

Improvement in Time Varying Multipath Channel Estimation

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Abstract

In this work, we propose a new algorithm that modifies the LS channel estimation technique by using a feedback LS channel estimator to improve upon its estimation capabilities and still retaining its simplicity. To examine its usefulness especially for wireless mobile applications, performance in terms of the symbol error rate is analyzed with varying Doppler frequency and delay parameters, which is found to be quite optimistic in comparison to LMMSE and LRMSE algorithms.

Keywords: Doppler Shift, OFDM, Pilots Symbols, Symbol Error Rate

1. Introduction

Wireless communication channels are practically time variant and frequency selective channels, which may lead to inaccurate signal reception for wireless mobile applications. Channel estimation is necessary to recover the original signal from channel irregularities^{1,2}. In pilot-assisted channel estimation techniques, inclusion of some pilot symbols in place of OFDM symbols for the purpose of channel estimation, results in decreasing the OFDM symbols rate; whereas, in blind channel estimation, instead of pilot symbols, statistical information about the channel is used without sacrificing any data rate. However, the probability of error with blind channel estimation techniques is higher and adds computational complexities and may be difficult to implement in case of real time applications^{1,3,4}. Pilot channel estimation is further classified as block type and comb type pilot arrangements. Comb type pilot arrangement is preferred over block type for frequency selective and better resistance to fast fading channels^{1,3,5,6}.

2. Literature Survey

Shin, Heath and Powers⁷ (2007) mentioned that for OFDM channel estimation on gradual channels of fading has been studied vastly. However those techniques of channel estimation were developed under the assumption that the channel is stable over an individual orthogonal frequency division multiplexing symbol.

Barhumi⁸ et al [2003] mentioned the frequency offset is regarded to be stable for entire multipath indicating the shift of Doppler frequency that is neglected for individual multipath. For OFDM channel estimation process can be categorized into two major classifications non blind and blind processes. The blind processes need huge number of data since they use received signal statistical behavior to evaluate the channel. Therefore they are not useful for fast fading channels. The estimation schemes of non-blind channel can be classified further into decision directed and data aided channel estimation process. Decision directed estimation of channel can be viewed as a special case of iterative channel estimation.

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According to Xiang Ren, Wen Chen, and Meixia Tao(2015), OFDM is sensitive to the time selectivity caused by high-mobility channels, which costs much spectrum or time resources to obtain the accurate Channel State Information (CSI). Therefore, the channel estimation in high-mobility OFDM systems has been a long-standing challenge and thus proposed position-based compressed channel estimation method for high-mobility OFDM systems. Thus pilot symbol and the placement are jointly designed by the proposed algorithm to minimize the system average coherence.

3. Proposed Feedback LS Channel Estimator

Mismatching of delay spread and the Doppler shift may degrade the system performance in LMMSE and LRMMSE channel estimation techniques. A modified technique is proposed that will be more robust against these impairments variations. To keep the complexity at lower side, we choose to work on the least complex LS channel estimator by using feedback mechanism. The improvement is obtained using the feedback mechanism (de-mapping signal block) which shall be exactly the output of channel equalizer and shall use this information to compensate the impairment variations that will improve the system performance by reducing symbol error rate to its lowest value compare to LS, LMMSE and LRMMSE channel estimators.

4. Performance Comparison

The proposed feedback-based least square algorithm was implemented using MATLAB platform and its performance was analyzed using parameters shown in Table 1.

Randomly generated data sequences and pilot sequences are transmitted with 16 QAM modulations simulated using MATLAB. The performance of proposed scheme is analyzed in terms of symbol error rates in comparison to LS, LMMSE, LRMMSE channel estimators for time varying multipath channel. Keeping in view the upcoming high data rate mobile applications, the performance is examined with varying Doppler frequency shifts and delay with different E_b/N_0

Table 1. Simulation parameters

OFDM symbols	100
Channel model	Rayleigh
Doppler Spread	Jake model
Number of subcarrier	128
Cyclic prefix	16
Modulation Technique	16 QAM
Time interval of the pilot signal	5
Delay	Del-I=[0 2e-6 4e-6 8e-6 12e-6] Del-II=[0 2e-4 4e-4 8e-4 12e-4] Del-III=[0 2e-2 4e-2 8e-2 12e-2]
Number of Multipath	5
Average time delay of the multiple channel (trms)	4e-6;
Sample time (t interval)	1e-6

4.1 Performance with Varying Doppler Frequency Shift

To analyze the impact of relative mobility of the receiver and transmitter w.r.t. each other on system's performance, Doppler frequency is varied from 20Hz to 200Hz, and results are shown in Figure 1 and Table 1 in terms of SER Vs E_b/N_0 . The multipath delay is fixed at [0, 2e-6, 4e-6, 8e-6, 12e-6].

