Investigation Minimal Mean-Squared-Error Algorithm For MIMO In Terms Of Bit-Error-Rate Communication Networks

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ABSTRACT

In this research conducted research on method development Multiple Input Multiple Output (MIMO) algorithm to improve transmission data communication. The MIMO has multiple antennas in the transmitter and receiver diversity, which is spatial diversity signals transmit, can be obtained from different locations. MIMO is also a technology used to provide high-speed data services in real time with good performance on multipath fading. By using minimal mean-squared-error algorithm at the receiver and compare its performance in terms of bit-error-rate. It can be seen that the investigation system can be significantly improved the signal quality at the receiver.

Keywords : ***Multiple Input Multiple Output, Minimal Mean-Squared-Error, and Bit-Error-Rate***

1. Introduction

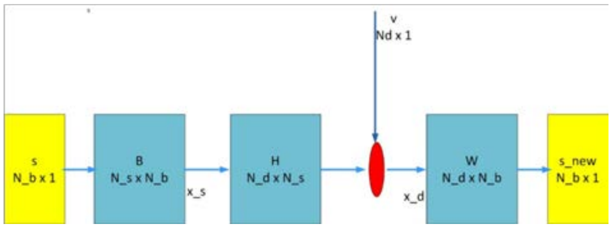
Multiple-input multiple-output (MIMO) is order to provide a reliable wireless transmission, one needs to compensate for the effects of signal fading due to multipath propagation and strong shadowing. Also, MIMO wireless systems employ multiple transmit and receive antennas to in-crease the transmission data rate through spatial multi-plexing or to improve system reliability in terms of bit error rate (BER) performance using space-time codes (STCs) for diversity maximization [1]. MIMO systems exploit multipath propagation to achieve these benefits, without the expense of additional bandwidth. More re-cent MIMO techniques like the geometric mean decom-position (GMD) technique proposed in [2] aim at combining the diversity and data rate maximization aspects of MIMO in an optimal manner. These advantages make MIMO a very attractive and promising option for future mobile communication systems especially when com-bined with the benefits of orthogonal frequency-division multiplexing (OFDM) [2]-[4]. In this paper, we investigated the performance of minimum mean-square-error MMSE) algorithm in a MIMO communication system in terms of bit-errorrate (BER) that are not included in [7]-[13]. Note that the MMSE algorithm has already been studied with MIMO communication system that is not included [6]. In this paper, we study the MMSE algorithm in MIMO communication system to reduces to matched filtering which the maximum achievable rate is naturally achieved by matched filtering. Our results show that algorithms in MIMO communication system have significant performance improvement.

The rest of the paper is organized as follows: the system model is described in Section II; in Section III we study the MMSE linier receiver in a MIMO communication system; Section IV shows the simulation results with MMSE algorithms under various system scenarios and the conclusion is given in Section V.

2. Research Method

System Model For Mimo Multi-Relay

Fig. 1 illustrates a MIMO communication system consisting of one source node, and one destination node. We consider a MIMO system with N_s transmit and N_d receive antennas communication through a frequency flat-fading channel. The generalization to the system with different number



of antennas at each source node is straightforward. The communication process between

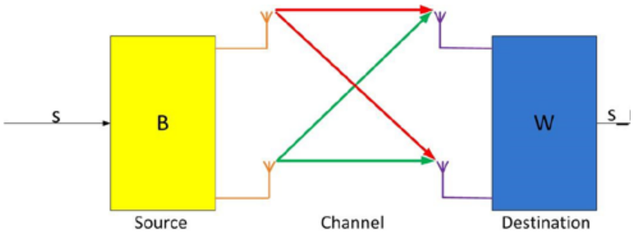


Figure. 1. System model for MIMO Channel.

the source and destination nodes is completed in a time slot. In the N_b×1 modulated symbol vector **s** is linearly precoded as

$$\mathbf{x}_s = \mathbf{B}\mathbf{s} \qquad (1)$$

where **B** is an $N_s \times N_b$ source precoding matrix. We assume that $E[\mathbf{s}\mathbf{s}^H] = \mathbf{I}_{Nb}$, where $(\cdot)^H$ denotes matrix (vector) Hermitian transpose, E[·] stands for statistical expectation, and $\mathbf{I}_n$ is an $n \times n$ identity matrix. The precoded vector $\mathbf{x}_s$ is transmitted to the destination nodes and the received signal at the destination node can be written as

$$\mathbf{x}_{d,i} = \sqrt{E_s}\mathbf{H}_{s,i}\mathbf{x}_{s,i} + \mathbf{v}_{d,i} \qquad i = 1,\cdots,K$$
$$\mathbf{x}_d = \sqrt{E_s}\mathbf{H}_s\mathbf{x}_s + \mathbf{v}_d \qquad (2)$$

where we define

$$\mathbf{H}_s \triangleq [(\mathbf{H}_{s,1})^T, (\mathbf{H}_{s,2})^T, \cdots, (\mathbf{H}_{s,K})^T]^T$$
$$\mathbf{v}_d \triangleq \left[(\mathbf{v}_{d,1})^T, (\mathbf{v}_{d,2})^T, \cdots, (\mathbf{v}_{d,K})^T\right]^T.$$

where $\mathbf{H}_{s,i}$ is the $N_d \times N_s$ MIMO channel matrix the destination node, $\mathbf{x}_d$ and $\mathbf{v}_d$ are the total received signal and the additive Gaussian noise vectors at the destination node, respectively where $E[\mathbf{v}_d\mathbf{v}_d^H] = \mathbf{I}_{Nd}$. The diagram of the equivalent MIMO system described by (2) is shown in Fig. 2.

