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AN ADAPTIVE FILTER BASED ANALYSIS ON ECG SIGNAL DENOISING

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ABSTRACT
Electrocardiogram (ECG) is an effective non-invasive method used to detect cardiac abnormalities. In our paper, we provide a study various noises, example power line disturbance (PLI), movement artifacts, electrode touch noise, muscle relaxation, base line drift, electromyography noise (EMG) and instrumentation noise etc. To remove above noises various algorithms of different filter, non-adaptive filter are used and we also provide discrete wavelet transform DWT. To filter random artifacts, filter with constant parameters, because hum manner is not accurate known relevant on time. For this problem to solve digital filter are used such as adaptive filters as smallest (least) mean square (LMS), Normalized mean square error (NLMS), Recursive least square (RLS), sign LMS, sign-sign LMS algorithms In the comparison among all have been tabulated. The quality of algorithms are evaluated by signal to noise ratio (SNR), mean square error (MSE), rate root mean difference (%PRD) and standardized mean square (NMSE). In the comparison to various adaptive algorithms sign-sign LMS gives better result for all parameters with MSE = 0.0253, NRMSE = 0.0033, %PRD = 0.3231, SNR = 5.327.

1. INTRODUCTION

ECG is generated by the heart muscle and measured on the skin surface of the body. When the electrical abnormalities of the heart occur, the heart cannot pump and supply enough blood to the body and brain. As ECG is a graphical recording of electrical impulses generated by heart, it is needed to be done when chest pain occurred such as heart attack, shortness of breath, faster heartbeats, high blood pressure, high cholesterol and to check the heart's electrical activity. An ECG is very sensitive, different types of noise and interference can corrupt the ECG signal as the real amplitude and duration of the signal can be changed. ECG signals are mostly affected by white noise, colored noise, electrode movement noise, muscle artifact noise, baseline wander, composite noise and power line interference. These noise and interference makes the incorrect diagnosis of the ECG signal [1-3]. So, the removal of these noise and interference from the ECG signal has become very crucial. Different types of digital filters (FIR and IIR) have been used to solve the problem [3-5]. However, it is difficult to apply these filters with fixed coefficients to reduce different types of noises, because the ECG signal is known as a non-stationary signal. Recently, adaptive filtering has become effective and popular methods for processing and analysis of the ECG signal [6-8]. It is well known that adaptive filters with least mean square (LMS) algorithm show good performance for processing and analysis of signal which are non stationary [1]. And in this study, we have used adaptive LMS and normalized least mean square (NLMS) filter to denoise the ECG signal. We also have evaluated their performance. But it is shown that NLMS filter removes all specified noise (mentioned above) more significantly.

Adaptive Filter

Adaptive filter have a property that the transfer function of Adaptive filter is self-adjustable, this self-adjustable transfer function is based upon the optimization algorithm and is controlled by error signal. Problem which is arises in these adaptive filters is complexity of the algorithms which is used for optimization. Due to this

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reason most of the adaptive filter which are used are digital in nature.

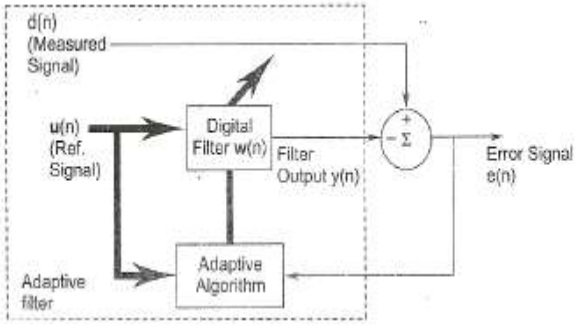

Figure 1. Block diagram of an adaptive filter

1.2 Digital Filter

Digital filter is nothing but a mathematical formulation or much precisely an algorithm which is used to implement desired hardware and software. Input and output both are digital type in digital filters, to achieve the objective of digital filters. The main objective to adopt a digital filter is that if there is a recovery of the signal and this recovery signal is distorted by noise, so the separation between two signals is highly needed which is provided by the digital filters.

1.3 Normalized LMS (NLMS) algorithm

Modification in the Least Mean Square algorithm is known as Normalized Least Mean Square (NLMS).As we all know that rate of convergence depends upon step size of two neighboring coefficients of filter. From the literature survey we found that the step size between the neighboring elements changes due to the change in input signal power as input signal power changes with time. Two types of signals affected the convergence rate one is small in nature and another one is large in nature, the signal which is large in nature produces an error in the signal. That's why the main objective of the NLMS algorithm is to maintain the step size with respect to the power of input signal.

So this process is called normalization of step size. Therefore the step-size parameter is said to be normalized. In the designing of adaptive filter one issue arises which is the selection of step size parameter ì. LMS algorithm have a severe problem which effects the stability of algorithm. This is due to the sensitivity of algorithm based on stability of input u (n). So due to this problem the stability of the algorithm is little bit affected.

