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An Effective Approach to De-Noise the Biomedical ECG Signal

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ABSTRACT

Now-days, computer-aided electrocardiogram (ECG) analysis has known itself as one of the advance dynamic research field in medical informatics. Prior to computerized examination, the noises exist in ECG need to be removed for correct diagnosis. As we know current era is entirely based on modern technology. Medical science is one of the significant requirements for human being. As we know ECG signal processing has become an efficient device for medical practices and research. Here the electrocardiogram(ECG) is one of the most significant biomedical signals occupied from a human body; it gives indirect data of blood flow to the heart muscle. Heart activity is measured by using this (ECG) tool. The study of the ECG signal requires great amounts of training. When the ECG signals are damaged by noise it can be extremely complicated even for a qualified physician to do a right diagnosis. The ECG signal can be damaged by different kinds of noise; in the proposed scheme white noise is considered. To eliminate the white noise CEEMDAN and kalman smoothening is used. The performance of system is measured in-term of its Mean Square Error (MSE) value.

Keywords: CEEMDAN, *ECG Signal, Kalman Smoothening Filter, MSE Value.*

I INTRODUCTION

According to study, there are about million heart patients in India and lakh heart surgeries performed every year. In India there are about million people dying due to heart diseases. Therefore, study of ECG signal plays a fundamental role. Significant conditions need these signals to be recorded on a long period dimension to recognize disturbance or noise in the signal. Hence, a cardiologist will need a lot of period to analyze these long ECG records. Involuntary processing lessens this burden by involuntarily analyzing these large data. These signals require being de-noised prior to involuntary processing to enhance performance and avoid false detection of diseases. ECG signal is a pictorial representation of cardiac movement and is employed to calculate different cardiac diseases and defects exist in the heart. It is a procedure of calculating and recording electrical movement of heart by putting electrodes on the skin. The major intention of ECG is to achieve data about the working of the heart. ECG signal is applied to discover a choice of types of diseases like arrhythmia, tachycardia, aberration, etc.

Recently cardiac diseases and associated failures are among the major reason of death in the world. Consequently it is essential to have an appropriate technique which concludes the cardiac state of the patient. Inspection of ECG is one of the techniques. Electrocardiography (ECG) is a device which is employed to know the condition of the heart. ECG report the electrical signals (activity) which are produced over the cardiac cycle via electrodes placed at different locations on the surface of body. ECG of a patient is observed visually in the time domain. But this ECG is complete of noise which can be decreased by means of signal processing. Signal processing is a significant and evident device in areas of biomedical engineering. Today the biomedical signal processing stream has superior to the phase of practical function of signal processing and model analysis methods. ECG signal is a protocol illustration of cardiac movement and it is applied to investigate different abnormalities which are present in the heart. Normally an ECG signal includes of P wave, QRS complex; T wave and any variation in these factors calculate and validate the abnormalities there in heart. Electrocardiogram (ECG) signals are typically tainted by baseline wander (BW) [1].

The input biomedical ECG signals are considered as an input, white noise is added to input signal. Complete Ensemble Empirical Mode Decomposition with Adaptive Noise (CEEMDAN) and kalman filters are employed to remove the noisy content in the signal. The output signal from the CEEMDAN is passed to kalman smoothening to obtain more clear and noiseless ECG signals. MSE is compute to calculate the supremacy of de-noised ECG signal.

The following of this paper is structured as follows:

Section II explains a brief summary of related and recent works on an effective approach to de-noising the Biomedical ECG Signal. It consists of different de-noising techniques used to eliminate these noises. Section III explains methods proposed in this paper to ensure a noise-free IMF, a CEEMD algorithm and kalman smoothening is used. Sections IV and V consists of results and conclusion.

II LITERATURE SURVEY

In this part we summarize referred some research papers that are worked on various methods De-noise the biomedical ECG signal.

