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New Approach of Equalizing Electrocardiographic Signals using Least Mean Squares Technique

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Abstract: ***The shortage of the specialist healthcare center in some regions far from the big cities leads to top urgent way to exchange medical information using the standard ways of communication, which is referred to as Telemedicine. Telemedicine plays an important role in a patient treatment and enhancement the patient health by digitizing and transmitting the medical information of the patient electronically. Recently the (CVD)s risk detection is needed for the cardiovascular disease (CVD). Electrocardiogram (ECG) is highly preferred for CVD prediction. Transmission of ECG signals is subjugated to inter symbol interference (ISI) through a channel of limited band. In this paper, a new approach of equalizing the effective transmitted ECG signal across the communication channel using the least mean squares (LMS) technique to improve the performance of symbol spaced adaptive channel equalizer. The Rayleigh fading and adaptive white Gaussian noise (AWGN) channels are considered in the implementation. The validation results using the proposed approach show significant bit error rate with respect to the existing similar works in literature.***

Keywords: Symbol Spaced Adaptive filtering, ISI, AWGN, ECG, LMS

1. Introduction

The cardiovascular deaths and disease have increased at a faster rate in the countries of low- and middle income,. Most important types of CVDs are coronary artery disease(also known as coronary heart disease and ischemic heart disease), peripheral arterial disease, rheumatic and congenital heart disease, stroke and aortic disease. With the help of an ECG wave, the CVDs can be predicted since ECG is used to assess heart function. The heartbeats regularity, heart champers location, and any heart defect or drug and devices effects on the hearts can be measured by using an ECG[1,2].

Hence in the recent times, ECG wireless transmission has become very essential. By the wireless transmission, the patients who live in rural areas can be treated in the hospital and the ECG report can be sent to the doctor and enable him to exam and treat the patient at his house specially in emergency cases[3,4].

The higher reliability of the wireless transmission in noise environment is considered the most important advantages of the wireless transmission. Most often, a phenomenon which is known as inter symbol interference (ISI) is accompanied with the digital transmission of signal. ISI indicates that a smearing out of the pulses which are transmitted so that pulses which are related to different symbols cannot be separated. Depending on the media of transmission cable lines are the major reasons for ISI because these lines has a cellular communications and a limited band according to multipath propagation. noise , Channel and minimized sources causes the ISI [5].

Hence it is important to decrease the ISI effects and specify where the equalizers are used to obtain a reliable system of digital transmission. The equalizers are needed because the interference of the transmitted signals with each another, this interference is resulted from the amplitude and phase shift of the channel. So, to solve this problem, we designed equalizers. The low value of BER (Bit Error Rate) and the high value of SNR (Signal-to-Noise Ratio) should be obtained, so, in this way equalizer must be worked.

2. Adaptive Equalization Techniques

The most widely used equalizers are Blind Equalization, Symbol spaced Equalizer, Fractionally Spaced Equalizer and Decision-Feedback Equalization.

2.1 Symbol Spaced Equalizer

Input signal samples should be stored, to achieve that, the symbol-spaced linear equalizer contain a tapped of delay line. For every symbol period the output of a weighted sum of the values in the delay line the weights for the next symbol period is updated. This type of equalizer is called symbol-spaced as the input and output sample rates are equal. Here the equalizer attempts to compose the spectrum inverse of the folded channel which is due to the input aliasing. The equalizer begins in training mode and later switches to decision –directed mode for typical applications. Fig.1 shows the general block diagram of symbol spaced equalizer.