The proposed scheme is better able to adjust the changing Doppler frequency shift effect. SER of proposed scheme is better than other estimators under consideration beyond certain E_b/N_0 and below that performance of all are comparable.

Table 2. SER comparison of different channel estimators with delay time [0 2e-8 4e-8 8e-8 12e-8]

	Estimation Scheme	SER at different E_b/N_0 (dB)				
		5 dB	15 dB	25 dB	30 dB	35 dB
Doppler Frequency 200 HZ	LS	0.7440	0.5210	0.4706	0.4650	0.4650
	LMMSE	0.7056	0.5505	0.4694	0.4651	0.4647
	LRMMSE	0.7107	0.5223	0.4856	0.4826	0.4825
	Proposed	0.7724	0.4718	0.2773	0.2459	0.2355
Doppler Frequency 100 HZ	LS	0.7079	0.3499	0.2205	0.2078	0.2046
	LMMSE	0.6532	0.3202	0.2152	0.2068	0.2040
	LRMMSE	0.6597	0.3486	0.2458	0.2370	0.2329
	Proposed	0.7566	0.3907	0.1080	0.0762	0.0617

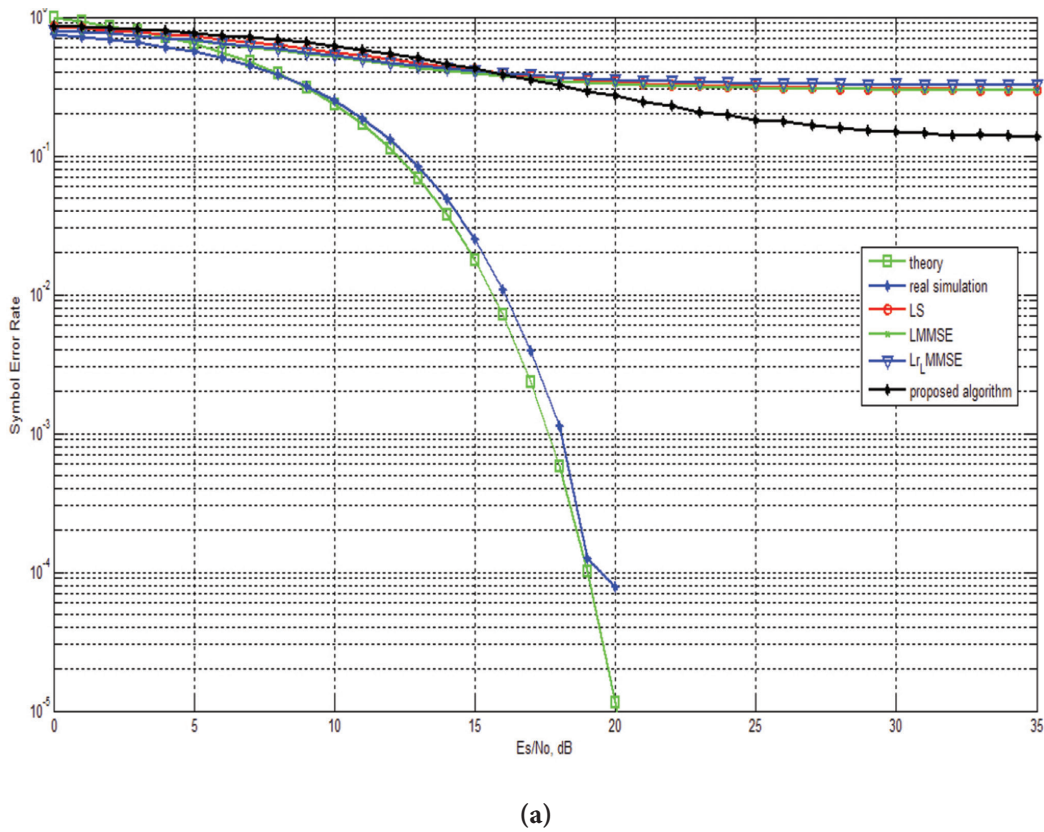
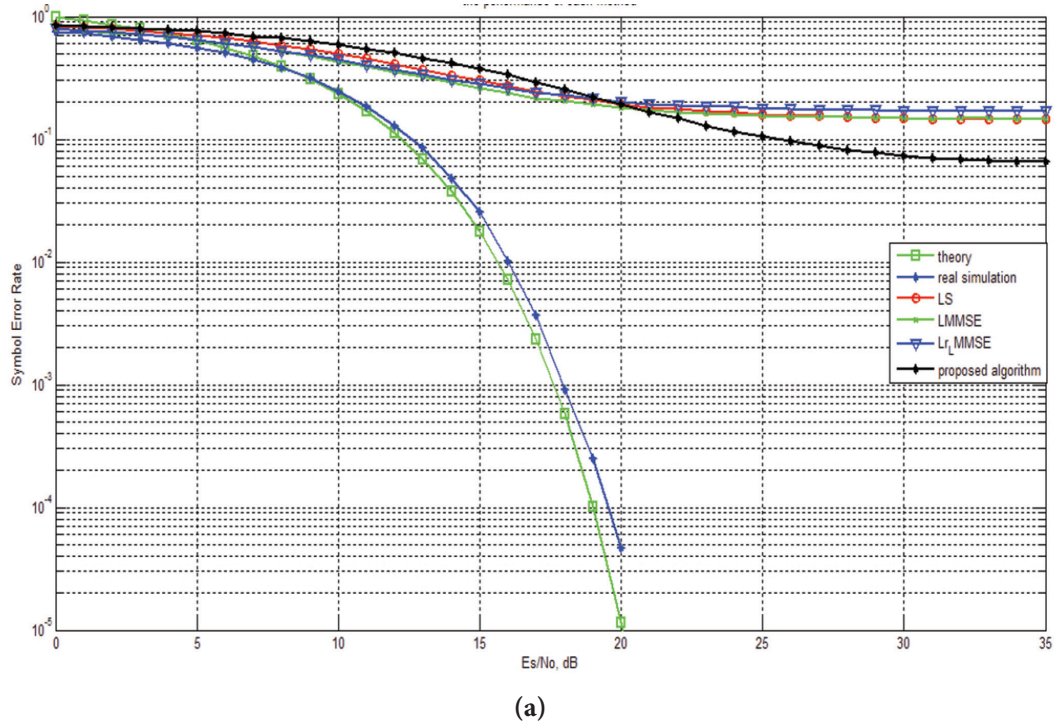


Figure 1. Performance of different channel estimators at different Doppler frequencies
a) 100 Hz b) 150Hz.

As shown in Table 2, the results are much improved for the proposed estimator as compared to the baseline LS, LMMSE and LRMMSE channel estimators. Typically above 10 dB (E_b/N_0) the order of merit is **Proposed (FLS)** > **LMMSE** > **LS** > **LRMMSE**. Due to Doppler spreading, signal undergoes frequency dispersion leading to distortion. Our proposed Feedback based Least Square (FLS) estimator perform better at higher Doppler frequency shift and results are much improved as E_b/N_0 (dB) moves from lower to higher value. For example at $E_b/N_0 = 25$ dB, SER for the proposed FLS is 0.2773, whereas for the LS, LMMSE, and LRMMSE algorithms it is 0.4706, 0.4651, and 0.4856 respectively at 200 Hz Doppler shift.

5. Conclusion

Channel estimation is crucial for correctly estimating the received data especially for high speed mobile data communications. Owing to the time varying and frequency selective channel characteristics, correct estimation of the channel becomes highly imperative along with the lower design complexity of such channel estimators. The main contribution of this paper is in offering a new Feedback based Least Square channel estimator (FLS) for time varying multipath channels that exploits low complexity features of LS algorithm and improves upon channel estimation by means of a feedback mechanism. The performance of proposed scheme in comparison to the existing channel estimation schemes (LS, LMMSE and LRMMSE), shows that with increasing Doppler frequency shift and under multiple clusters of reflections FLS can effectively reduce the channel estimation error exhibiting superior performance.

6. References

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