Neelam Bhardwaj et.al[2], Accurate learn of ECG signals becomes complex when a lot of noise such as AC obstruction, Baseline wandering, electrode motion, Electromyogram (EMG), channel noise, motion artifact, electrode motion, Gaussian noise high frequency noise depends on the frequency variation are available in the ECG signal. Thus, for superior analysis and classification of ECG, noise elimination becomes a necessary part. De-noising of ECG signals plays a very vital role in analysis and recognition of various cardiovascular diseases. The different techniques accessible for de-noising of ECG signals consist of linear filter, self-determining and Principal Component study, Neural networks, EMD, adaptive filtering etc. In modern studies by several researchers computed to the above mentioned de-noising techniques EEMD and Discrete Wavelet Transform (DWT) are found to be more useful in decreasing noise from ECG signal. This paper shows the performance analysis on ECG de-noising methods in EEMD and wavelet domains by calculating SNR and RMSE in way to compute the use of these two techniques in eliminating the noise.

Kiran Kumar Patro et.al [3], an ECG signal is exceedingly responsive as it varies with time. It is principally degraded by noises such as Power Line Interference, EMG noise during data capturing and Baseline wandering noise. These noises add at various frequency speed of ECG and noise creates the signal analysis much difficult. A number of researches with different of processing method have been taking position so as to retain the morphology of ECG signal. Cascading of window based FIR filters are implemented for eliminating low, mid and high frequency noise from the noisy real ECG. Several ECG signals from MIT-BIH NSR, ECG ID databases are taken and the outcomes were calculated using MATLAB software. Ultimately performance method of SNR, MSE and PSD of de-noised ECG signal is measured and evaluated with noisy real ECG.

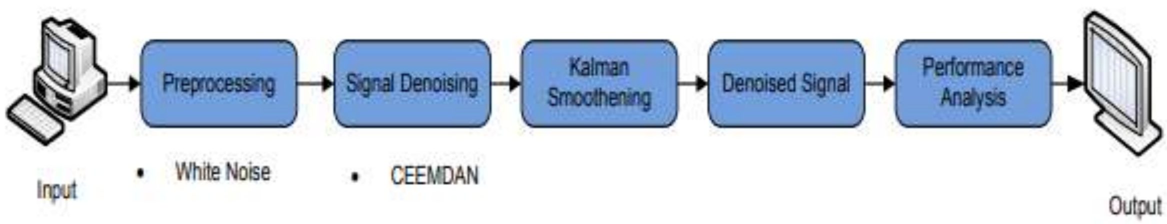
Jianhong Wang et.al [4], a parallel-type fractional zero-stage filtering method depends on the centre Grunwald – Letnikov differ integrator is offered. First a left and a right Grunwald–Letnikov differs integrators, which are general magnitude-and-stage modulations. The centre equal convolution mask is constructed to execute the projected fractional zero-phase filter. The technique offered removes the phase distortion while presenting an enhanced cooperation in between signal de-noising and signal data preservation than conventional filtering techniques. To demonstrate this, the differ integrator and predictable filters were used to electrocardiogram signals. The outcome indicates that the method has better presentation computed with conventional de-noising techniques.

Amel Baha Houda ADAMOU-MITICHE et.al [5], ECG signal plays a vital job in the primary diagnosis, survival study of heart diseases and prognosis. Some noises are source of ECG signal degraded such as strong electromagnetic effect, electrode association and muscle noise. The principle of methods based wavelet based on decrease the wavelet coefficients in the wavelet field. These methods demonstrate their effectiveness for their capability to detain the power of a signal in few power transform principles when eliminating the noise. A de-noising strategy on the grouping of three levels DWT and Elliptic filter evaluation is offered. To confirm and terminate to the success of approach, a physical signal is processed as well by technique as with two recent de-noising methods, namely the DWT thresholding. Based on two significant measures, the advantage of technique is confirmed.

Santosh Kumar Yadav et.al [6] ECG signals are typically corrupted by power-line interference, baseline wander, etc. a number of methods have been projected to eliminate these noises. The ECG signals it gets interrupted by the additive white Gaussian noise (AWGN) in case of wireless recording. For the accurate diagnosis, elimination of AWGN from ECG signals becomes essential as it affects the diagnostic characteristics. The natural signals display relationship with their samples and this property has been subjugated in different signal restoration roles. Encouraged by that, in this study propose a non-local WT domain ECG signal de-noising technique which make use of the correlations between both local and non-local models of the signal, in the proposed technique, the same blocks of the models are collected in a matrix and then de-noising is attained by the shrinkage of its two-dimensional DWT coefficients. The experiments executed ECG signals illustrate major quantitative and qualitative developments in de-noising performance over the present ECG signal de-noising techniques.

