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Research paper

Hybrid Approach for Channel Estimation Using Iterative Compensation and LMS Algorithm

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Abstract

In Orthogonal Frequency Division Multiplexing, the concept of channel equalization and estimation plays a vital role to improve the performance of the system by reducing the effects of distortion in the signals that occurs due to fading, multipath, delay spreads. In this study a hybrid channel estimation technique is developed by collaborating the iterative compensation mechanism with Least Mean Square technique. The performance of the proposed work is observed to be more effective and efficient than the Iterative compensation based channel estimation technique in the terms of Mean Square Error (MSE).

Keywords: *OFDM, Channel Estimation, Equalization, Iterative Compensation, Least Mean Square (LMS).*

1. Introduction

The channel characteristic serves as the most prominent factor which degrades the transmission signal quality in communication systems based on terrestrial wireless approach [1],[2].Transmission signals in fading channels that vary along with time suffer multipath effect which causes ionospheric and channel fading disturbances. Such disturbances results in the introduction of various kinds of signal distortions. Due to this high degree of variations in Signal to Noise Ratio (SNR) at receiver can be observed which may include values varying in the range of 1dB to 10dB.Increased multipath fading is caused by the introduction of noise and interference into the significant data. Channel estimation is considered to be the most vital factor in ensuring the higher efficiency levels offered by the system. It is required for maintaining the accuracy rate of the system under low SNR along with faster transmission rates under varying SNR values.

To obtain an efficient equalizer that enhances the performance levels of entire system including the receiver a reliable algorithm that is capable of providing greater performance are required [3]-[5]. Algorithms employed for channel estimation are classified into two classes depending on requirements of pilot or training symbol. First, the data-aided channel estimations algorithms are based on pilot or training symbol and other algorithms are classified as blind channel estimation algorithms The statistics of channel fading process pertaining to second or higher order were utilized in determining the process of channel estimation that was involved in traditional blind channel algorithms [6]-[8] ..Despite being highly robust and efficient such algorithms required number of samples due to which they were not applicable for fast-changing channels.Various other communication approaches like demodulation, decoding and corresponding integration in iterative settings are considered for employing blind channel estimation in developing other techniques. Such methods do not require large number of sequences of samples [9]-[12].The deterministic blind estimation is referred to as the process of exposing data structure of over sampled system to certain manipulations which is utilized for developing blind estimation methodologies [13]-[15].Higher performance along with sufficient robustness is provided by such algorithms as no supplementary information is required by them. The need for large hardware resources along with high complexity of algorithm restricts its employment in various application fields that involves multiple channels.

The conventional methods that were used for multipath channels included algorithms based on data-aided channel estimation which depends on pilot-training symbol. Such traditional algorithms are less complex and highly convenient to implement. The least-squares (LS) solutions provided the base for developing channel estimator that operated over pilot or training symbol approach which is proposed in [16]. This estimator was capable of reducing the sum of errors that occurred between the received distorted pilots and actual pilots. Such channel estimators are associated with low complexity a level which enhances its efficiency making them suitable for applications based on wireless communications. Despite being highly efficient, LS algorithms are greatly impacted by interference and noise which may result in reduced performance over additive white Gaussian noise channel. Several channel estimation methodologies are based on Minimum Mean Square Error (MMSE) algorithm which tends to provide more accurate results as it considers the noise effect to be a vital factor for estimation process [17]. This methodology involves relatively more complex computational process which makes its application bit difficult.The channel estimation can also be achieved by employing adaptive least mean square (LMS) algorithm based on training patterns which proves to be more effective than other methods [18]. The convergence performance of this algorithm is enhanced by the use of training patterns that facilitates quick impulse response. Despite offering lower convergence efficiency than Recursive Least Square (RLS) it is less complex algorithm associated with least noise enhancement. Algorithms like normalized LMS (NLMS) elaborated in [23]-[26], variable step-size (VLMS) proposed in [19]-[22] operate over this algorithm which are capable of providing enhanced convergence performance but the complexity levels pertaining to hardware remains the same as it was in LMS. The convergence performance offered by VLMS hybrid method is similar to the case of RLS algorithm.

