Joint Channel Estimation and Data Detection in massive MIMO Systems

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Abstract - Designing spectral efficient, high-speed wireless links that offer high quality of-service and range capability has been a critical research and engineering challenge. In this thesis, we mainly address the complexity and performance issues of channel estimation and data detection in massive multiple-input multiple-output (MIMO). We derive the probability density function expressions of the condition number (i.e., the maximum-to-minimum-singular-value ratio, MMSVR) of the channel state information matrix of m-MIMO systems. It is shown that this ratio is directly related to the noise enhancement in open-loop systems and provides a significant insight on the system capacity. A decision-directed (DD) maximum a posteriori probability (MAP) channel estimation scheme of MIMO systems is derived. We propose an iterative channel estimation and data detection scheme for MIMO systems in the presence of inter-carrier-interference (ICI) due to the nature of time-varying channels. An ICI-based minimum-mean-square error (MMSE) detection scheme is derived. An Improved expectation-maximization (IEM) based least square (LS) channel estimator is proposed to minimize the mean-square error (MSE) of the channel estimates and to reduce the complexity of the implementation. With the estimate of the channel and initially detected symbols, ICI is estimated and removed from the received signal. Thus more accurate estimation of the channel and data detection can be obtained in the next iteration. An IEM-based MAP channel estimator is derived by exploiting the frequency/time correlation of the pilot and data sub-carriers. Performance comparison is made between the proposed schemes and the ideal case – time-invariant channels and perfect channel estimation..

***Key Words*:** MSE, MMSE, MIMO, IEM, BER

1. INTRODUCTION

Estimation theory deals with the basic problem of inferring a set of required statistical parameters of a random experiment based on the observation of its outcome. It is assumed that it is possible to produce an effect in the experiment by means of a controlled excitation signal. This approach is normally adopted in practical communications systems where channel estimation is an essential part of standard receiver designs [1] and carried out by transmitting training symbols commonly known as pilot symbols [2]. In this case, the random experiment can be seen as an unknown system that is identified by observing how the system reacts to the applied excitation or training signal. Traditionally, the most widely used channel estimation technique is pilot-assisted training where the pilots are multiplexed in time or frequency. This is widely known in the literature as pilot symbol assisted modulation (PSAM) [2] and is denominated as pilot-assisted transmission (PAT) [3]. This scheme employs a nonrandom training pilot sequence known a priori by the transmitter and the receiver. The training pilots are periodically inserted into certain positions in the time (frequency) with the information-bearing symbols, before modulation and transmission. Using the knowledge of the training symbols and the corresponding received signal, the channel estimation block at the receiver is able to make an estimate of the channel impulse response (CIR).

2. Proposed Methodology

MIMO communication techniques can be applied with OFDM to increase spectral efficiency. It has recently become one of the most significant technical breakthroughs to solve the bottleneck of high data rate requirement and it is the key technology in the emerging high data rate standards such as IEEE 802.16 and IEEE 802.11n. In MIMO OFDM systems, flexible transmission and signal processing techniques can be implemented to provide high quality measured by the bit-error rate (BER) and/or high data rate by exploiting either the diversity gain and/or the spatial multiplexing gain. Realizing these gains requires knowledge of CSI at the receiver, which is often obtained through channel estimation.

2. Result and Discussion

Mean square error (MSE) comparison of proposed algorithm

Figure 1 is a plot SNR V/S MSE, in which it shows the performance of proposed algorithm. It has been observed that proposed algorithm is more resistant than other conventional algorithm. It is also analysed that the performance of proposed algorithm can be improved by increasing the length of FFT, as shown in the figure 2 for N= 256, L = 8. For FFT size is equal to 256 gives the better result as compare to FFT size of 128 & 64.