III. METHODOLOGY

In this section we present the methodology. As we already know there is need of fast system with good quality maintain system. In this work the proportional study between various kinds of existing design for ECG noise removal application.



3.1. Pre-Processing

The attained ECG data are pre-processed to eliminate noise, artifacts, and baseline wander that do not display spectral overlap with the ECG .When learning human performances and behaviour; it is difficult to know what this data can tell us exclusive of pre-processing. The preprocessing stage is a main stage in the data mining procedure. This changes the raw data into a different format that is understandable.

3.1.1. ***White Noise (WN)***

WN is a form of noise that is generated by combining sounds of all variety frequencies together. If select all of the possible tones that a human can hear and shared them together, would have WN. The adjective "white" is employed to express this form of noise because of the method white light works. White light is light that is complete of all of the dissimilar frequencies of light joint mutually. In the same manner, WN is a grouping of all of the dissimilar frequencies of sound.

3. 2. Signal De-noising

It is familiar to engineer and researchers who work with a real world data that signals do not be present without noise, which may be insignificant under assured circumstances. However, there are several cases in which the noise interrupted the signals in a major way, and it must be separated from the data in way to continue with additional data analysis. The procedure of de-noising is commonly referred to as signal de-noising or basically de-noising. The expression "signal de-noising" is universal; it is generally dedicated to the improvement of a digital signal which has been infected by AWGN, rather than other forms of noise for example, non-additive noise, Poisson/Laplace noise, etc.

The optimization standard according to which the presentation of a de-noising technique is calculated is generally taken to be mean squared error (MSE)-based, involving the original signal (if exists) and its modernized version. This general principle is employed mostly due its computational simplicity. Furthermore, it typically leads to terms which can be delt with systematically. However, this condition may be improper for several tasks in which the condition is perceptual feature driven, though perceptual feature estimation itself is a complex problem, particularly in the nonexistence of the original signal.

3.1.2. **CEEMDAN**

The major enhancements of the CEEMDAN technique refer to attaining a insignificant modernization error and resolve the difficulty of several numbers of forms for different understanding of signal plus noise. Before decomposing a signal into a generally small amount of the intrinsic mode functions (IMFs), the signal is de-noised by wavelet de-noising technique on description of the original signal with stochastic noise.

Let's describe operator IMF i(S) which gives IMF (pure EMD) of its input and to offer local mean, i.e. M(S) = S – IMF(S) then the algorithm is represented below:

Step 1: Generate Gaussian noise ensemble $W = \{wi\}$, where $i \in [1 \dots N]$, and decompose them employing EMD.

Step 2: For input signal S determine grand standard of local means from signal disconcerted by scaled noise first IMF

$$R_1 = \frac{1}{N}\sum_{1}^{N} M\left(S + \beta_0 IMF_1(w^i)\right)$$

Step 3: Assign first cIMF to be

$$C1 = S - R1$$

Step 4: Calculate

$$R_k = \frac{1}{N}\sum_{i=1}^{N} M\left(R_{k-1} + \beta_{k-1} IMF_k(w^i)\right)$$

Step 5: Compute k^{th} cIMF as

$$Ck = Rk - 1 - Rk$$

Step 6: Iterate step 4. and step 5. until set of $\{S, Ck\}$ executes EMD stopping condition.

