REVIEW ON NOISE REMOVAL TECHNIQUES OF ECG

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Abstract— The field biomedicine that governed the amusement ofengineers is that of electrocardiography (ECG). It is the most widely used, noninvasive medical diagnostic test. One of the major challenges is to boost the performance of the ECG system by increasing the number of coincidentally recorded biosignals, attaining better signals to noise ratio (SNR). The ascend in data acquisition rate is also a concern in the design of any ECG systems. ECG has substantial and utmost significance in the field of medicine, and the applications of ECG monitoring are vividly used. There are various types of noise due to which ECG gets altered, falsified and corrupted. The various noise types considered were 50Hz power line interface, base line drift due to respiration, abrupt base line shifts, and a composite noise constructed from all of the other noise types. In this paper study is done on different noise removal techniques like adaptive filter, wavelet transform and various types of filters.

Keywords— Electrocardiogram (ECG), SNR, Adaptive filter, Wavelet transform, AWGN, Power Line Interference.

I. INTRODUCTION

Human heart is a muscular organ with many essential functions in our body like pumping blood. It is our body's engine which works incessantly. It is sensible to nurse the heart carefully as heart related diseases have risen steadily over the last hundred years largely because of changes in diet and lifestyle. It has become one of the main causes of mortality among adults. Around the world, 7.2 million people die from heart disease every year. Resting ECG is a simple, modest and relatively inexpensive diagnostic method, that can be done at home by the patient's bed. It checks for the heart's electrical activity. Hence acquiring the heart signals precisely, accurately, meticulously and with minimum distortion is essential.

The tool that is extensively used to evaluate and study the electrical and muscular activity of the heart is ELECTROCARDIOGRAM — abbreviated as EKG or ECG. The illustrative output plot produced by the ECG is Electrocardiograph. It is a sporadic, mobile signal. Willem Einthoven invented the first ECG in the early 1900's. The system was large and required assistance of many people to operate it. Present day ECG monitoring devices are comparatively smaller and easier to use. The electrocardiograph is the machine used to perform electrocardiography and produce electrocardiogram. Every wave on an ECG plot and the intervals between them is specific and have an acceptable range and size. Any deviation from the normal plot is potentially pathological and therefore of clinical significance.

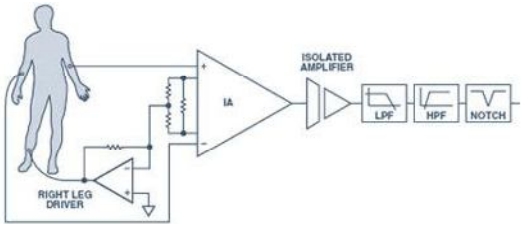

Fig 1: Simplified ECG recording system

II. NOISE REMOVAL TECHNIQUES

A. Types of Noise affecting ECG

ECG measurements may be falsified and distorted by many sorts of unwanted signals. A few are listed below:

- power line interference,
- electrode contact noise,
- motion artifacts,
- EMG noise, and
- instrumentation noise

Power line interference happens because of two reasons: capacitive and inductive coupling. Electrode contact noise occurs due to variations in the position of the heart with respect to the electrodes and changes in the propagation medium between the heart and the electrodes. This causes abrupt changes in the height and magnitude of the heart signal, as well as baseline shifts. EMG noise is caused by the contraction of other muscles besides the heart. The device used in ECG signal acquisition also contributes noise. Dismally instrumentation noise can't be completely excluded as it is inherent in electronic components.

B. Adaptive Filtering as denoising Technique

Adaptive filter may be understood as a digital filter that alters itself and adjusts its coefficients in order to reduce an error function. This error function is also referred to as cost function, is a distance measurement between the reference or desired signal and the output of the adaptive filter. An adaptive algorithm is a procedure of adjusting the parameters of an adaptive filter. The desired signal is represented by d(n). The error signal is denoted by e(n) which is the difference between the desired response and the output of the filter y(n).

$$e(n) = d(n) - y(n) \quad \text{.....(1)}$$

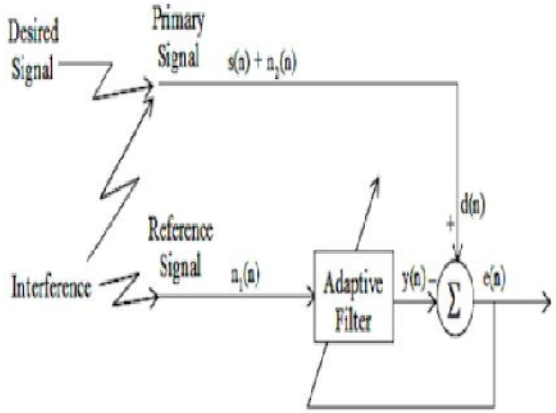

Fig 2: Adaptive Algorithm

The reference noise is processed by an adaptive filter, with time varying parameters w_0 (n), w_1 (n), ……....., w_{M-1}(n), to produce the output signal y(n) The adaptive algorithms used in the paper are LMS and NLMS. The filter is designed by updating the filter coefficient in each iteration by using the previous filter coefficient and error signal. The updated filter coefficient for LMS algorithm is as below:

$$y(n) = \sum_{k=0}^{M-1} wk(n)\ v1(n-k)$$

where

w (n) = [w0 (n), w1 (n).....]t , is the taped weight vector at the nth index. The output of the filter is given by :