Despite of being highly efficient MMSE, LMS and LS are inapplicable to the cases which involve 0dB echoes associated with multipath interference due to the reason that interference and noise completely covers the significant data. In order to serve this purpose training sequence based fast correlated algorithm is introduced [27]. This proposed algorithm is able to work well even in situations that involve 0dB echoes. The occurrence of certain error estimation during the channel parameter estimation serves as drawback of the proposed algorithm. This error estimation must be taken into account in the cases involving serious multipath interference. The iterative compensation based LMS is the hybrid approach to overcome the limitations of existing methods. This approach involves the compensation process of original estimation values obtained from fast correlated channel in iterative manner. This hybrid approach exhibits the ability of eliminating error estimations in fast correlated channel estimation along with high accuracy levels. The feasibility and availability of this algorithm based on hybrid approach is depicted in the simulation results.

Algorithms like LSE and LMMSE includes the issue of matrix inversion due to which it cannot be applied to Wiener-Holf equation problem [18].The solution to this problem can be obtained by LMS algorithm which does not require statistical information as primary information. A summarized review of LMS algorithm is given in the section below:

1. $\hat{H}_{r,t'}^{LS}$ is utilized for first iteration so as to initialize LSE method.
2. After evaluating filter co-efficient the channel estimation is given by the equation below:

$$\hat{H}_{r,t}^{LMS}[n] = \hat{W}^{H}[n]\hat{H}_{r,t}^{LMS}[n] \quad (1)$$

where,

$$\hat{H}_{r,t}^{LMS}[n] = \left[\hat{H}_{r,t}^{LMS}[n]\hat{H}_{r,t}^{LMS}[n-1]\ldots\ldots\hat{H}_{r,t}^{LMS}[n-1+M]\right] \quad (2)$$

where,
M is the length of LMS filter

3. Error at n^{th} iteration is evaluated by the following equation:

$$E[n] = \hat{H}_{r,t}^{LMS} - \hat{H}_{r,t}^{LMS}[n][n] \quad (3)$$

4. This error is utilized for updating theco-efficient by the equation given below:

$$\hat{w}[n+1] = \hat{w}[n] + \mu\hat{H}_{r,t}^{LS}[n]E^{*}[n] \quad (4)$$

Where,
The step-size parameter denoted by μ is determined by correlation between data.

5. After coefficients are updated ,the weighted error is evaluated by following equation:

$$\epsilon[n] = w[n] - \hat{w}[n] \quad (5)$$

1. Problem Statement

Channel estimation is must to perform before de-modulation. There are two types of channel estimation techniques namely blind and non blind respectively. The example of blind channel estimation technique is Pilot assisted technique in this technique the Known symbols are built on sub carriers of each OFDM symbols. Then interpolation is applied to the received signals for channel estimation. Non-Blind estimation technique is an estimation technique which is implemented with high or complex computations and work on large amount of data. It accesses the previous information of the channel in order to estimate the channel. Other than blind and non-blind mechanism, the traditional work implements the iterative compensation for performing the channel estimation in OFDM communication system. The enhanced accurate channel estimation parameters were utilized by performing the compensation of estimated errors. The drawback of the traditional iterative compensation technique was that it was quite limited to generate effective results which make it less expensive. Thus there is a need to replace the traditional iterative compensation based channel estimation technique by adding some advancement**.**

2. Proposed Work

After reviewing the working of traditional iterative compensation based channel estimation technique, it is observed that it was less effective and efficient. Therefore, in present study an enhanced channel estimation technique is developed by hybridizing the Iterative Compensation mechanism with LMS technique (Least Mean Square). The LMS is applied because it is observed to be more beneficial than other channel estimation techniques. The property of simplicity and less complexity makes the LMS a prominent mechanism. Following is the generalized iteration based LMS algorithm can be implemented by using the following three steps:

1. The following formulation is used for evaluating the output of FIR filters:

$$y(n) = \sum_{i=0}^{N-1} w(n)x(n-i) = x^{T}(n)x(n) \quad (5)$$

2. Error estimation is evaluated by using:

$$e(n) = d(n) - y(n) \quad (6)$$

3. **The weights corresponding to FIR vector are upgraded in preparation for the next iteration as**

$$W(n+1) = W(n) + 2\mu e(n)x(n) \quad (7)$$

The LMS algorithm requires 2N addition and 2N+1 multiplication for each iteration respectively.