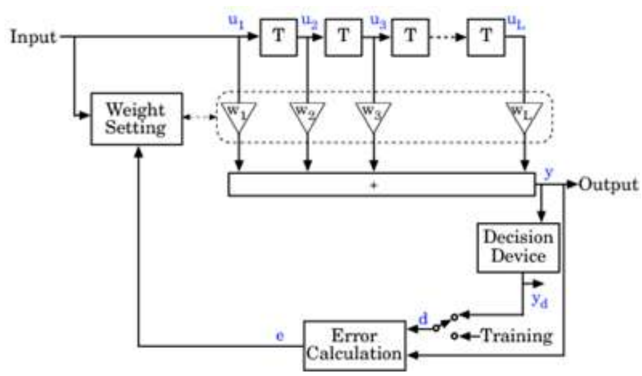

Figure 1: The General Block Diagram of Symbol Spaced Equalizer

2.2 Decision Feedback Equalizer

A decision feedback equalizer (DFE) is a nonlinear equalizer. To eliminate the ISI on pulses that are being demodulated it uses previous detector decision. In other words, the subtraction of previous pulses from the current pulse causes the distortion. The basic concept of a DFE is that by subtracting the past symbol values with appropriate weighting ISI can be cancelled at the output of the forward filter provided, the values of the symbols previously detected are known. Criterion of minimizing the MSE can be fulfilled by simultaneously adjusting the forward and feedback tap weights. DFE structure is very useful For equalization a high amplitude distortion of channels[6].

2.3 Blind Equalization

In blind equalization the equalization of the transmission channel can be achieved without transmission of a training signal. Multimodal's algorithm (MMA) and Constant modulus algorithm (CMA)are the two algorithms of the blind equalization that have been suggested. The mean squared error (MSE) is reduced to acceptable levels by these algorithms. In communication systems, a blind equalization is used as an adaptive equalization without training sequences assistance[7]. In this algorithm, the coefficients of equalizer is updated by quantization the output of equalizer. the decision directed equalization limitations could be avoided, using a statistical measurement based on the properties of priori symbol, at the receiver, the desired signal can be estimated. thus, a blind equalization can be achieved by this technique[8].

2.4 "Fractionally Spaced Equalizer"

The linearity behavior of fractionally spaced equalizer makes it like a symbol-spaced linear equalizer. It However, a fractionally spaced equalizer receives the input samples say K (K represents an integer value). After that it generates one output sample and then updates the weights. Usually in most of the applications K equal 2.1/T and K/T represent the rate of output sample and the rate of input sample respectively[9]. At the output rate the updating of the weight occurs. At times the input is over sampled in a way that the symbol interval longer than the sample interval and a fractionally spaced equalizer is resulted. Advantages of FSE are it is not affected by problem of aliasing, provides rapid convergence and symbol rate is more compared to the sample rate. This paper focuses on the Symbol spaced as a based technique for equalization[10].

3. Proposed Methodology

The general block diagram of the proposed system for equalizing ECG across the transmission channel is summarized in the Fig (1) and Fig (2) for transmitter and receiver sides, respectively.

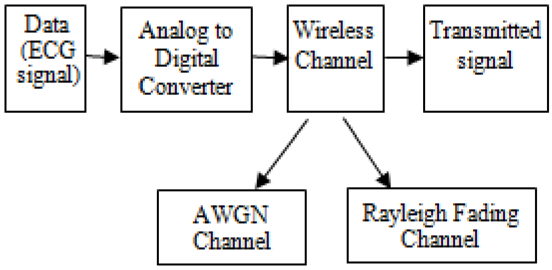

Figure 2: Transmitter Side

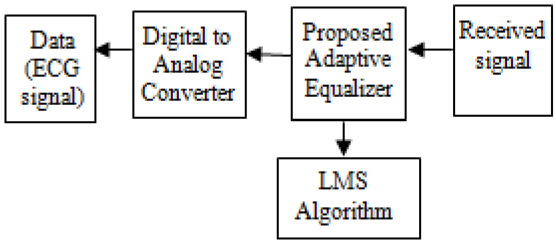

Figure 3: Receiver Side

3.1 Transmitter

In the transmitter side, the data (ECG signal) to be transmitted is given to the Analog to Digital converter comprising of the sampler, PCM encoder and quantizer to produce a digital ECG data by converting analog data of ECG to a digital data of ECG. A process of digital modulation is to receive the transmitted signal without any loss of information at the receiving end by impressing a digital symbol onto the signal which is transmitted[11]. In modern digital communication system the most widely used modulation scheme is a modulation technique called Quadratic phase shift keying (QPSK). It has a high performance on bit error rate and efficiency of bandwidth. Data into the modulator is then transmitted through the wireless channel. The wireless channels considered in this paper are Rayleigh fading and AWGN channel.

3.1.1 Rayleigh Fading Channel

In wireless communications, reflectors present in the environment surrounding a transmitter and receiver creates multiple paths that a transmitted signal can be traversed. This result a different path is traversed at the receiver due to the superposition of multiple copies of the transmitted signal. The delays associated with different signal paths in a multipath fading channel change in an unpredictable manner. The time-variant impulse response of the channel is modeled by application of The central limit theorem as a complex-valued Gaussian random process, in case if there are a large number of paths. Rayleigh fading channel is the channel in which the impulse response is modeled as a zero mean complex-valued Gaussian process.