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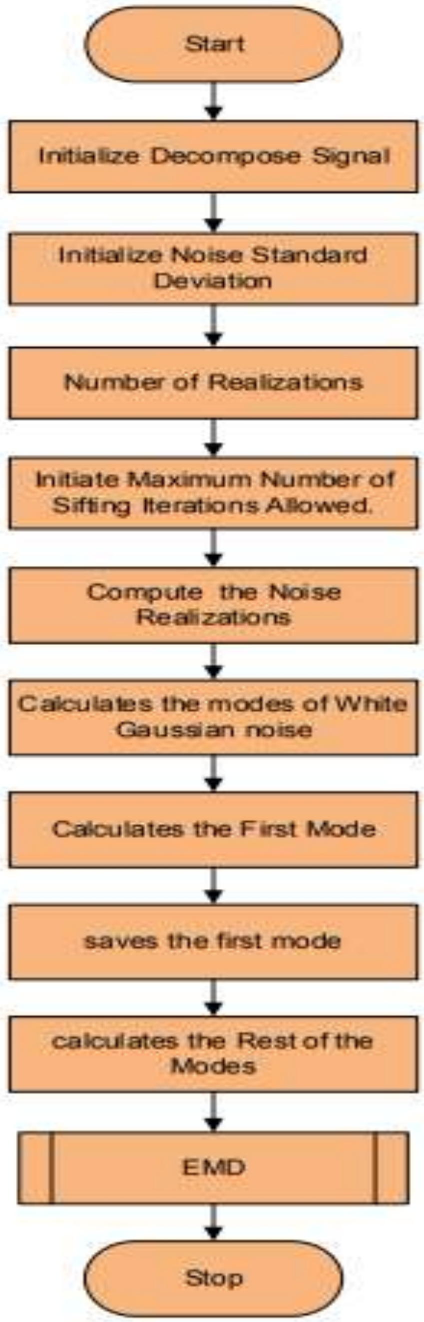
As it can be seen a family of factors has been involved in the technique. These scalars compare to the quantity of decomposed noise employed to calculate cIMFs. These factors are random, but it's recommended in enhanced version to set them as $\beta_k = €_o \sigma(R_k)$, where represents a standard divination of argument and is one more arbitrary factor. Looking at step



One can notice that for remainder we are employing IMF calculated from noise. This is a difficult, because EMD decomposes signal into a fixed set of apparatus and it can occur that there isn't IMF. In this case creators are suggesting to assume element to be equal. Benefit of this difference comes from the fact that produced decomposition completely modernizes input. T is in difference to EEMD which doesn't guarantee such totality. However, with CEEMDAN problems increase concerning the sense of further scaled IMFs of noise. Augmenting signal with collection of pure noise generates perturbations of input exclusive of any well-known route.

Dimensions, one of the most familiar and often-employed device is what is known as the KF. The KF is basically a set of mathematical equations that execute a estimator-corrector form prediction that is optimal in the sense that it reduces the approximated error covariance when several supposed conditions are met. Since the period of its introduction, the Kalman filter has been the matter of widespread research and function, mainly in the field of autonomous or assisted navigation.

The KF addresses the common difficulty of trying to approximate the state of a discrete-time managed procedure that is governed by the linear stochastic variation expression

$$X_K = AX_{K-1} + W_{K-1} \qquad (1)$$

with a dimension that is

$$Z_K = HX_K + V_K \qquad (2)$$

The random variables W_k and V_k denotes the procedure and calculating noise. They are assumed to be free (of each other), white, and with normal probability distributions

$$P(w) \sim N(0, Q) \qquad (3)$$

$$P(v) \sim N(0, R) \qquad (4)$$

In observe the procedure noise covariance Q and dimension noise covariance R matrices might modify with each moment step or dimension, however here we guess they are stable. The dimension noise here is the lung sound signal. The procedure noise takes into description the inaccuracies due to state change model is totally unknown and the uncertainty integrated because of the procedure models. The condition here is the weight which when developed with the mixed heart and lung sound model provides the desired heart sound.

Finally we are getting hopeful result i.e. de-noised signal, which is explained in detail the part of result section.

IV. RESULT

The detailed explanation for running a program and outcomes attained in each phase is explained in brief. Analysis the experimental effect in the procedure of analyzing the experiment outputs are carried on the system. The

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confirmed function has been tested with different inputs and the outcomes are analyzed for its presentation and accuracy. The given Figures

(3) and (4) are completed study of the experiments. Performance is calculated by using following equations.