The procedure for implementing the proposed work is shown in figure 1 below:

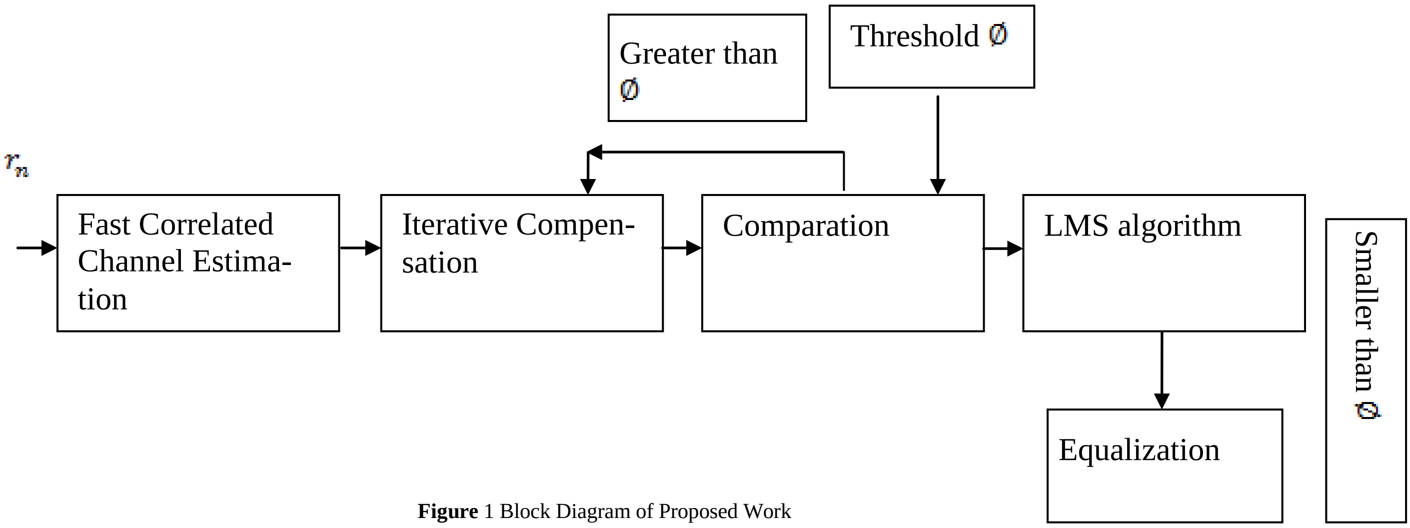

Figure 1 Block Diagram of Proposed Work

1. First step in proposed work is to receive the signals from the sender which carries the information.
2. Then at the receiver side fast correlated channel estimation is applied to the received signals.
3. Next step is to implement the iterative compensation process to the estimated signals.
4. Perform Comparation. In this step a threshold value is assigned and then it is compared with the value of ∅, if it greater than ∅ then the iterative compensation is performed until it remains greater.

Next step is to apply the LMS algorithm and then the comparison is performed to check whether it is smaller than $\emptyset$ *or not*. If it is, then the channel equalization is achieved

4. Results and Discussion

The IC-LMS is a channel estimation technique which is based on iterative compensation and LMS mechanism to perform channel estimation. This section represents the results that are obtained after implementing the proposed work in MATLAB to reduce the MSE of OFDM system. The value of MSE signifies the level of acceptance of minimum error in the system.

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2 \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

The results are operated or evaluated on the basis of the different value of compensation that is represented by variable i. The graph in figure 2 delineates the MSE of proposed OFDM system and traditional system. The y axis in the graph represents the value of MSE. The MSE of IC is observed to be high in comparison to the MSE of IC-LMS.

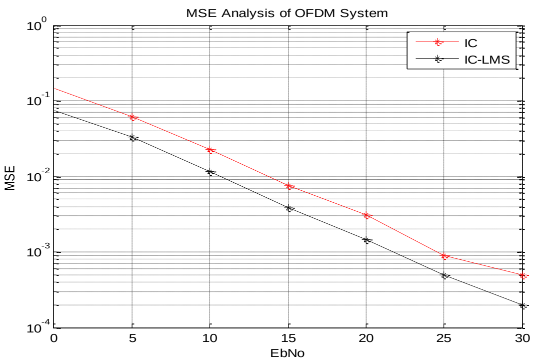

Figure 2 Comparison of MSE

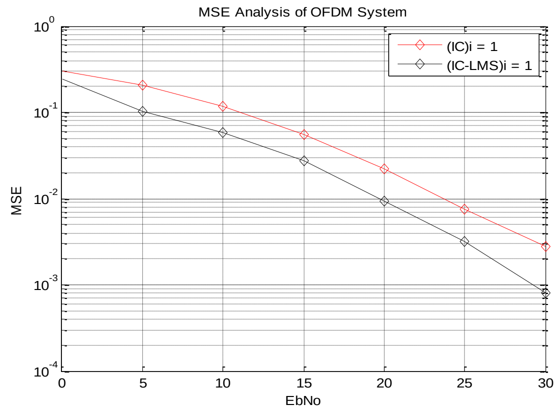

Figure 3 Comparison of MSE at i=1

The IC-LMS is evaluated on the basis of different iterations i.e. 1,2,3 and 4. The graph in figure 3 depicts the comparison of IC-LMS and IC on the basis of i =1. The MSE is evaluated on the basis of the EbNo. The graph represents that the MSE of IC is higher than IC-LMS in case of i=1.

