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ECG Signal processing using Adaptive filters

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ABSTRACT: The electrocardiogram(ECG) has the considerable diagnostic significance, and applications of ECG monitoring are diverse and in wide use. Noises that commonly disturb the basic electrocardiogram are power line interference(PLI), instrumentation noise, external electromagnetic field interference, noise due to random body movements and respiration movements. These noises can be classified according to their frequency content. It is essential to reduce these disturbances in ECG signal to improve accuracy and reliability. The bandwidth of the noise overlaps that of wanted signals, so that simple filtering cannot sufficiently enhance the signal to noise ratio. It is difficult to apply filters with fixed filter co-efficient to reduce these noise. Adaptive filter technique is required to overcome this problem as the filter coefficients can be varied to track the dynamic variations of the signals. Adaptive filter based on the least mean square (LMS) algorithm and recursive least squares (RLS) algorithm are applied to noisy ECG to reduce 50 Hz power line noise and motion artifact noise. ECG signal is taken from physionet database. A ECG signal (without noise) was mixed with constant 0.1 mVp-p 50 Hz interference and motion artifact noise processed with Adaptive filter based on the least mean square (LMS) algorithm and recursive least squares (RLS) algorithm. Adaptive filter based on Recursive least squares (RLS) algorithm gives better performance as compared to adaptive filter based on least mean square (LMS) algorithm.

KEYWORDS: Adaptive filter, Least mean square (LMS) algorithms ,Recursive least squares (RLS) algorithms.

I.INTRODUCTION

The ECG may be monitored continuously when the patient is in emergency care, in a coronary care unit, an intensive care unit or during stress tests[1]. In these cases only one lead, usually lead II is monitored, on a display[2]. ECG machine is a vital part of hospitals and aid the doctors to keep track of patient's vital sign during emergency. The electrocardiogram is the graphic recording or display of time variant voltage produced by the myocardium during Cardiac cycle. The electrocardiogram is used clinically in diagnosing various diseases and conditions associated with the heart[3]. It also serves as a timing reference for other measurements. Engineers working in the medical profession are encouraged to learn as much as possible about medical and hospital practices and in particular about physiology of human body[4]. It is only by gaining such an understanding that they can communicate intelligently with medical professionals. This interaction between the two fields has led to the development of sophisticated medical equipment and systems. The heart is made of a special kind of muscle, so that it can beat automatically without having to be told to do so by the brain. The left side of the heart drives oxygen rich blood out of the aortic semi-lunar outlet valve into circulation where it is delivered to all parts of the body. Blood returns to the right side of the heart low in oxygen and high in carbon dioxide and is then pumped through the pulmonary semi-lunar pulmonic valve to the lungs to have its oxygen supply replenished before returning to the left side of the heart to begin the cycle again. We have to suppress 50 Hz noise and motion artifact noise. Adaptive filtering is able to remove the time-varying power line signal effectively. Motion artifacts are transient baseline change due to electrode skin impedance

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with electrode motion. It can generate larger amplitude signal in ECG waveform. An adaptive filter can be used to remove the interference of motion artifacts.ECG signal is taken from physionet having sampling frequency of 500 Hz.

II. METHODOLOGY

ECG signal is taken from physionet ECG database with sampling frequency of 500 Hz as shown below in Figure 1. A ECG signal was added with constant 0.1 mVp-p 50 Hz interference and motion artifact noise shown in Figure 2 and its frequency domain is shown in Figure 3.

