Noise Removal from Electrocardiogram (ECG) a Comparison Approaches

Rajesh D. Wagh, Kiran R. Khandarkar, Dipanjali D. Shipne, Shaila P. Kharde

Abstract— Electrocardiograms mainly used in the medical area. ECG signals are very sensitive and due to the small noise, characteristics of ECG signals gets changed. To get original ECG signal, it is compulsory to filter the signal. In short, filtering is important issue for real time heart monitoring system. To remove the noise from ECG signals various filters are , most commonly used filters are Notch Filters, FIR filters, IIR filters, Wiener filter, Adaptive filter Algorithms, LMS, NLMS, DLMS, SRLMS, NSRLMS etc. In this paper various filters comparisons is given to remove various noise from ECG signal.

Index Terms— Adaptive filter Algorithms, ECG, Notch Filters, FIR filters, Wiener filter.

I. INTRODUCTION

Heart related problems are increasing day by day and hence the Electrocardiogram signals are very important in diagnosis of heart related problems. There are various noise affects or get added in these Electrocardiogram signals at the time of taking signals from the body of the patient and change the original signal. There is a need of removal of this different noise from the original signal. The electrocardiogram (ECG) is a graphical representation of the electrical activity of heart and it is widely used in medical area for the diagnosis of heart diseases by the cardiologist. While taking signals from the body of the patient different signals are added to the ECG. These added signals are nothing but the noise signals, and due to these signals original signal is not given to the cardiologist. There are different types of noise added to the ECG like Power line interference, Muscle contraction noise, Electrode contact noise, Patient movement, Baseline wandering and ECG amplitude due to respiration Instrumentation noise generated by electronic devices used in signal processing, and other less significant noise resource. Figure1 shows typical ECG signal with noise.

Different researchers have worked on the removal of the interferences in the ECG signal. Syed Ateequr Rehaman and R. Ranjith Kumar et al. [2] gives performance comparison of Adaptive Filter Algorithms for ECG Signal, V S S Reddy Ogireddy and Dr. I Santi Prabha et al. [3] describe Noise Suppression from ECG Signal Using LMS and RLS Technique, Md. Zia Ur Rahman, Rafi Ahamed Shaik and D V Rama Koti Reddy et al. [4], describe noise cancellation in ECG signals using computationally simplified Adaptive Filtering Techniques, M. S. Chavan, R. A. Agarwala and M. D. Uplane et al. [14], presents the design of the FIR filter using rectangular window .There are different noise which are added to the Electrocardiogram signals, these are

Power line interference: It consists of 50 Hz pickup and harmonics, which can be combination of sinusoid. Typical parameters: Frequency content-50 Hz (fundamental) with harmonics; Amplitude-up to 50 percent of peak-to-peak ECG amplitude.

Muscle contraction noise: The baseline electromyogram is usually in the microvolt range and therefore is usually insignificant. Parameters: Standard deviation-10% of peak-to-peak ECG amplitude; Duration-50ms; Frequency-10000 Hz.

Electrode contact noise: This kind of noise caused by loss of contact between the electrode and skin, which effect the measurement of signal. Parameters: Duration-1s; frequency-50 HZ time constant-about 1s.

Patient movement: Patient movements are transient (but not step) baseline changes caused by variations in the electrode skin impedance with electrode motion. Parameters: Duration-100 to 500ms; amplitude-500% peak-to-peak.

Electrosurgical noise: It completely destroys the ECG signal. It can be represented by large amplitude. Parameters: Amplitude-200 % peak-to-peak; Frequency 100 kHz to 1 MHz; Duration-1 to 10s.

