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Multiuser MIMO Channel Estimation

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ABSTRACT
In this paper, three beamforming design are considered for multi user MIMO system. First, transmit beamformers are fixed and the receive (RX) beamformers are calculated. Transmit beamformer (TX-BF)is projectedas a null space of appropriate channels. It reduces the interference for each user. Then the receiver beamformer is determined which maximize the SNR. This beamforming design provides less computation time. The second case is joint TX and RX beamformer for SNR maximization. In this transmitter and receiver beamformer are calculated using extended alternating optimization (EAO) algorithm. The third one is joint transmitter and receiver beamforming for SNR and SINR maximization using EAO algorithm. This algorithm provides better error performance and sum rate performance. All the design cases are simulated by using standard multipath channel model. Our simulation results illustrate that compared to the least square design and zero forcing design, the joint TX and RX beamforming design using EAO algorithm provides faster beamforming and improved error performance and sum rate**.**
Keywords: Beamforming, Interference channel, Massive MIMO, Optimization

I. INTRODUCTION

Massive MIMO is an antenna array systems using huge amount of antenna.In Massive MIMO, Base stations are equipped with very large number of antenna, so that each BS antenna simultaneously serves many tens of user equipment [1]. The benefits of Massive MIMO include reduced latency, and robustness to interference and intentional jamming.Beamforming means transmitting and receiving the signal in specific direction and beamforming is used to control the directionality of transmitter and receiver on a transducer array. It is used to reduce the interference in communication systems.Threebeamforing design are considered,where the transmit and receive beamformers are calculated.In the first case, thetransmit (Tx) beamformers are fixed and the receive (Rx) beamformers are calculated. The secondcase is jointly optimizing the Transmitter and Receiver beamformers for constrained SNR maximization.The third one is joint Tx–Rx beamforming for SNR and signal-to-interference-plus-noise ratio maximization.All cases can include a linear constellation precoder design for extracting multipath diversity. Linear constellation precoder design matrix improves the error performance and it has less computational complexity.

[7], [8], MEA offers large increase in capacity compared to the single antenna system. The capacity of multielement antenna is the sum of individual sub channel capacities and the Multi element antenna (MEA) systems use diversity at both transmitter and receiver in which the large capacity growth occurs even if the transmitter has no information of the channel. Fading correlation and multi element capacity is determined using abstract model. In this model the essential channel Characteristics can be clearly illuminated. The advantage of using this model is simple and intuitive model [9].

The multi-user massive MIMO systems exhibit a hidden joint sparsity structure in the user channel matrices due to the shared local scatterer in the physical propagation environments. Here compressed sensing technique is used to reduce training sequence as well as feedback overhead in the channel state information at transmitter side (CSIT) and a joint orthogonal matching pursuit recovery algorithm is used to perform the CSIT recovery performance with the capability of exploiting the concealed joint sparsity in the user channel matrices [1], [11].

In [12]Multiple antennas are used at the base station and at the user terminals. A double level of spatial multiplexing is used, from thatthe users are spatially multiplexed (SDMA) and each user receive the spatially multiplexed bit streams (SDM). Multi user interference is a potential performance limitation in this scheme. To avoid this, we used a pre-filter with a null space constraint that blockdiagonalize the channel matrices, which results reducing the multi user interference (MUI). Each terminal then only has to reduce its own interstream interference, which does not require information from the other users' channel. Joint TX-RX requires more channel knowledge at both sides and a prefilter with a null space constraint is used to cancel multiuser interference completely.

II. SYSTEM DESCRIPTION

1.1 System Model

There are *K* pairs of multi-antenna terminalswhich are striving to share simultaneously the spectrumin time and space. The channel is modeled as 1) a tapped delayline (*L* + 1 taps) according to the IEEE 802.11n propagationmodel or 2) a single-tap flat fading channel with a perfect spatial correlation matrix. The Kusers all have M_t transmit antennas and M_r receive antennas, and all users utilize each of the Psubchannels. The transmit beamformer for i^{th} user at P^{th} subcarrier are written as $v_i(p) \in C^{M_t \times 1}$ and similarly the receiver beamformer are $u_i(p) \in C^{M_r \times 1}$ for $i \in \{1\ldots\ldots K\}$ and $p \in \{0\ldots\ldots P\text{-}1\}$.

