Semnan University
Faculty of Electrical & Computer Engineering

M.Sc. Thesis in Electrical Engineering

Analysis and Improvement of the Performance of Linear Receivers in Massive MIMO Communication Systems

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Abstract

In this paper we are going to analyze massive MIMO systems. We consider a Massive MIMO system which consists of one BS and *K* active users. The BS is equipment with *M* antennas, while each user has a single-antenna. In a massive MIMO system, the number of BS antennas *M* is always larger than number of users *K*, i.e. $1 \leq K \ll M$. It is known that in this case, linear receivers (MRC, ZF and MMSE) perform fairly well and therefore As a result we will analyze the performance of linear receivers in a massive MIMO system in great details in this paper. In order to have a full analysis, the SINR probability function in each receiver is required.

Considering the fact that due to complexity matters, the closed form derivation of the SINR for MRC receivers is not practically possible, it is calculated analytically.

But, it cannot be used to obtain close form expresstion for the analytical performance of the systems. It can be noted that when $M \gg K \geq 1$, the form of SINR distribution look like that of a gamma distribution. Therefore, we will approximate the SINR distribution of MRC receiver with gamma distribution.

In our paper the performance of linear receivers is analyzed for two scenarios: In the first scenario the BS has perfect CSI, but in the second one it is estimated at the BS. In the first scenario the parameters to be analyzed are achievable rate, effective achievable rate, outage probability, and the bit error rate. The relations corresponding to each of these parameters will also be calculated. At first the closed form of the upper and lower bounds on achievable rate is computed. Then the closed form of the upper bounds on optimal number of users to maximize the overall user rates will be available.

For the second scenario we consider a system which can optimize pilot sequence length symbols, power of the each pilot symbol, power of the each data symbol, and the number of users. In order for the analysis to be accurate, the closed form for the upper and lower bounds on the achievable rate will be calculated for each user. In order to improve performance, the closed form for the optimum power of the data signal, and an optimization problem to find the optimum number of users to maximize the aggregate of the achievable rate is introduced.

Also, all the derived theoretical results are compared with those of the Monte Carlo simulation for validity verification purposes.