Transmit Antenna Selection in a Massive MIMO System using convex optimization

K Samhitha[1] G Anusha[2]

[1]EE16BTECH11019

[2]EE16BTECH11011

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Introduction

Massive MIMO, also known as very-large MIMO or large-scale antenna array deploys more antennas by possibly orders of magnitude than conventional MIMO.
A major limiting factor in deployment of MIMO systems is the cost of multiple analog chains such as low noise amplifiers, mixers and analog-to-digital converters.
Antenna selection at the transmitter is a powerful technique that reduces the number of analog chains required, yet preserving the diversity benefits obtained from the massive MIMO. The selection criteria can be maximization of channel capacity, signal-to-noise ratio at the receiver or minimization of bit-error-rate.

System Model Description and Problem Statement

We consider the downlink of a base station(BS) communicating with K single-antenna users.
The base station employs M transmit antennas. Perfect channel station information over all antennas is assumed to be known at the BS.
Based on the CSI, the best N(K<N≤M) antennas are select out the M antennas according to some criteria to serve K users.
The signal model of the system is

$$Y = Hd + n$$

where d denotes the transmitted data intended for all K user. H represents the channel vector of size K x M from the BS to all user. n is AWGN with zero-mean and its variance is $\sigma_n^2 I$.

System Model Description and Problem Statement

The optimum algorithm to select N of M antennas is exhaustively searching over all possible antenna combination, i.e. calculating C_M^N *determinants for each channel instance*.
our selection method is based on maximizing total receive power of all users.
Our optimization problem is

$$\text{maximize } \operatorname{tr}(H_N^+ H_N)$$

Where
H_N *is the channel from the selected N antennas at the BS to K users*, while subscript (N) denotes N columns are selected out of M in the full propagation matrix H, $\operatorname{tr}(H_N^+ H_N)$ *means total receive power of all users*.

Antenna Selection Via Convex Optimization

For antenna selection, we introduce an M x M, M diagonal matrix Φ with the diagonal elements $\phi_i (i = 1, 2, , M)$, which are binary variables and indicate the ith antenna is selected or not. At the same time it must be satisfied

$$\Sigma_{i=1}^{M} \phi_i = N, \tag{1}$$

i.e. N transmit antennas are selected. Via selection matrix Φ, *our optimization problem can be described as*

$$\begin{aligned} \max_{\Phi} \quad & \mathbf{tr}(H^{+} \Phi H) \\ \textit{subject to} \quad & \phi_j \in \{0, 1\} \\ & \sum_{i=1}^{M} \phi_i = N \end{aligned}$$

Cont..

For massive MIMO where M can be more than one hundred, the exhaustive search can hardly be done due to an extremely large number of possible antenna combination. We can use convex optimization method to solve. Note above constraint of
$\phi_i \; \epsilon \; \{0,1\}$ is not convex and other constraints are all convex.
So the original problem can be relaxed to the following

$$\begin{aligned} \underset{\Phi}{\max\text{imize}} \quad & \mathrm{tr}(H^{+}\Phi H) \\ \text{subject to} \quad & 0 \leq \phi_i \leq 1 \\ & \textstyle\sum_{i=1}^{M} \phi_i = N \end{aligned}$$

Cont..

The original problem thus becomes a convex optimization problem solvable in SeDuMi or CVX.
This relaxation yields a fractional solution of ϕ_i,
from which the N largest ones are selected, and their indices represent the selected N antenna at the base station.
Simulation results show that the optimal solution ϕ_i
of the problem via the software CVX is just one or zero and not fractional solution. It is interesting, and it indicates that our optimization problem is simple and can be tractable.

And last

Thank You