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Performance Analysis of Massive Mimo Receiver Using Svd Based Mmse-Pic Detection

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Abstract: ***Multiple Input and Multiple Output (MIMO) systems have been introduced to increase the wireless network capacity and spectral efficiency. MIMO system is used to provide ergodic capacity, which linearly grows with the minimum number of transmitter and receiver antennas. In this paper, Minimum Mean Square Error- Parallel Interference Cancellation (MMSE-PIC) detection method is introduced which reduces the block of data be using matrix inversion. The complexity of the system increases due to matrix inversion.The Singular Value Decomposition (SVD) based MMSE-PIC algorithm is proposed for the efficient channel interference cancellation and to obtain the better Bit Error Rate (BER) performance without matrix inversion using Quadrature Amplitude Modulation (QAM) technique. The existing and proposed detection algorithms are analyzed using Matlab Simulation environment. From the simulation rsults, Bit Error Rate (BER) performance of SVD based MMSE-PIC detection is superior to the conventional methods.***

Keywords: ***Massive MIMO, BER, MMSE, SVD, MMSE-PIC, QAM, Signal Detection.***

I. INTRODUCTION

MIMO system technology is becoming emerging technology for wireless communication networks like LTE and Wi-Fi [1]. The huge antennas at base station and user terminal is provided with more possible signal paths to yield better data rate and reliability [2]. Massive MIMO systems have tens to hundreds of antennas that can be operated fully coherently and adaptively [3]. The advantages of the massive MIMO include low power, latency reduction, simplified Media Access Control (MAC), and robustness [4]. In [5], a differential QAM modulation was introduced for differential encoding and detection. The MMSE-PIC algorithm was presented [6], which gives significant BER and reduced complexity. However, the MMSE-PIC is still having higher complexity due to matrix inversion and Gram matrix. In [7], the MMSE and Zero Forcing (ZF) linear detection methods are introduced. Due to its matrix inversion the complexity has been increased. In [8], MIMO SVD system was discussed to find the ergodic capacity for fading channels. For uncoded data transmission, the MIMO SVD algorithms are presented in [9-10]. In [11], SVD with large matrix is dealt to evaluate the joint orthogonality for massive MIMO system. This research work is discussed as follows. Sections II and III present the MIMO model and SVD decomposition respectively. The results are discussed in section IV and the conclusion is given in section V.

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II. SYSTEM MODEL

A massive MIMO system model is configured with N_t and N_r transmitting and receiving antennas with $N_t \le N_r$. $\overline{X} = (\overline{X}_1, \overline{X}_2, \ldots \overline{X}_{N_t})^T$ is represented as transmitted signal vector simultaneously by all users in one channel where $X_n \in A = (a_1, a_2, ..a_2 Q)$ represents the transmitted symbol from user n. Each X_n corresponds to Q symbols. Then system is modelled like in equation (1).

$$\overline{Y} = \overline{H}\,\overline{X} + \overline{N} \qquad (1)$$

Where $\overline{Y} = (\overline{Y}_1, \overline{Y}_2, \ldots \overline{Y}_{N_r})^T$ is received signal vector with $N_r \times 1$. $\overline{X}_i \in \Omega$ is data transmitted through i^{th} antenna and Ω represents set of M complex symbols of 16-QAM. $\overline{H}$ denotes the channel matrix with $N_t \le N_r$. $\overline{N}$ is represented as i.i.d. Gaussian vector with $N_r \times 1$. Then

$$Y=HX+N \qquad (2)$$

The Log Likelihood Ratio of the system is defined as

$$L^O(C_{n,q}) = \ln \frac{\sum_{X_n \in A_q^0} p(Y \mid X_n) p(X_n)}{\sum_{X_n \in A_q^1} p(Y \mid X_n) p(X_n)} - L^d(C_{n,q}) \qquad (3)$$

Where, $L^d(C_{n,q}) \rightarrow$ output extrinsic LLR of the decoder.

III. SINGULAR VALUE DECOMPOSITION

Singular Value Decomposition (SVD) computations with complex numbers are more complicated than that with real numbers. Consider a complex matrix $H=H_R+iH_I$, where H_R represented as real part and H_I denoted as imaginary part respectively. Then the SVD decomposition of H is represented by $H=UDV^T$, where unitary matrices represented by U and V. The diagonal matrix denoted by D. Then H can be written as

$$H_k = \begin{bmatrix} H_R & -H_I \\ H_I & H_R \end{bmatrix} \qquad (4)$$

Then the SVD can perform complex calculation by using equation (4).

