. Primary step includes computing the output of a transversal filter produce by a set of tap input and second step includes generation of estimation error by computing this output to a desired response.An Adaptive process, which includes the automatic updating the tap weight according to the estimation error of the filter. Since a feedback loop around the LMS algorithm, establish by the combination of these two processes as illustrated in fig 2.The filtering process is performing by transversal filter so that LMS algorithm is built around transversal filter. Adaptive control mechanism is performing by adaptive filter as explain in fig 2.A hot over the symbols is used for the tap-weight vector to differentiate from the value obtained by using the steepest descent algorithm. The result in three basic relations as follows:

1] Filter output: $Y(n) = \hat{w}(n).u(n)$ ----- (3.1)

2] Estimation error: $E(n) = d(n) - y(n)$----- (3.2)

3] Tap-weight adaptation:

$\hat{W}(n+1) = \hat{w} + \mu u(n)e^{*}(n)$ ---------- (3.3)

The computation of the estimation error e(n) which is based on the present evaluation of the tap-weight vector ŵ(n) is given by equation (3.1) and (3.2). Note that the correlation that is applied to the current estimate of the tap-weight vector, ŵ(n) is represented by the second term μu(n) e*(n), on the right side of equation (3.3). The correlative procedure is started with an initial guess ŵ(0). The algorithm described by equation (3.1) to (3.3) is the complicated form of the adaptive least-mean-square (LMS) algorithm. At each time updating, it is also necessary to know a prior knowledge of the recent values u(n), d(n) & w(n).

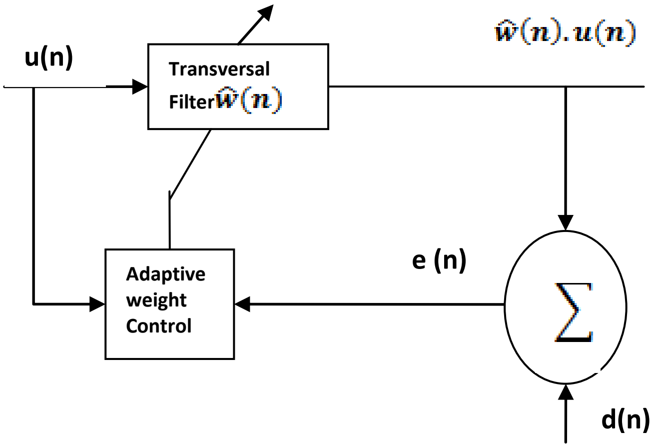

Fig 2: Basic block diagram of Adaptive Processing

B. Simple Implementation steps for the LMS algorithm:

1. Firstly define the desired response. Set each coefficients weight to zero.
2. Second step is that to move all the samples in the input array one position to side right position, then load the present data sample k into input array. Calculate the output of the filter by multiplying every element in the filter array of filter coefficients by the corresponding element in the input array and all results are added up to give the output corresponding to data that was earlier loaded into input array.
3. Before filter coefficients can be updated error must be calculated, simply find difference between the desire responses and filter output.
4. To update filter coefficients multiply the error by μ, called as learning rate parameter and then multiply result by filter input and sum up this values of result to previous filter coefficients value.

IV. APPLICATIONS OF ADAPTIVE FILTERING

There are many applications of adaptive filtering such as identification which includes Channel identification, Plant identification and Channel identification. Other applications of adaptive filtering are Linear predictor, Inverse modeling, Jammer Suppression, Echo cancellation, voice and data echo cancellers,Multiple-input multiple output(MIMO) echo cancellation, adaptive feedback cancellations in hearing aids, Fetal monitoring in which cancelling of Maternal ECG during labour, Electroencephalogram filtration, digital communications, smart antenna systems, Blind system equalisations and many more.

ISSN: 2321-8169
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We will focus on details of filtering of Fetus electrocardiogram.

A. Fetal Electrocardiography

Procedure of fetal electrocardiogram (FECG) extraction has played an important role in medical diagnosis during stage of pregnancy. Heart rate of fetus supervising is one of the possible solution to test fetal well-being and to diagnose possible future abnormalities. Fetal monitoring during pregnancy stage empowers the physician to diagnose and recognize the pathological condition especially asphyxia [7].

The LMS algorithm based adaptive filter use for the filtration of cardiac signals. The Least Mean Square Algorithm will use two measured signals i.e. Electrocardiogram of mother as well as Electrocardiogram of fetus to perform the adaptive filtering.