- Signal to Noise Ratio (SNR)

$$SNR = \frac{\sum_{t=0}^{L-1} S^2(t)}{\sum_{t=0}^{L-1} n^2(t)} \qquad (5)$$

- Mean square error (MSE)

$$\mathrm{MSE} = \frac{1}{N}\sum_{n=1}^{N}(x[n] - \hat{x}[n])^2 \qquad (6)$$

Case 1

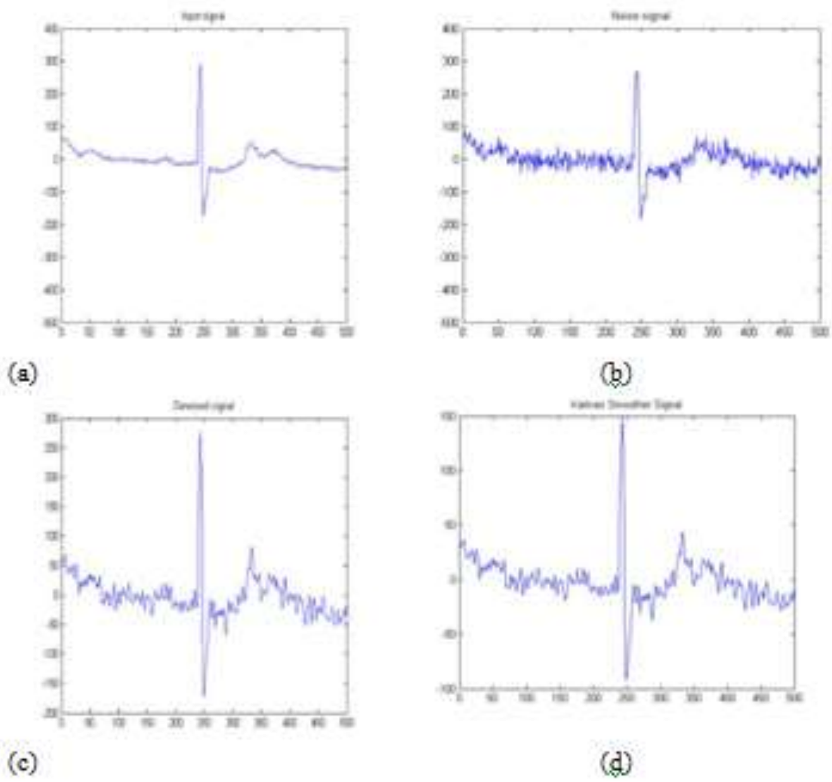

Figure 3 :(a) Input Signal (b) Noise Signal (c) De-noised Signal (d) Kalman Smoother Signal.