The question arises here is that is there any other advantage of NLMS algorithm then yes it reduces the gradient noise amplification issue. This problem arises when the value of When the convergence factor is too large. Normalized algorithm has an advantage that it has lower value of step size than the traditional LMS algorithm. Due to the lower value of step size & utilization of variable convergence factor normalized algorithm is much faster than the conventional LMS algorithm. It also minimizes instantaneous output error. ECG signal is easily distorted by noise signal so reduce this signal an efficient algorithm is used which is known as NLMS algorithm.

2. MATERIALS AND METHODS

2.1 ECG RECORDING

MIT-BIH arrhythmia database was also use to recording ECG signal. It consist of 48 annotated records, obtain from 46 subjects studied by the arrhythmia lab of bath Israel hospital in Boston between 1975 and 1979 the database contain several record in the 100 series were taken for our research purpose every record in the arrhythmia database is slightly over 30 min. In size having sampling frequency 360 Hz. Header files include information about leads used the patient's age, sex and medications.

2.2. VARIOUS TYPES OF NOISES:

2.2.1. Power line interference

Power line interference (PLI) noise occurs due to two coupling such as capacitive coupling and inductive coupling. Capacitive coupling refers to the transfer of energy between two circuits by means of coupling capacitance present in the two circuits. Inductive coupling is caused due to

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mutual inductance between two conductors. Capacitive coupling and inductive coupling responsible for high frequency and low frequency noise respectively. Inductive coupling is more dominant for power line interference in ECG. The power line disturbance noise is causes due to 50 Hz or 60 Hz depending on the power supply.

2.2.2. Electrode contact noise

It is caused due to changes in the position of the heart with respect to the electrodes and changes in the propagation medium between the electrode position and heart. This causes variations in the amplitude of the ECG signal, as well as frequency baseline shifts. poorer conductivity between the electrodes and the skin decrease the strength of signal.

2.2.3. Motion Artifacts

Motion artifacts are due to changes of baseline cause by electrode motion. The main cause of movement artifacts are vibrations, movements etc. In this ECG signal the baseline drift occurs at low frequency (less than 1Hz). Motion artifacts depend on the electrode properties and electrolyte properties.

2.2.4. Electromyography Noise (EMG)

EMG noise is causes due to the contraction of muscles besides the heart. EMG noise is randomly in nature and designed by Gaussian distribution function. The mean of this noise is assumed to be zero and variance depends on the environmental changes. Frequency of EMG noise is in between 100-500 Hz.

2.2.5. Instrumentation noises

Noises also introduced due to measuring instrument, major source of such noise are electrical probes, cables, signal amplifier and analog to digital converter. Another types of noise is colour noise or flicker noise is low frequency electronics noise.

3. METHODOLOGY

This paper comprises of NLMS algorithm. First of all the detail of this algorithm is given in the paper. Then the validation and development of this algorithm also mentioned in the paper. The main objective of NLMS algorithm in this paper is to remove the non- trivial noise in ECG signal. First of all the component analysis which are important and can effectively separate out artifacts in ECG which are induced by motion done. The set of parameters which are selected for the better and quicker response also play an important role for the recognition & recovery.

2.1 Implementation of NLMS algorithm

If we want to apply the LMS filter to any signal then a standard format is desired for the application of LMS filter. The adjustment which is applied to the tap weight vector of the filter has various iterations and it consists of three terms:

i. The filter designing parameter which is known as step size μ can be chosen by the designer.

ii. Second parameter is the source of information which is supplied to the input. It is denoted by tap input vector u (n).

iii. Third parameter related to error. Which is called as estimation error e (n), this error is calculated on each iteration (n).

The improvement which is done in the step size has a direct correlation with tap input vector u (n). So if the value of step size is high then Least Mean Square filter has some limitations due to gradient noise amplification problem. The maximum value of step size μ gives a highly stable signal u (n). The best method to optimize the speed of convergence with tap vector adjustment kept in mind; the numbers of iterations are n+1 in the normalized way with respect to the squared Euclidean norm of the tap –input vector u (n) at iteration n –hence the term "normalized". It can be briefly described as follows:

• Initialization: Suppose that the value of tap weight vector w (n) is available, then we algorithm is used to find out an appropriate value of **w** (0), else set **w** (0) = 0.

CONCLUSION

Analysis of ECG signal, both of noisy ECG signal and filtered signal reveals that adaptive NLMS and LMS filter both reduces the white noise, colored noise, muscle artifact noise, electrode movement noise, baseline wander noise, composite noise and power line interference properly. But the different

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performance parameters SNR, %PRD, MSE and also visual parameters PSD, frequency spectrum and convergence reveals that adaptive NLMS filter is more appreciable for removing various types of noises from ECG signal.

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