GEOMETRICAL SPACE DIVERSITY AND DISTRIBUTED SPACE DIVERSITY TECHNIQUES FOR WIRELESS COMMUNICATION SYSTEMS

ABSTRACT

This research produces a novel space diversity scheme based on geometrical concept for optimizing the Signal to Noise Ratio (SNR) of the equal-gain Multiple Input and Single Output (MISO) communication system. In the second stage, this method is extended to Multiple Input and Multiple Output (MIMO) systems. These methods are proposed to solve the main problems of the conventional closed-loop MISO and MIMO systems such as high Complexity, feedback delay, the unknown average SNRs, dependant on transmit antennas, non-adaptivity to channels, and phase ambiguity. In the third stage, the structure of the proposed Scalar Equal Gain Transmission and Generalized Maximum Ratio Combining (SEGT/GMRC) scheme is followed to design the limited-feedback codebooks for MISO and MIMO systems which provide a different methodology as compared to the previous well-known codebooks. The proposed quantized equal-gain (QE) codebooks, requires the minimum number of feedback bits to form the beamforming vector. In the fourth stage, the proposed QE codebooks are employed to provide the distributed spatial diversity in a wireless relay network. Since transmit antennas are independent, the extension to relay network is straightforward. The new design is named Distributed QE (DQE) codebooks, in which each relay node stores a QE codebook. In this research, the wireless open-access research platform (WARP) is employed for prototyping the proposed QE codebooks. The proposed new geometrical space diversity system eliminates the searching process and serves as the optimal system for equal-gain MISO transmission systems. By extending this method to the distributed space diversity (DQE), the
main problem related to the conventional methods such as complexity, global Channel state Information (CSI), feedback delay, dependent relay nodes, and unknown average SNR are solved. Many encouraging results are obtained for QE and DQE codebooks, where some of them are as follows. It is shown that the proposed QE codebooks perform near optimal, and also it is proven that a system with one bit of feedback per each phase angle cannot perform near optimal. The performance gap of the proposed codebooks signals using QPSK and BPSK modulation schemes with 90 degrees of freedom are less than 0.25-0.75 dB at the symbol error rate of $10^{-5}$. This gap is reduced for the codebooks signals using 8PSK and 16QAM modulation schemes with 45 and 30 degrees of freedom, respectively. The Warp platform validates the geometrical design of the QE codebooks and it is shown that the proposed QE codebooks are easier to implement and the lower order QE codebooks are more suitable for the channels with the line of sight path. The DQE network can also be implemented easily with minimum complexity. It is shown that the proposed DQE codebooks perform better than direct transmission independent of their location in the distributed network. Number of relay nodes plays an important role on the performance of the network. For example, the error performances of 3 relay nodes located near to the source and each of them employing distributed QPSK or 8PSK codebook, is improved by 14 dB at the error rate of $10^{-5}$ when the number of distributed relay nodes is increased to 8. It is also shown that the DQE codebooks outperform its QE counterpart when the relay nodes are close to the source node. The amount of improvement is around 1 dB for distributed QPSK codebook and around 2 dB for distributed 8PSK codebook. This significance of the proposed geometrical scheme as compared to the well-known works are as follows: the searching methods to find the optimal equal gain beamforming and distributed beamforming vectors are eliminated, therefore the complexity and the system delay become lower while the performances are still optimal; the phase
ambiguity problem is fixed; the average SNR of the receive antennas are available; transmit antennas and the relay nodes are independent which enable the system to employ more than one feedback link; the limited feedback beamforming vectors depend on the modulation scheme, which facilitates the design for more simpler codebooks using lower constellation orders; the new system can adapt itself for any change in channel behavior without performing any matrix operations.