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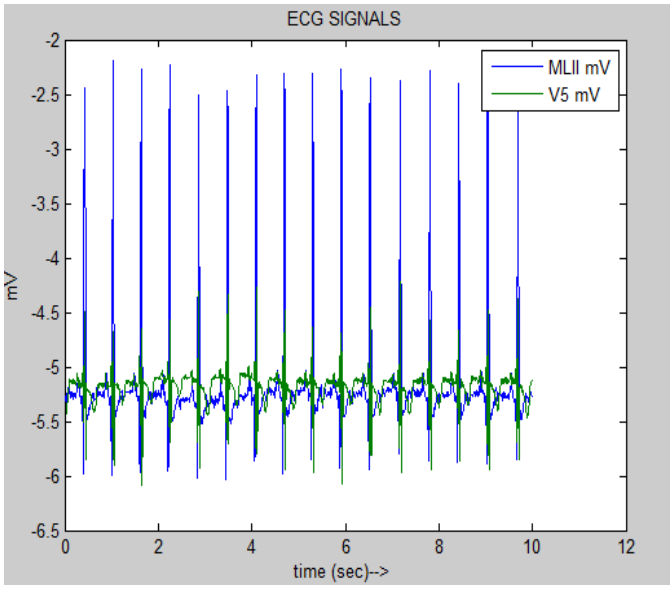

Figure 1 Typical ECG signal with noise

II. LITERATURE REVIEW

Syed Ateequr Rehaman and R. Ranjith Kumar et al. [2] gives performance comparison of Adaptive Filter Algorithms for ECG Signal, in this paper Performance comparison of SRLMS, NSRLMS, LMS, NLMS and DLMS ALGORITHMS for Power-Line Interference is given.

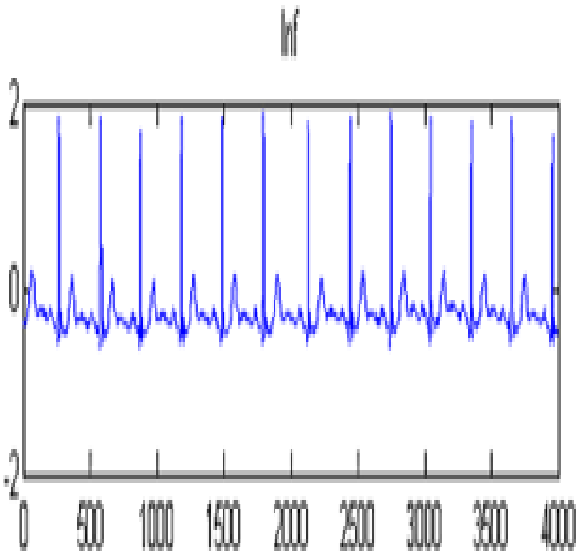

Figure A.

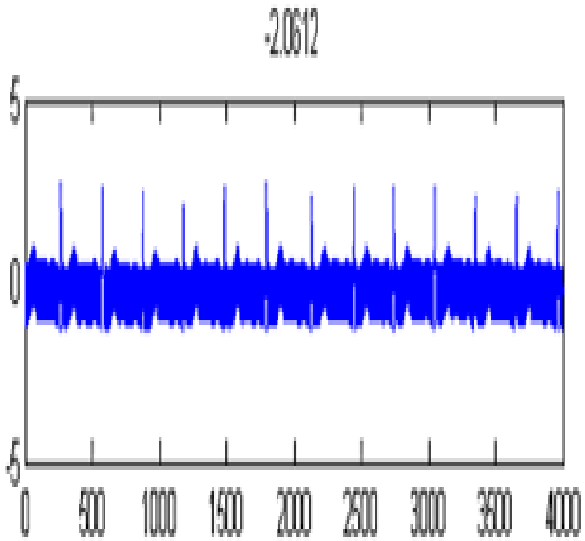

Figure B.

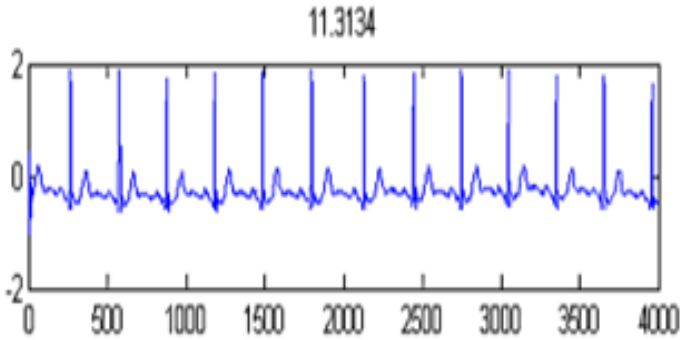

Figure c.