The frequency selective channel from the μth transmit antenna of the i^{th} transmitting user to the v^{th} receive antenna of the r^{th} receiving user is denoted by the delay-time function $h_{v\mu}^{r,i}(l)$ where $v \in \{1\ldots\ldots M_r\}$, $\mu \in \{1\ldots\ldots M_t\}$ and $r \in (1\ldots K)$ .The received signal vector for the i^{th} user represented by

$$y_i(p) = H_{i,i}(p)v_i(p)s_i(p) + \sum_{i' \neq i}^{K} H_{i,i'}(p)v_{i'}(p)s_{i'}(p) + n_i(p) \quad (1)$$

From Kronecker model $H_l^{r,i} = (R_l^r)^{1/2} G_l (R_l^i)^{T/2}$ is the l^{th} channel tap matrix where $h_{v\mu}^{r,i}(l) = [H_l^{r,i}]_{v,\mu}$ and $G_l \in C^{N_r \times N_t}$ is a complex matrix with zero mean and unit variance Gaussian entries. where R_l^r represent receive spatial correlation matrix and R_l^i represent transmit spatial correlation matrix. For a special type of uniform linear antenna array, the correlation of the fading between two antennas spaced $d_{v,\mu}$ apart can be modeled by

$$\rho_{v,\mu}^{r,l} = R^l{}_{XX}(D) + jR^l{}_{XY}(D) \quad (2)$$

Where $D = 2\pi d_{v,\mu} / \lambda$ and

$$R^l{}_{XX}(D) = \int_{-\pi}^{\pi} \cos(D\sin(\phi)) f^l(\phi) d\phi$$

$$R^l{}_{XY}(D) = \int_{-\pi}^{\pi} \sin(D\sin(\phi)) f^l(\phi) d\phi$$

Here λ is the wavelength, and $f^l(\phi)$ is the probability density function for the power azimuth spread (PAS).

III. BEAMFORMING DESIGN

3.1 ReceiverBeamforming design for SNR maximization

In this transmit beamformer are fixed. The transmit beamformeris given by

$$v_i = N(H_{K+1-i,i}) \quad (3)$$

Where v_i represent transmit beamformer for i^{th} user.The next step to determine u_i that it maximizes the signal to noise ratio of the i^{th} user. Then receiver beamformer are calculated using the given equation

$$u_i = \frac{H_{i,i} v_i}{\| H_{i,i} v_i \|} \quad (4)$$

Finally calculating the SNR using transmit and receive beamforming.SNR for i^{th} user is given by

$$SNR_i = \frac{u_i^H H_{ii} v_i v_i^H H_{ii}^H u_i}{\sigma^2{}_{ni} u_i^H u_i}$$

3.2 Joint TX-BF and RX-BF for SNR maximization

In this, joint Tx-BF and Rx-BF are designed for the constrained SNR maximization by using the extended alternating optimization (EAO) algorithm for multi objective optimization.

Transmit beamformer for 1^{st} user is denoted by

$$J_1 = -v_1^H (G_1 + G_2) v_1 \quad (5)$$

Where

$$C_1 = [(H_{1,2} v_2)^H \ldots\ldots (H_{1,K} v_K)^H]$$

$$G_1 = H_{1,1}^H [N(C_1)]_1 [N(C_1)]_1^H H_{1,1}$$

$$G_2 = H_{1,1}^H [N(C_1)]_2 [N(C_1)]_2^H H_{1,1}$$

Then finally receiver beamformer are calculated by using transmit and receiver beamformer. The receiver beamformer for 1^{st} user is given by

$$u_1 = w_{max}(H_{1,1} v_1 v_1^H H_{1,1}^H) \quad (6)$$

Then SNR calculation for 1^{st} user is given by

$$SNR_1 = u_1 H_{1,1} v_1 v_1^H H_{1,1}^H u_1^H$$

SNR calculation for i^{th} user is denoted by

$$SNR_i = u_i H_{i,i} v_i v_i^H H_{i,i}^H u_i^H \qquad (7)$$

Where v_i represent transmit beamformer for i^{th} user and u_i represent receiver beamformer for i^{th} user and $H_{i,i}$ represent channel coefficients.