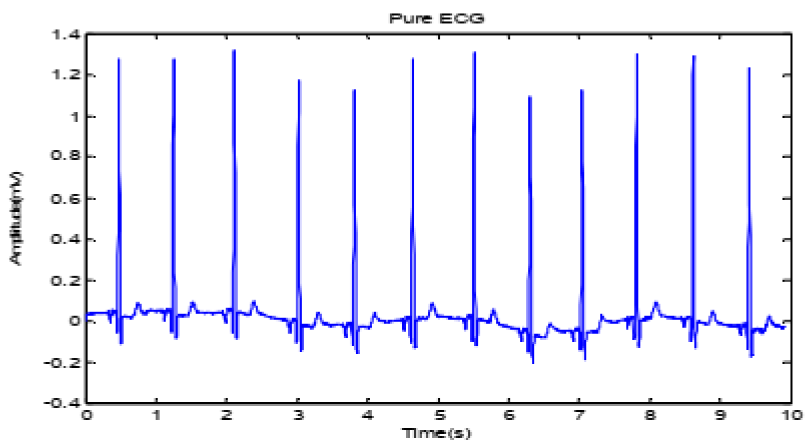

Figure 1 :Input ECG

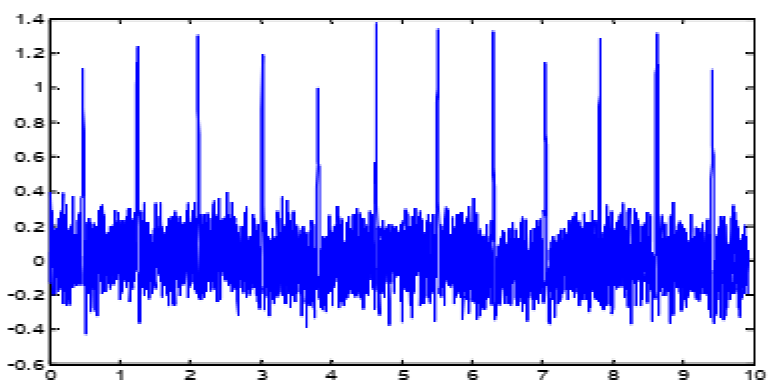

Figure 2: ECG signal added with 0.1 mVp-p 50 Hz interference and motion artifact noise.

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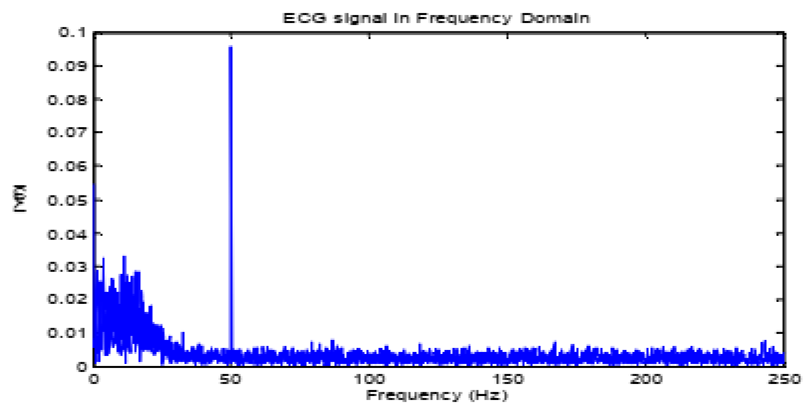

Figure 3:ECG signal with added noise in frequency domain.

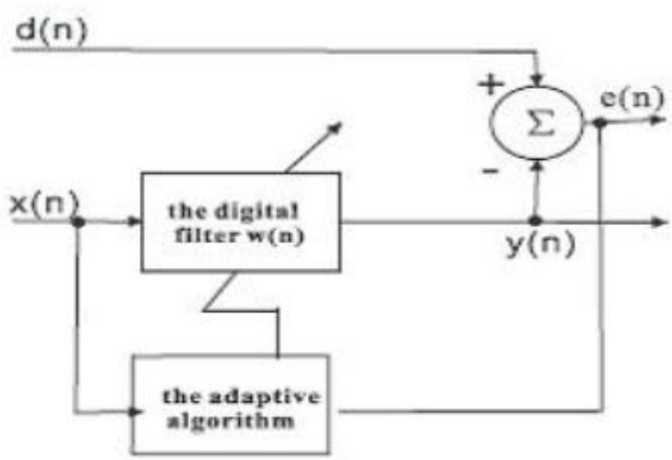

Figure 4: block diagram of adaptive filter

The coefficients for a filter of order N are defined as
$W(n) = [W_n(0), W_n(1), \ldots W_n(N-1)]^T$
The output of the adaptive filter [5,6]y(n) which is given by
$y(n)=W(n)^T x(n)$
The error signal or cost function is the difference between the desired and the estimated signal
$e(n)=d(n)-y(n)$
the variable filter updates the filter coefficients at every time instant

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$W(n+1)=W(n)+\Delta W(n)$
where $\Delta W(n)$ is a correction factor for the filter coefficients. The adaptive algorithm generates this correction factor based on the input and error signals.