3.1.2 AWGN Channel

Additive white Gaussian noise (AWGN) is often used as a channel model in which a linear wideband addition or white noise with amplitude Gaussian distribution and constant spectral density is the only impairment to communication. This model does not account for frequency selectivity, fading, interference, non-linearity or dispersion. AWGN is commonly used to simulate background noise of the channel which is under study, in addition to multipath, interference, terrain blocking, self interference that modern radio systems encounter in terrestrial operation[12].

3.2 Receiver

At the receiver end, the received ECG signal is subjected to ISI. Inter symbol Interference superinduced with the transmitted ECG signal is removed by using algorithm of LMS of Adaptive Equalization technique. Then the Digital ECG data will be converted to Analog ECG data by the digital to analog converter [6].

3.2.1 Least Mean Square Technique

The LMS algorithm in general, consists of two basics procedure:

1) Process of filtering, by this process a transversal filter output is determined due to the inputs of tap and the difference between the desired response and the filter output will produce the error term.
2) Process of an adaptive, by this process the weights of the tap is adjusted due to the error term".

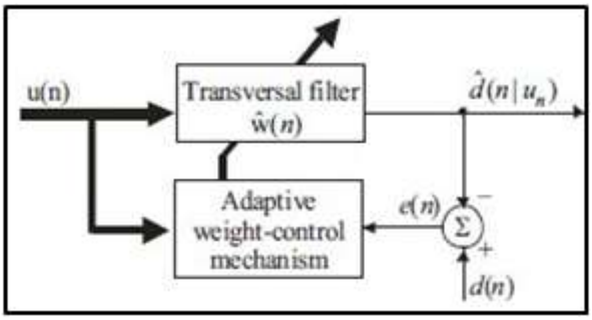

Figure 4: Adaptive transversal filter employing LMS Technique

process of filtering, which involve, generating an estimation error by comparing a desired response with computed output, calculating(d(n-d)) which is the output of a linear filter responded to the input signal [13] as shown:

$$e(n) = d(n) - y(n) \qquad (1)$$

y(n) represents the desired response (filter output)at time n.

Process of adaptive, in which the filter's parameter is automatically adjusted in accordance with the error estimated.

$$w\hat{}(n+1)= w\hat{}(n) + \mu(u)e^{*}(n) \qquad (2)$$

When μ is the size step,
(n + 1)= tape weight vector estimation at time(n + 1)
set (n) = 0 If the vector (n) prior knowledge tape weight is not available.
a feedback loop is constituted by working of these two processes together, as illustrated in the Fig. 4.

4. Results and Discussion

To illustrate that algorithm of LMS is efficient in medical cases for the elimination of channel noise and inter symbol interference, by using an ECG signal the method has been validated.

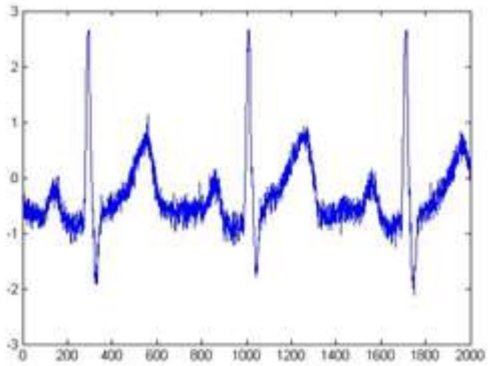

Figure 5: Transmitted ECG Signal

Fig.5 is the normal **electrocardiograph** signal which is transmitted through the wireless channel.

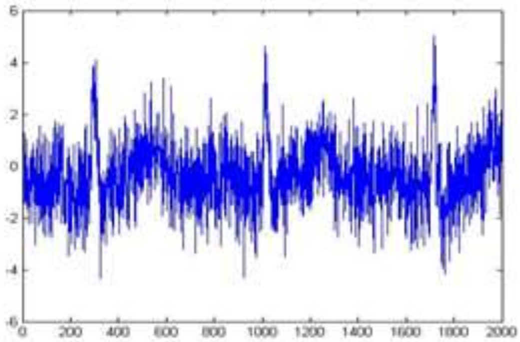

Figure 6: Received ECG Signal

Fig. 6 is the ECG Signal received at the receiver side which has been subjected to Inter symbol interference.

