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Pre- and Post-Coding for Capacity Enhancement in MIMO Systems

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Abstract

A linear scheme at the transmitter (pre-coder) and the receiver (post-coder) is proposed to improve the performance of MIMO systems under a specific configuration for transmitting and receiving antennas over fading channels. This is achieved by generating a linear pre- and post-coder matrix that depends on the correlation matrix of the channel state information (CSI). Through MATLAB simulation, the results show that the use of appropriate coder matrix enhances the MIMO channel capacity and reduces the sensitivity on CSI.

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Keywords: MIMO; pre-coder; post-coder; channel capacity

1. Introduction

Demands for capacity in wireless communications, driven by cellular mobile, internet and multimedia services, have been rapidly increased worldwide. On the other hand, the available radio spectrum is limited and the communication capacity needs cannot be met without a significant increase in communication spectral efficiency. Advances in coding made it feasible to approach the Shannon capacity limit in systems with a single antenna link.

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Further significant advances in spectral efficiency are available through increasing the number of antennas at both the transmitter and the receiver sides which is known as a MIMO system[1, 2].

A MIMO channel can be realized with multi-element array antennas, of particular interest are propagation scenarios in which individual channels between certain pairs of transmit and receive antennas are modeled by an independent flat fading process, which is realistic for environments with a large number of scatters, where a signal transmitted from every individual antenna appears uncorrelated at each of the receive antennas[1].

Based on the statistical information of the channel, the use of diagonal pre-coding can greatly improve the system performance[3, 4]. For channel diagonalization, it has been shown[2] that the MIMO channel can be decomposed into parallel eigen sub-channels, or equivalently eigen-modes, by means of singular value decomposition (SVD). Moreover, a general framework for pre- and post-coder designs for MIMO systems using partial channel knowledge on transmit and receive correlation matrices at the transmitterhave been presented by Bahrami and Le-Ngoc[5.] It has been shown that the optimal linear pre-coder for any uncoded and coded MIMO system based on the minimum mean square error (MMSE) or ergodic capacity criterion is an eigen beam-former that transmits the signal along eigenvectors of the transmit correlation matrix and the optimal post-coder is the inverse of the eigenvector. Based on the eigen-values of both transmit and receive correlation matrices, power loading across the eigen-beams is determined by water filling algorithm; which is a power allocation scheme used to rearrange the power at each sub channel of the MIMO system at different signal to noise ratio (SNR)[6].

In addition, transceivers design based on geometric mean decomposition (GMD) for identical parallel channels has been obtained and then improved[7, 8], while new channel decomposition strategy (called LDH^{H}) has been presented and used for low complexity MIMO pre-coder design[9]. On the other hand, employing a pre-coder matrix with full rank, have been extensively investigated for the subspace-based channel estimation[10]. Jung, Hwang and Choi have proposed a multi-mode pre-coding scheme based on the interference minimization[11] in order to maximize the total system capacity based on mode selection.

In this paper, we present a search algorithm to design linear MIMO pre- and post-coders with a specific configuration of transmitting and receiving antennas over flat fading sub-channels. Simulation results show that our proposed pre- and post-coder enhances the system capacity under a set of power constrain with partial CSI knowledge at different patterns of correlation in the channel matrix.

2. System Description

Consider the MIMO communication model depicted in Fig. 1. The input bit-stream is pre-coded and modulated to generate at least one output symbol stream then it is launched into the MIMO channel using N_T separate antennas. Afterwards, the post-coder receives this stream and performs a decoding process to regenerate the transmitted data stream.