LMS algorithm :
It is a stochastic gradient descent method in which the filter weights are only adapted based on the error at the current time. According to this LMS algorithm[7,8,9] the updated weight is given by
$W(n+1)=W(n)+2.\mu.x(n).e(n)$ where μ is step size.
RLS algorithm
RLS algorithm iteration expressions are following:
$\pi(n)=P(n-1)x(n)$
$k(n)= \pi(n)/(\lambda+xT(n)\pi(n))$
$e(n)=d(n)-wT(n-1)x(n)$
$w(n)=w(n-1)+k(n)e(n)$
$P(n)=\lambda-1P(n-1)-\lambda-1k(n)xT (n)P(n-1)$

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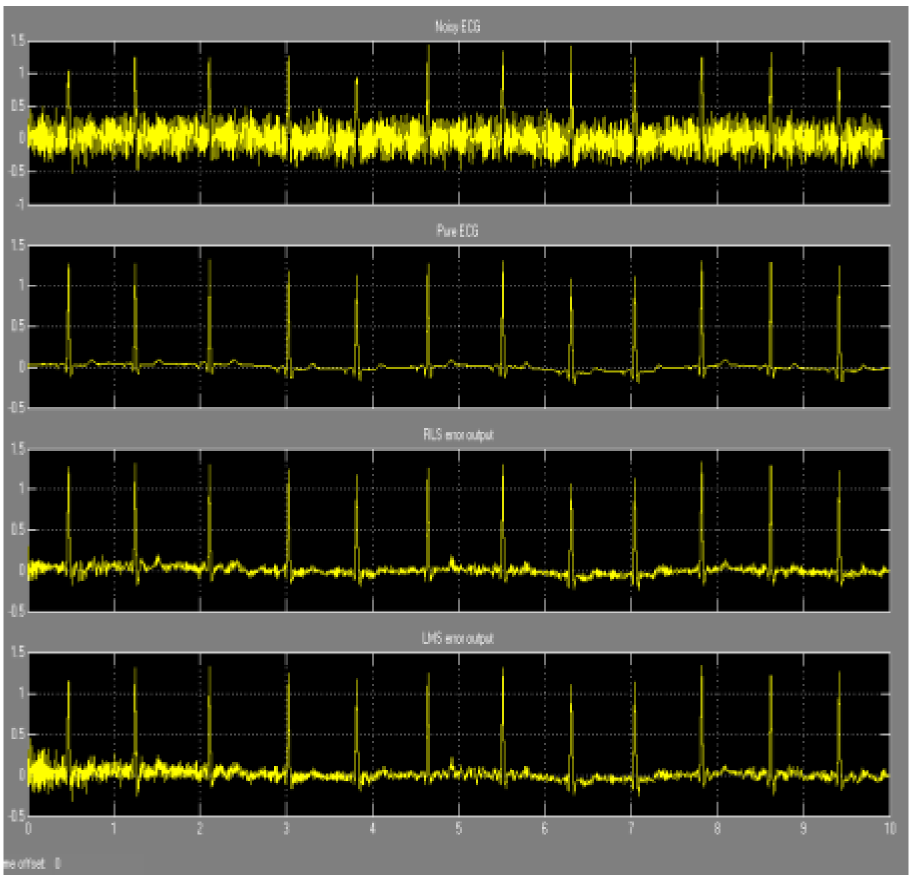

Figure 5: The output of LMS and RLS adaptive filters

III.RESULTS

Performance of adaptive filters are measured using SNR and MSE

Algorithms	SNR of input ECG	MSE	SNR of output ECG
LMS	5.0332dB	0.00013	17.8163 dB
RLS	5.0332dB	0.00062	23.206 dB

IV. CONCLUSIONS

Performance of RLS filter is better as far as SNR is concerned. The output signal of RLS filter is close to pure ECG signal.

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