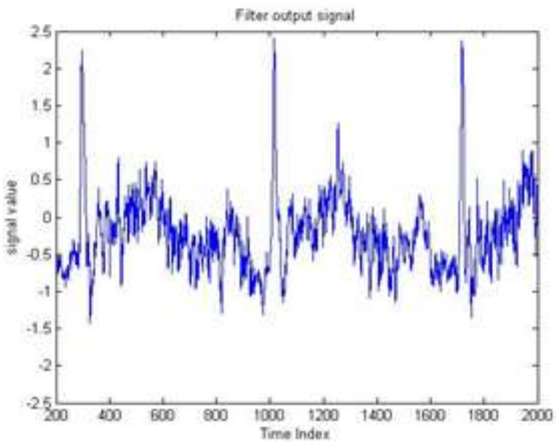

Figure 7: Output Signal

Fig. 7 shows the proposed system output. the noise will be reduced to some extend by the LMS filter which helps in the clinical diagnosis.

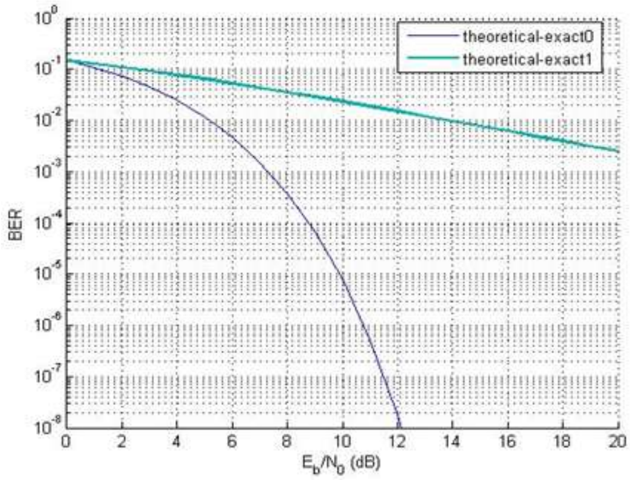

Figure 8: Theoretical Readings of Bit Error Rate

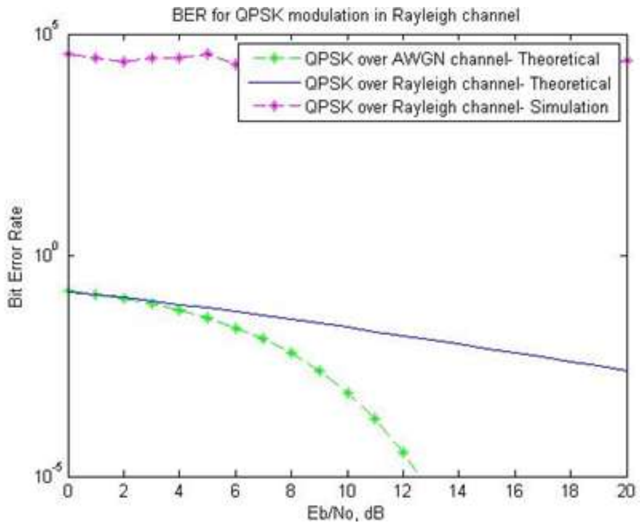

Figure 9: Simulation Results of Bit Error Rate

The simulation results in Fig. 8 and Fig. 9view that the theoretical and simulated bit error rate for AWGN Channel and Rayleigh Channel is quite close and the values of bit error rate for the two different channels are illustrated in table (1).

Table 1: Simulation Results of BER across the AWGN and Rayleigh Channels

Eb/No (dB)	BER	
	AWGN Channel	Rayleigh Channel
2	0.0375	0.1084
4	0.0125	0.0771
6	0.0023	0.0529
8	1.90E-4	0.0354
10	3.87E-6	0.0232
15	9.12E-16	0.0077
20	1.04E-35	0.0024

5. Conclusion

In this paper, a new approach of equalization ECG signals has been proposed to improve the performance of the Symbol spaced adaptive Equalizer using LMS Algorithm for wireless ECG transmission. The proposed approach has validated using AWGN and Rayleigh channels. The simulation results view that the original ECG transmitted signal is highly correlated with the received signal.

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