IV. RESULTS AND DISCUSSION

The performance of SVD based MMSE-PIC receiver for massive MIMO system is assessed through the Monte-Carlo simulations using Matlab.

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The BER analysis and comparison of various detection methods are discussed as follows. The BER performance of SVD based MMSE-PIC, and the other methods are obtained for various transmit and receive antenna configurations with 16-QAM modulation by using Rayleigh fading channels. The summation results are discussed in the following.

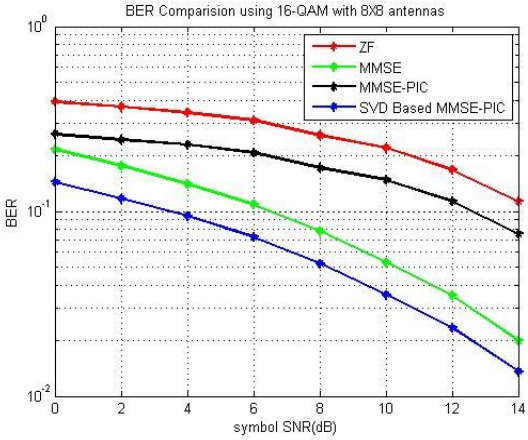

Figure.1 BER performance comparison (N_t =8, N_r =8)

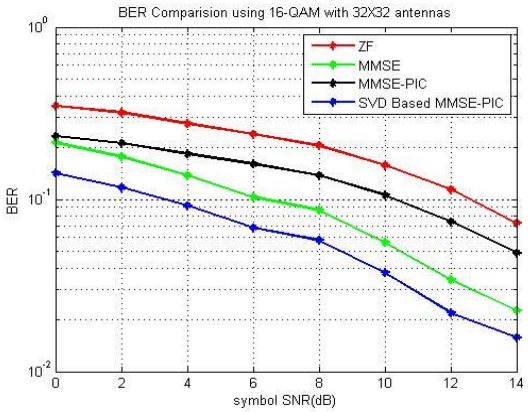

Figure.2 BER performance comparison (N_t =32, N_r =32)

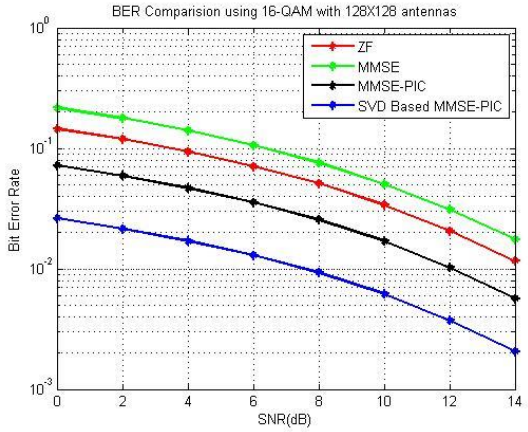

Figure.3 BER performance comparison (N_t =128, N_r =128)

Figure.1 depicts the BER comparison of SVD based MMSE-PIC, MMSE, ZF, and MMSE-PIC receivers using 16-QAM modulation with N_t =8 and N_r =8. From the figure.1, it shows that the SVD based MMSE-PIC detection provides better BER performance compared to the conventional methods. Figure.2 shows the BER comparison of SVD based MMSE-PIC, MMSE, ZF, and MMSE-PIC receivers using 16-QAM modulation with N_t =32 and N_r =32. Figure.3 depicts the BER comparison of SVD based MMSE-PIC, MMSE, ZF, and MMSE-PIC receivers using 16-QAM modulation with N_t =128 and N_r =128. From the simulation results, it is observed that BER performance of SVD based MMSE-PIC provides optimum results for large antennas compared to the existing methods.

V. CONCLUSION

SVD based MMSE-PIC detection scheme is introduced for massive MIMO system. The proposed method uses SVD Decomposition which has less computational complexity because it does not need matrix inversion. The simulation results of SVD based MMSE-PIC detection method and other exiting methods are carried out using Rayleigh fading channel for the large antennas using 16-QAM. Simulation results show that SVD based MMSE-PIC massive MIMO receiver provides better performance than the other receivers.

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