In this paper, we try to improve the system BER performance by using minimal mean-squard-error (MMSE) equalizer. A simple approach to design the $P_s > 0$ is the transmit power available at the source, and $(\cdot)^H$ denotes matrix Hermitian.

MMSe Linier Receiver For Mimo Communication Networks

We study the following detection algorithms for MIMO communication networks such as the MMSE equalizer. If we consider the received signal vector at the destination in (2) then our proposed MIMO channel (Fig. 1) reduces to a Blok Diargam MIMO channel (Fig. 2) into MIMO channel with the equivalent channel matrix of **Hs** + **v** where **H** = $\mathbf{H}_s\mathbf{B}$, the signals vector of **s** and the equivalent noise vector of $\mathbf{v} = \mathbf{v}_d$. Now we can analyze the signal detection at the destination receiver with the MMSE equivalent MIMO channel. One possibility is to minimize the total resulting noise to fine *W* using the decoding technique to be described in this paper is the performance MMSE technique at destination. The MMSE technique meeting the constraint as

$$E\{[\mathbf{W}^H\mathbf{x}_d - \mathbf{s}][\mathbf{W}^H\mathbf{x}_d - \mathbf{s}]^H\}. \qquad (3)$$

where *E* is statistical expectation. The solution to this problem is given by the classical MMSE filter

$$\mathbf{W} = \sqrt{\frac{N_s}{E_s}}\{\mathbf{H}^H\mathbf{H} + \mathbf{I}_{N_d}\}^{-1}\mathbf{H}^H. \qquad (4)$$

The estimated signal at destination (2) is given by

$$\mathbf{s}_{new} = \mathbf{W}_H\mathbf{x}_d. \qquad (5)$$

W is also known as MMSE filtering reduces to matched filtering as $N_d \times N_b$ matrix and $(\cdot)^{-1}$ indicates simple matrix inversion. In order for a pseudo-inverse to exist, N_d must be greater than or equal to N_b. Using the MMSE technique approach described above at the destination.

3. Discussion

In the simulations, the transmission signaling is in spatial multiplexing mode (i.e., the source transmits independent data streams from different antennas) with total transmit power uniformly distributed among the transmit antennas. We study the performance of the proposed MMSE technique algorithm for MIMO communication networks. All simulations are conducted in a flat Rayleigh fading environment using the BPSK constellation, and the noises are i.i.d. Gaussian random variables with zero mean and unit variance. The channel matrices have zero-mean entries with varianσ_s^2/N_s for $\mathbf{H}_s$.

We transmit 1000 randomly generated bits in each channel realization, and the bit-error-rate (BER) results are averaged through 200 channel realizations.

In the first example, we study the effect of the number of source antenna nodes and compare the system BER performance of the MMSE technique at destination algorithm (proposed algorithm) with the without MMSE (WO-MMSE) technique at destination algorithm [8]. We choose variances of N_s and N_d. From Fig. 4, it can be seen that the WO-MMSE algorithma has the worst performance. The MMSE technique algorithmas outperform the WO-MMSE approaches. It can be seen that BER = 10^{-2}, we achieve a 6-dB gain from the [8] to the proposed algorithm. In the second example, we study the effect of the number of source and destination antenna

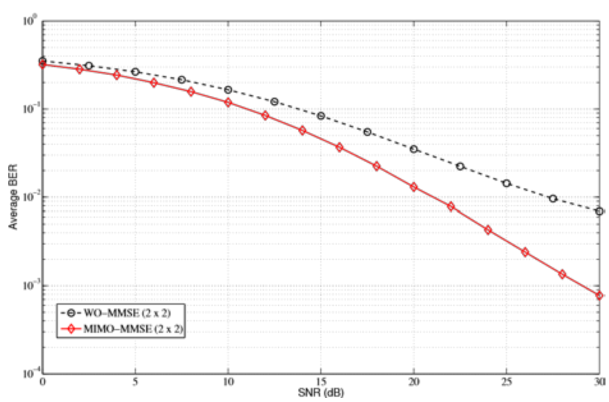


Figure. 3. BER versus SNR_s. $N_s = N_d$ =2 for MIMO channel.

nodes and compare the system BER performance of the MMSE technique at destination algorithm (proposed algorithm) with choose variances of N_s and N_d. From Fig. 4, it can be seen that BER = 10^{-2}, we achieve a 3-dB gain from the variances antennas 2 to 8 algorithms.

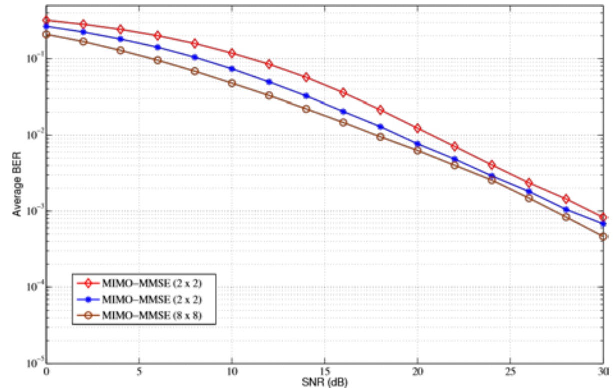


Figure. 4. BER versus SNR_s. $N_s = N_d$ =2,4,8 for MIMO channel.

4. Conclutions

In conclusion, we have demonstrated the advantage of using MMSE equalizer algorithm in MIMO communication network. Our results demonstrate that MMSE equalizer algorithms outperform [8] algorithm. Future works may include analysis the MMSE equalizer for MIMO relay communication networks and optimizing the source and the relay matrices to allocate power efficiently in a MIMO relay network.

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