$$\mu(n) = \mu / [p + x^t(n)\, x(n)]$$

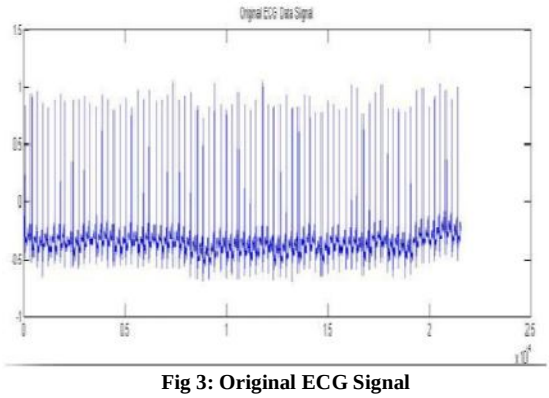

Fig 3: Original ECG Signal

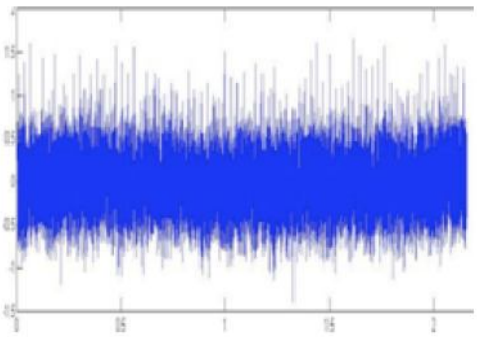

Fig 4: ECG with AWGN

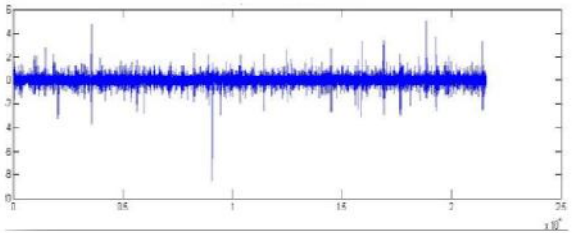

Fig 5: Filtered ECG signal from LMS algorithm

C. Wavelet Transform as Denoising Technique

Wavelet Transform is an upcoming technique to study and analyse nonstationary biomedical signals. The wavelet method acts as a mathematical microscope in which we can observe different parts of signal by adjusting the focus. Wavelets is a relatively new signal processing method. A wavelet transform is almost always implemented as a bank of filters that decompose a signal into multiple signal bands. Wavelet denoising has incorporated using different thresholding techniques to remove major sources of noise from the ECG signal. The DWT is an enactment of the wavelet transform using a distinct set of the wavelet scales and translations following some specified rules. DWT decomposes the signal using HPF and LPF. The coefficients obtained are named as *details* and *approximations respectively.*

Wavelet shrinkage is done by using one of two chief thresholding stratagem. The hard threshold filter H_h, removes coefficients below a threshold value t_0, determined by the noise variance. This is sometimes referred to as the "keep or kill" method [10]. The soft threshold filter H_s, shrinks the wavelet coefficients above and below the threshold. Soft thresholding reduces coefficients toward zero. Soft thresholding is used if the requires output is smooth. On the other hand, for better output and result hard thresholding is preferred.

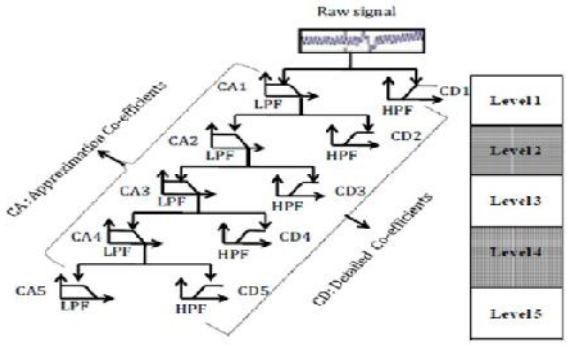

Fig 6: Decomposition by Wavelet Filter Banks Wavelet Denoising

Algorithm:

In order separate the noises , the following denoising algorithm is used:

- Firstly, decompose and separate the input signal using DWT. Select a wavelet. Choose the decomposition level of a wavelet transform N, then implement N layers wavelet decomposition of signal S.

- Pick the Thresholding method and Thresholding rule for quantization of wavelet coefficients and apply the Thresholding on each level of wavelet decomposition.
- Finally, the denoised signals reconstructed without affecting any features of signal interest. The reconstruction was done by performing the Inverse Discrete Wavelet Transform (IDWT).

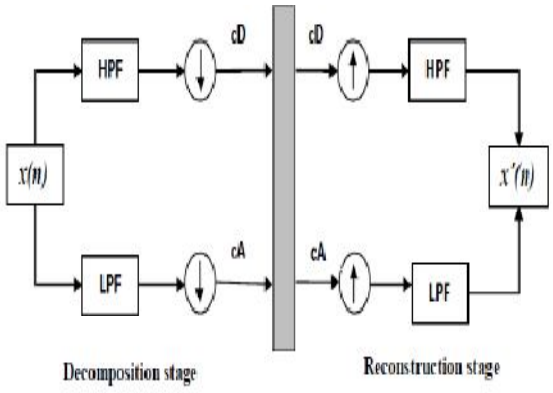

Fig 7: Decomposing & Reconstruction by Wavelet Transform

CONCLUSION

This paper enlightens on the basics of ECG, noises corrupting the ECG signal and ECG enhancement using different algorithms.

Table 1: Comparison between Adaptive filter and wavelet filter bank

Sr No	Adaptive Filter	Wavelet filter Bank Technique
1	Weight update mechanism is used here. Weights are decided by the error obtained each step.	Low & high frequency components analysed by passing it through a chain of HPF & LPF.
2	Disadvantage:- Increase in steady state error in unsigned algorithms like LMS algorithm.	Much trusted method with minimum distortion in ECG.

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