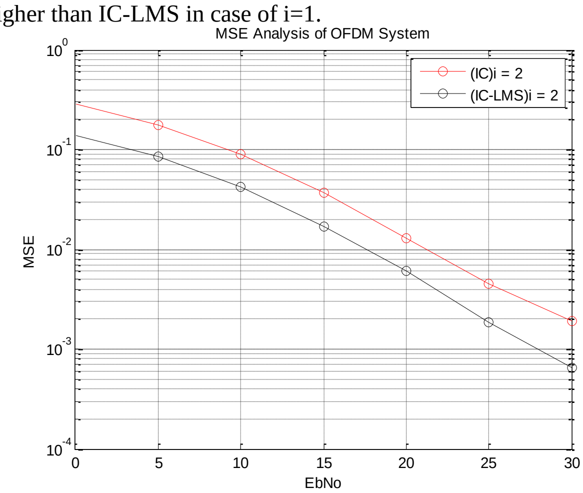

Figure 4 Comparison of MSE at i=2

The graph in figure 4 presents the value of MSE in IC and IC-LMS at i=2. The graph proves that the mean square error of traditional mechanism is higher in comparison to the proposed work at the same value of i i.e. 2.

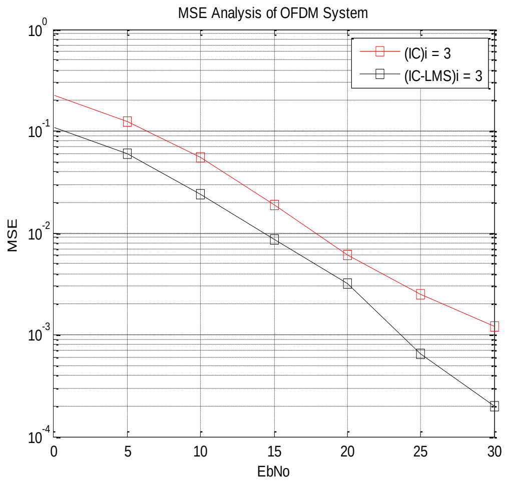

Figure 5 Comparison of MSE at i=3

The graph in figure 5 and 6 render the MSE of IC and IC-LMS ate i=3 and 4 respectively. It is observed in both cases the MSE of IC-LMS is much efficient and lower than IC channel estimation mechanism. The lesser value of MSE demonstrates that the technique is quite effective and leads to the lower error rate.

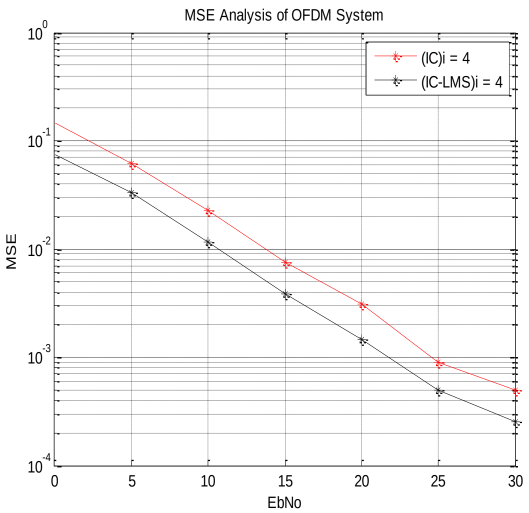

Figure 6 Comparison of MSE at i=4

5. Conclusion

The hybrid channel estimation technique is used to estimate the errors of OFDM communication system. To sum up, on the basis of the observations, it can be said that the IC-LMS mechanism is outperforms the IC channel estimation technique. As the evaluation of the IC-LMS is performed on the basis of four different iterations i.e. i=1,2,3 and 4. In each and every case the MSE of IC-LMS is observed to be lower than the MSE of traditional IC based channel estimation technique.

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