Case 2

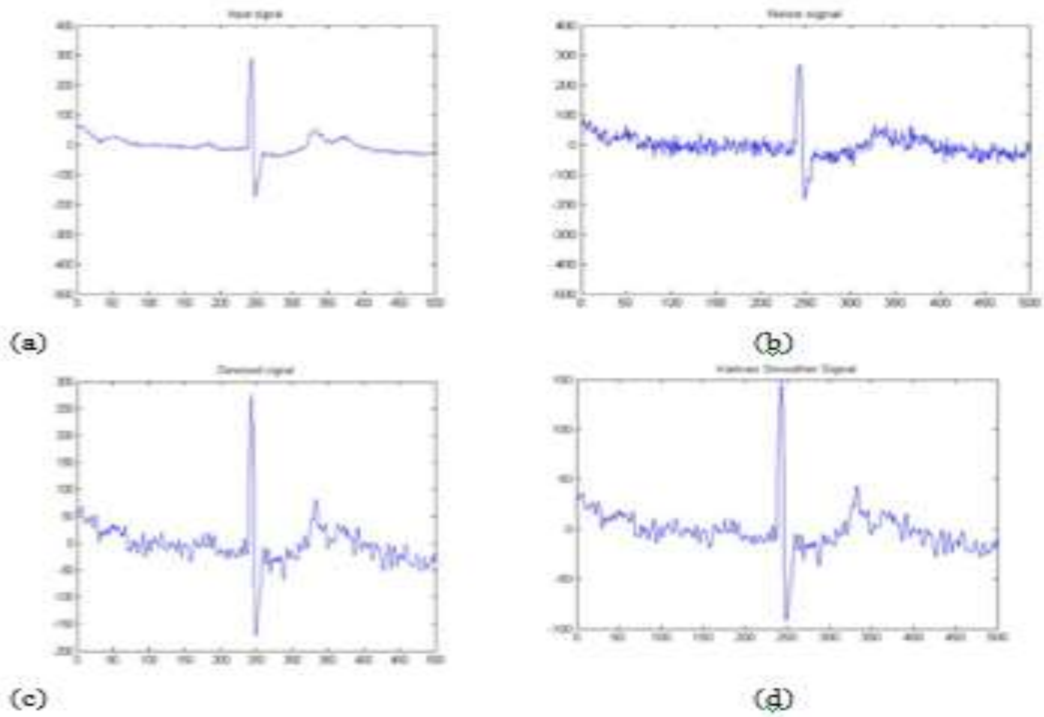

Figure 4 :(a) Input Signal (b) Noise Signal (c) De-noised Signal (d) Kalman Smoother Signal.

The following Table (1) represents our proposed scheme is gives better accuracy than the existing system. Figure (5) and (6) shows the comparison graph for MSE and SNR performance analysis.

Table 1: Comparison Table for proposed Method and Existing Method

SI .No	Paper	Method	SNR	MSE
1	Filtering of Biomedical signals by using Complete Ensemble Empirical Mode Decomposition with Adaptive Noise	Ensemble Empirical Mode Decomposition with Adaptive Noise	15.76	0.3137
2	Proposed method	CEEMDAN and Kalman smoother Filter	17.0428	0.2477

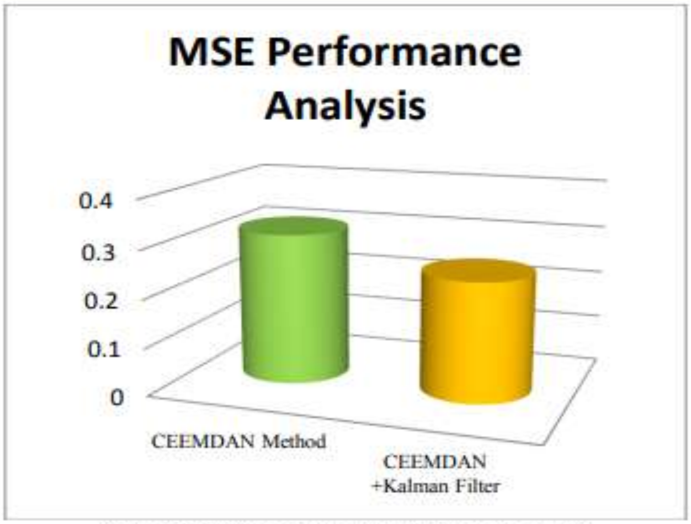

Figure 5: MSE (Mean Square Error) Performance analysis.

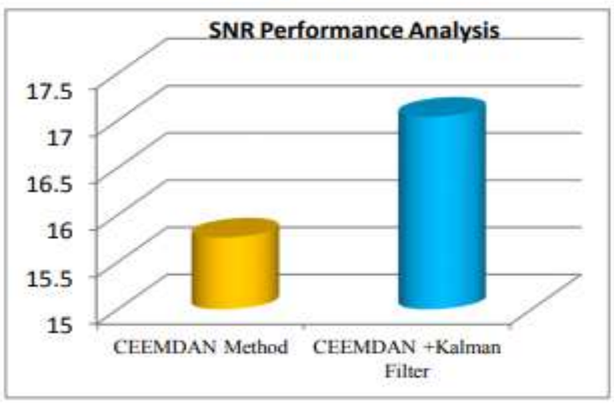

Figure 6: SNR (Signal to Noise Ratio) Performance analysis

V. CONCLUSION

In this paper we have described a technique for de-noising biomedical ECG signal. During the signal acquisition and forwarding of ECG signal in the clinical environment, the signal gets corrupted by various types of noises e.g. AWGN, electrode contact noise, EMG noise, etc. For accurate diagnosis, de-noising of ECG signal is essential as it affects the diagnostic features. In the proposed system to ensure a noise-free IMF, a CEEMD algorithm and kalman smoothening is used. The system can give more accurate and noise free signal.

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