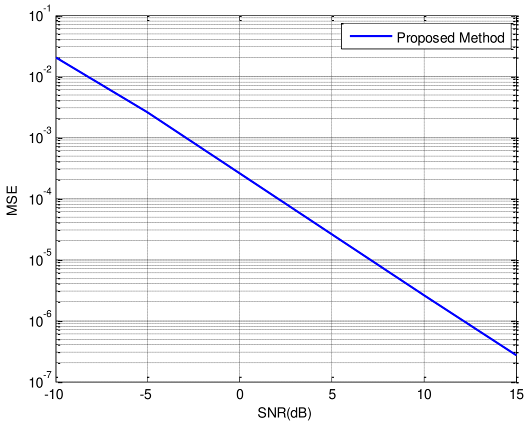
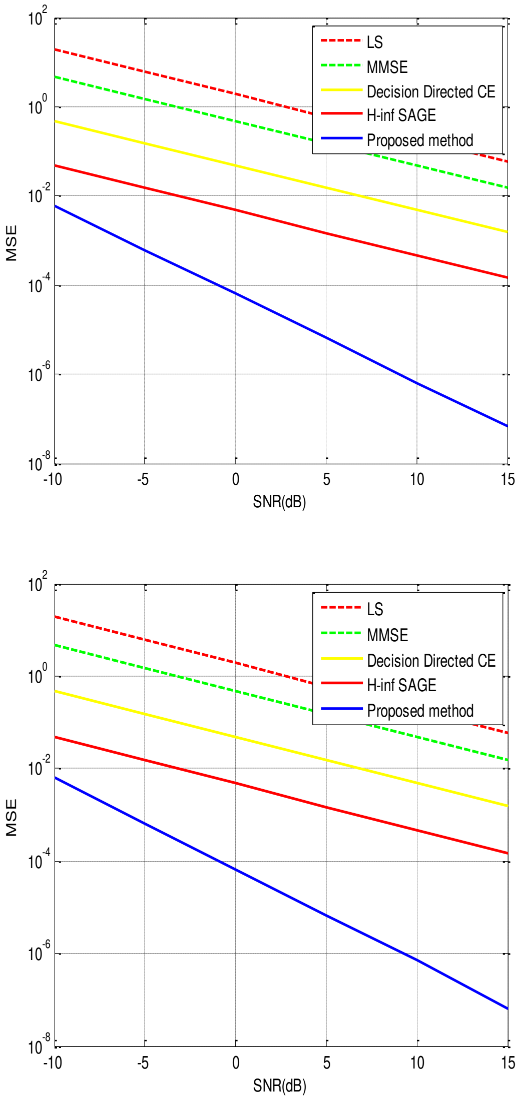


Figure 1: Performance of proposed method



a)N= 256, L =4 b) N= 256, L=8

Figure 2: MSE Plot V/S SNR a) N= 256, L=4 & b) N= 256, L= 8

Figure 3 shows the MSE V/S SNR for N= 64, 128,256 for L= 4 & in figure 4 for N= 64, 128,256 for L= 8. From the figure we can easily conclude that the FFT with 256 gives the better result.

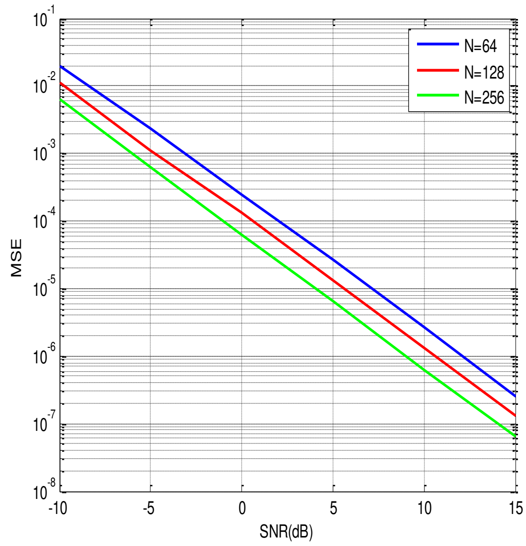


Figure 3: Comparison performance of different size of FFT for channel length is 4

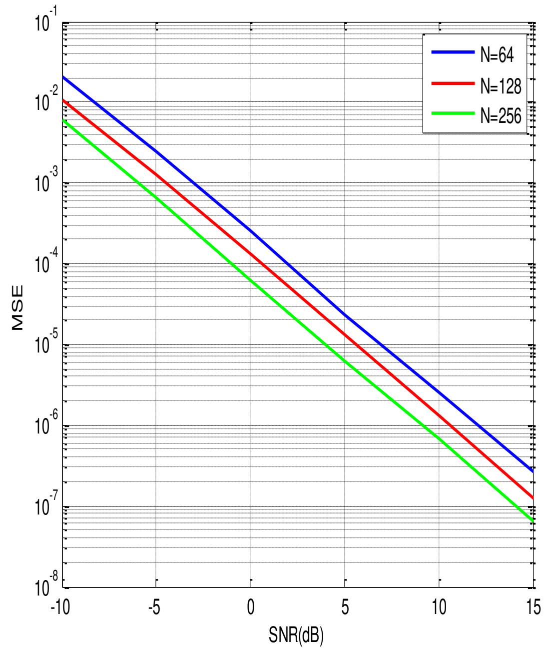


Figure 4: Comparison performance of different size of FFT for channel length is 8

3. CONCLUSIONS

In this paper, solutions to address various challenging physical layer issues of mobile MIMO-OFDM systems have been proposed, including channel analysis and modeling, channel estimation, and data detection. The analysis provides a simple and effective way to predict the relative performances of different MIMO OFDM configurations. Secondly, a decision directed maximum a posteriori probability (MAP) channel estimation scheme for symbol-by-symbol detection in MIMO systems has been derived. This scheme has a low complexity and can be applied to time-varying Rayleigh fading channels with an arbitrary spaced-time correlation function. Numerical results indicate that a long memory depth is unnecessary for a system to work well. The channel estimation quality deteriorates as the number of transmit antennas increases. The fading rate has a high impact on system performance and the proposed scheme is more appropriate for the channels with low to medium Doppler shifts. Large block length between adjacent pilot blocks can be deployed with the proposed scheme. This results in minimum overhead for pilot symbols.

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