Figure.2. Typical filtering Results of Power-line Interference (a) Original ECG Signal (b) ECG Signal with 60 Hz noise (c) Recovered ECG Signal using Differential LMS Algorithm.

Above Figure shows that the signal to noise ratio in the original ECG signal is infinity because of noise being zero. Performance comparison of SRLMS, NSRLMS, LMS, NLMS and DLMS ALGORITHMS for Power-Line Interference is given into the following table.

Algorithm	DLMS	NLMS	LMS	NSRLMS	SRLMS
SNR before filtering	-2.0612	-2.0612	-2.0612	-2.0612	-2.0612
SNR after filtering	11.3134	9.8341	9.7336	8.8915	8.8786
SNR Improvement	9.2522	7.7729	7.7124	6.8303	6.8174

Table1. Performance comparison of algorithm

In this paper performance comparison is based on signal to noise ratios, from the above table that the basic algorithm like SRLMS produces an SNR which is less compared with NSRLMS, which means that normalizing improves the SNR. Same is the case with LMS and NLMS also. Whereas the highest SNR is obtained with DLMS algorithm but the drawback with this algorithm is computational complexity is very high.

V S S Reddy Ogireddy and Dr. I Santi Prabha et al. [3] describe Noise Suppression from ECG Signal Using LMS and RLS Technique; in this paper Adaptive filter based algorithms are applied to remove noises mainly power Line Interference from ECG signals. In this paper propose two techniques i.e. LMS (least mean square) and RLS (Recursive least square) to remove noise from ECG signal. Comparison of ECG signal will be done by using mean square error of LMS and RLS algorithms. RLS algorithms typically shows fast convergence compare to LMS algorithm. The result shows that RLS based algorithm is more powerful than that of the LMS based algorithm in noise reduction in EGC signal.

Md. Zia Ur Rahman, Rafi Ahamed Shaik and D V Rama Koti Reddy et al. [4], describe noise cancellation in ECG signals using computationally simplified Adaptive Filtering Techniques. In this paper, several signed LMS based adaptive filters are described, which are used to cancel noise from the ECG signals. They applied algorithms on real ECG signals obtained from the MIT-BIH data base and compared their performance with the conventional LMS algorithm. After using algorithm they observe that the performance of the signed regress or LMS algorithm is better than conventional LMS algorithm.

Yogesh Sharma and Anurag Shrivastava et al. [5], describe Periodic Noise Suppression from ECG Signal using Novel Adaptive Filtering Techniques. In this paper they describe, Performance analysis shows that the best result is obtained by using Adaptive filter to remove various noises from ECG signal and get significant SNR and MSE results and a novel adaptive approach by using LMS algorithm and delay has shown which can be used for pre-processing of ECG signal and give appreciable result.

Hong Wanl, Rongshen Ful, and Li Shil et al. [11], describe the LMS Adaptive Filtering Algorithm for elimination of 50 Hz Power Line Interference from ECG. In this paper they provide new variable step size LMS adaptive filtering algorithm to eliminate 50 Hz power line interference, which provide faster convergence rate and smaller mean square error (MSE). The result shows that this algorithm compared with traditional LMS algorithm and other improved LMS algorithm and gives much more effective to eliminate the 50 Hz interference from ECG signal.

Fatemeh Bagheri, Nafiseh Ghafarnia and Fariba Bahrami et al. [12], describes the Hopfield neural network (HNN) is applied and proposed for ECG signal modeling and noise reduction. The Hopfield neural network (HNN) is a recurrent neural network that stores the information in a dynamic stable pattern. This algorithm retrieves a pattern stored in memory in response to the presentation of an incomplete or noisy version of that pattern. Computer simulation results show that this method can successfully model the ECG signal and remove high-frequency noise. To reduce noise, methods employing filters and wavelet transform have been applied. Although they demonstrated good performance, they tend to be sensitive to varying parameters. Neural Networks have widely been used for modeling, showing significant success and being less sensitive to varying parameters. In this study a Hopfield Neural Network is applied for ECG signal modeling and denoising. The algorithm was applied to two different ECG signals. Results showed that the method can successfully model ECG signals with low SNR. More tests will be conducted to further investigate the performance of HNN in the future. Other kinds of ECG signals will also be used to examine the clinical application of the method.