Measured Maternal Electrocardiogram (MME): The recorded signal obtained from the chest of the mother is called as Measured Maternal Electrocardiogram (MME). Approximately heart rate for this signal is 89 beats per minute, and the signal peak voltage is nearly equal to 3.5 millivolts [5].

Measured Fetal Electrocardiogram (MFE): The recorded signal obtained from the abdomen of the mother is called as Measured Fetal Electrocardiogram (MFE). This signal is influenced by the mother's heartbeat signal that passes from the cavity of chest to the abdomen of mother [6]. The heart of a fetus beats concern faster than that of the mother. The range of heart beats is from 120 to 160 beats per minute for fetus [5]. The amplitude of the fetal electrocardiogram is also much powerless than that of the maternal electrocardiogram. The peak voltage of the Measured Fetal Electrocardiogram signal is nearly equal to 0.25 millivolts. The recorded Measured Maternal Electrocardiogram (MME) and Measured Fetal Electrocardiogram (MFE) both signals are stored as a data file. It includes the values of three variables:

MFE: the measured fetal electrocardiogram

MME: the measured maternal electrocardiogram

F: the sampling frequency of the ECG data.

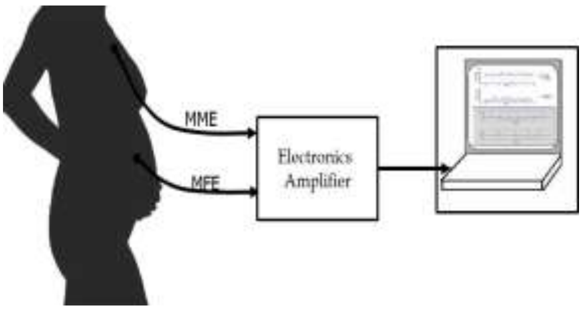

Fig 3: Block diagram of fetal and Maternal ECG taken from Mother

Figure 3 shows the block diagram of Fetal and Maternal Electrocardiogram taken from Mother and transferred to Digital form. In filter design we used Finite impulse response filter and made it adaptive in nature. FIR filter is always more stable than IIR Filter [8]. The LMS filter mimics the mother's body from the chest to the stomach. The Adaptive LMS filter set the order of the filter and w coefficient is initialized.

Adaptive filter follows below 5 steps:

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 (n) = $\sum_{k=0}^{M-1} w_k(n)u(n-k)$
3. Calculate the estimation error

e(n) = d(n) – y(n)

4 Compute the new *w* coefficients as the adaptive new weights.
w(n+1) = w(n) + µu(n)e(n)

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

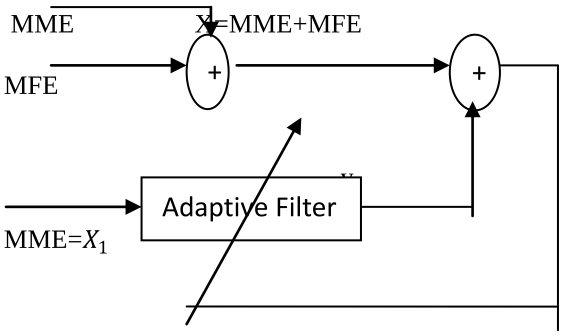

Fig 4: Adaptive Noise Canceller

Figure 4 show that adaptive filters needs the application of two input signals for removal of artifacts and background noise from fetal electrocardiogram signals using ; The primary signal is Measured Fetal Electrocardiogram signal added with Measured Maternal Electrocardiogram signal and the secondary signal is the reference signal which is the noise to be canceled i.e., Measured Maternal electrocardiogram signal. The Measured Maternal signal (MME) is used as reference signal. Adaptive FIR filter minus the filtered Measured Maternal Electrocardiogram from Measured Fetal Electrocardiogram by least mean square algorithm which is used by adaptive FIR filter.

V. CONCLUSION

It was verified how adaptive algorithms are used to adjust the coefficients of a digital filter to achieve a desired and time-varying response in several practical situations as well as applications .Impact was given on the description of different adaptation algorithms. LMS is an adaptive algorithm based on a stochastic gradient descent method. An adaptive noise canceller based on extraction of fetal electrocardiogram is studied and we can conclude that

LMS algorithm can be filtered MFE from the abdominal electrocardiogram signals by changing tap-weight vector.

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