Performance Evaluation of Algorithm for Maximizing Sum-Rate in Multiuser MISO System with Perfect and Imperfect CSIT

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***Abstract*—This paper studies the performance and results of sum-rate (SR) maximization algorithm proposed in [2]. We evaluated the algorithm for Multi User Multiple Input Single Output (MU-MISO) Broadcast (BC) system with 2 and 4 users. We have considered different Channel State Information at Transmitter (CSIT) scenarios as described in [1] and [2]. The objective of this paper is to evaluate the performance of algorithm that maximizes the SR or weighted SR (weights can be thought as a prioritizing factor) under perfect CSIT and maximizes Ergodic sum-rate (ESR) under imperfect CSIT. Numerical simulations show the ESR gains for different downlink channel SNRs and feedback channel qualities.**

I. Introduction

THE use of multiple antennas at the transmitter and many single antenna receivers have proved to increase of overall throughput of a wireless communication system by exploiting spacial multiplexing capability. This technique is also called as transmit beamforming. The simple transmit beamforming techniques such as Zero Forcing Beamforming (ZF-BF) and Minimum Mean Square Error (MMSE) beamforming do not maximize the sum-rate but minimize the correlated and un-correlated noise.

A. Contributions

[1] proposes an iterative algorithm to find the optimum transmit filter that maximizes the sum-rate. In this algorithm, a Weighted Minimum Mean Square Error (WMMSE) matrix is calculated as an alternative way to find the optimum Weighted Sum-Rate (WSR). In each iteration three steps are involved in finding MMSE receive filter matrix, weight matrix (in context to WMMSE) and finally the updated transmit filter matrix.This is repeated till convergence. This algorithm assumes a perfect CSIT exists.

In a wireless communication system, channel estimation is done at the receiver which is mostly assumed to be perfect. This CSI is fed back to the transmitter through a different uplink channel in case of FDD or if TDD is employed the estimation is done at transmitter, but at different time of the same channel. This raises doubts about the reliability of the CSI at the transmitter and hence we are forced to consider scenarios with imperfect CSIT.

To combat this uncertainaty in the CSIT, [2] proposes an iterative algorithm that maximizes the ESR with the help of Average Sum-Rate (AVR). This algorithm is similar to the one in [1] but the key difference is in each iteration, the cost function is built on an average of many channel samples. More details are presented in IV

B. Organization

In this paper we have evaluated the performance and compared the results of both the algorithms for different channel and system scenarios. The structure of rest of the paper is as follows. Next section tells about the system model we had considered for the evaluation of the algorithm followed by section III and IV that describes the details of both algorithms. Finally the results and conclusion are presented.

II. System Model

Consider a MU-MIMO system where the Base Station (BS) has N_t antennas and K users with single antenna each, such that $K \leq N_t$ and $\mathcal{K} \triangleq \{1, ..., K\}$. The received signal at kth user is given as

$$y_k = \mathbf{h}_k^H \mathbf{x} + n_k \tag{1}$$

where $\mathbf{h}_k^H \in \mathbb{C}^{N_t}$ is the channel vector between BS and the kth user, $\mathbf{x} \in \mathbb{C}^{N_t}$ is the transmit signal vector, and $n_k \sim \mathcal{CN}(0, \sigma_{n,k}^2)$ is the Additive White Gaussian Noise (AWGN) at the kth user. The transmitted signal has a power constraint defined by $\mathrm{E}\{\mathbf{x}^H\mathbf{x}\} \leq P_t$ and we assume equal noise variances across all users, i.e $\sigma_{n,k}^2 = \sigma_n^2$, $\forall k \in \mathcal{K}$. By definition the transmit SNR can be written as SNR $\triangleq P_t/\sigma_n^2$.

A. CSIT Knowledge

The channel state is given by $\mathbf{H} \triangleq [\mathbf{h}_1, ..., \mathbf{h}_K]$ that varies according to an ergodic stationary process with probability density $f_{\mathrm{H}}(\mathbf{H})$. The receivers are assumed to have a perfect CSIR and transmitter are assumed to have an imperfect CSIT of the downlink channel. So the channel state estimate at transmitter is given by $\widehat{\mathbf{H}} \triangleq [\widehat{\mathbf{h}}_1, ..., \widehat{\mathbf{h}}_K]$, the error in the estimate is given as $\widetilde{\mathbf{H}} \triangleq [\widetilde{\mathbf{h}}_1, ..., \widetilde{\mathbf{h}}_K]$ and hence the overall channel relation can be written as $\mathbf{H} = \widehat{\mathbf{H}} + \widetilde{\mathbf{H}}$. However the magnitude of $\widetilde{\mathbf{H}}$ is allowed to vary w.r.t SNR by assuming that the feedback bits increase or decrease w.r.t downlink SNR. The gradient of this change is represented by an α factor and the error variance can be defined by $\sigma_{e,k}^2 = P_t^{-\alpha}$

B. Precoder and Transmit Signal Model

At a particular channel usage, lets consider the symbol streams be $\mathbf{s} \triangleq [s_1, ..., s_K]$ for K users, and are mapped to the transmit antennas through a precoding matrix $\mathbf{P}_p \triangleq [\mathbf{p}_1, ..., \mathbf{p}_K]$, where $\mathbf{p}_k \in \mathbb{C}^{N_t}$ is the kth user's precoder. This yields a transmit signal model $\mathbf{x} = \sum_{k=1}^{K} \mathbf{p}_k s_k$. Assuming the data symbol distribution as $\mathrm{E}\{\mathbf{s}\mathbf{s}^H\} = \mathbf{I}$, the transmit power constraints boils down to $\mathrm{E}\{\mathbf{x}^H\mathbf{x}\} = \mathrm{tr}(\mathbf{P}\mathbf{P}^H) \leq P_t$.

III. Algorithm with Perfect CSIT

IV. Algorithm with Imperfect CSIT

V. Results

VI. Conclusion

The conclusion goes here.

Appendix A
Proof of the First Zonklar Equation

Appendix one text goes here.

Appendix B

Appendix two text goes here.

Acknowledgment

We thank

References

[1] Søren Skovgaard Christensen, Rajiv Agarwal, Elisabeth de Carvalho, and John M. Cioffi *Weighted Sum-Rate Maximization using Weighted MMSE for MIMO-BC Beamforming Design*. IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS, VOL. 7, NO. 12, DECEMBER 2008

[2] Hamdi Joudeh and Bruno Clerckx *Sum-Rate Maximization for Linearly Precoded Downlink Multiuser MISO Systems With Partial CSIT: A Rate-Splitting Approach*. IEEE TRANSACTIONS ON COMMUNICATIONS, VOL. 64, NO. 11, NOVEMBER 2016.