R. Sameni, M.B Shamsollahi and C. Jutten et al. [13], describe he Extended Kalman Filter (EKF) has been used for the filtering of Electrocardiogram (ECG) signals. The method is based on a previously nonlinear dynamic model proposed for the generation of synthetic ECG signals. The results show that the EKF may be used as a powerful tool for the extraction of ECG signals from noisy measurements; which is the state of the art in applications such as the noninvasive extraction of fetal cardiac signals from maternal abdominal signals. Extended Kalman Filter (EKF), for the filtering of noisy ECG signals. This model is highly reliant on the underlying dynamics assumed for the ECG signal. It was shown that by using a flexible nonlinear dynamical model, together with the EKF, it is possible to construct a filter which can remove environmental noises and artifacts. This filter may find vast applications for low SNR ECG signals such as the fetal ECG. Future works include the combination of the proposed EKF model with source separation techniques, for the extraction of maternal and fetal cardiac signals from multi-channel surface electrode recordings.

M. S. Chavan, R. A. Agarwala and M.D.Uplane et al. [14], presents the design of the FIR filter using rectangular window, where three filters are designed namely low pass filter high pass filter and notch filter. These filters are cascaded and applied on the ECG signal in the real time manner for this, they used 711B add-on card. Results clearly indicate that there is noise reduction in the ECG signal. They used the different window technique Windows like rectangular, Hamming, Hanning and Kaiser were compared to design and implement low pass, high pass and Notch filter and the Comparative Results are Provided in the table.

Type of Filter	Filter Order	Signal power before Filtration in dB	Signal Power After Filtration dB	Effect on PQRST Waveform
Rectangular Window	100	-12.5	-16	Modified
Hanning Window	100	-12.5	-15	Modified
Hamming Window	100	-12.5	-15	Modified
Kaiser Window	100	-12.5	-17	Modified

Table2. Performance comparison of algorithm

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Zahoor-uddin and Farooq Alam Orakzai et al. [15], describe the baseline noise removal from electrocardiogram (ECG) signal. This is a blind source separation problem and various noises affect the measured electrocardiogram signal. Major ECG noises are baseline noise, electrode contact noise, muscle noise, instrument noise. Baseline noise distorts the low frequency segment of ECG signal. The low frequency segment is s-t segment, which contains the information related to heart attack and hence this segment is very important. In this paper they have applied projection pursuit gradient ascent algorithm to remove this noise from the measured ECG signal. This algorithm separates the independent signals from a mixture of signals. Efficient removal of baseline noise might give us certain information that are hidden from the doctors until now which may save the life of a person. Results for different baseline noise signals were analyzed. Different signal from MIT-BIH database were also analyzed for error in term of standard deviation and mean of error signal. Finally we did a comparative study of the results of different algorithms like kalman filter, cubic SP line and moving average algorithms and showed that projection pursuit is the efficient one.

Several authors have worked in this area, Thakor NV and Zhu YS et al. [7], describe the adaptive filtering method for ECG analysis. Widrow B., Glover JR, and Goodlin RC et al. [6], describe basic principles and applications for adaptive Noise cancelling. Slim Y. and Raoof K. et al. [8], developed an adaptive structure with an ECG reference signal carried out by wavelet decomposition. Suresh H. N. and Puttama dappa C. [10], this paper proposed method which contains combination of adaptive noise canceller (ANC) and adaptive signal enhancer in a multilayer recurrent neural network to remove ECG artifacts.

III. CONCLUSION

The main use of Electrocardiogram (ECG) is to diagnosis the heart disease by using signals generated by heart. ECG signal contains different noise signals which are removed by using different algorithms, these algorithms are reviewed in literature review and it also shows accuracy of algorithms.

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BIOGRAPHIES

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