3.3 LS TX-BF Design

The TX-BF design with least square is formulated as

$$v_i = \max_{i=1.....K} t_i t_i^H$$

The TX-BF design with LS reduces to

$$v_i = \max_{i=1...k} \frac{1}{|\det(H_i)|^2} \sum_{\substack{j=1 \\ i \neq j}}^{K} |\det(H_{i\{ji\}})|^2 \qquad (8)$$

Where $H_{\{ji\}}$, the cofactor of H is, denotes the submatrix of H obtained by deleting row j and column I of H and v_i represent the transmit

Where H(s) represents concatenated channel vector for the set of scheduled users and $\lambda = \frac{1}{P} tr[(H(s)H(s)^H]^{-1}$ andtr(.) is the trace operator and P represent average transmit power. Where

u_i represent receiver beamformer for i^{th} user. After calculating receiver beamformer then calculating the signal to noise ratio. SNR calculation for i^{th} user is given by

$$SNR_i = \frac{u_i^H H_{ii} v_i v_i^H H_{ii}^H u_i}{\sigma_{ni}^2 u_i^H u_i} \qquad (9)$$

beamformer for i^{th} user , H_i represent channel coefficients. Then calculating the receiver beamformer with the help of transmitbeamformer. Receiver beamformer for i^{th} user is given by

$$u_i = \frac{H_{i,i} v_i}{\| H_{i,i} v_i \|}$$

3.4 Zero forcing Transmitter beamforming design

The transmit beamforming design for zero forcing is given by

$$v^{ZF} = H(H^H H)^{-1} \qquad (10)$$

Where H denotes the $M_t \times K$ channel matrix between BS and all users and M_t represents number of transmitter antenna. In zero forcing beamforming the transmit beamformer is calculated by

$$v(s) = \frac{1}{\lambda} H(s)^H (H(s)H(s)^H)^{-1} \qquad (11)$$

IV. RESULTS AND DISCUSSION

4.1 Performance measures

For simulation, the number of users are assumed to be K=11 andnumber of transmitter antenna (M_t) per user is K+1and number of receiver antenna (M_r) per user is K. so that number of transmitter antenna is 132 and number of receiver antenna is 121.In simulation all user uses QPSK modulation for measuring the BER performance.

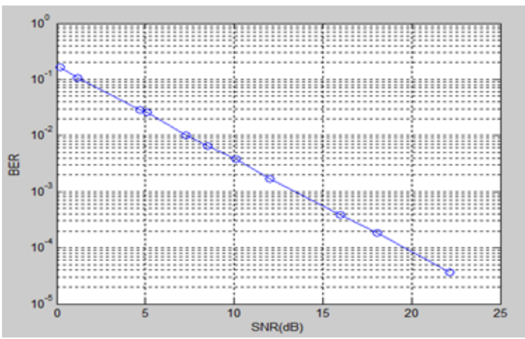

Fig.1.BER Performance for receiver beamforming

Fig 1 shows BER Performance for receiver beamforming design. From the graph, it is observed that if the signal to noise ratio increases then the bit error rate decreases. From these the signal to noise ratio is maximum and the computation time is minimum.

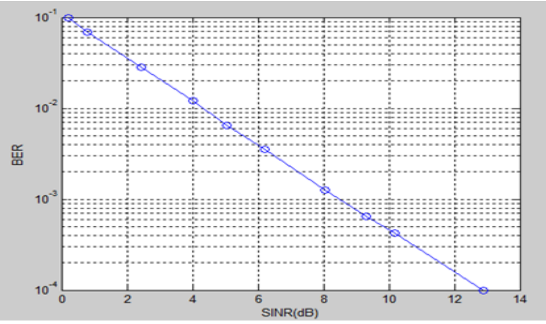

Fig. 2. Receiver beamforming design for SINR

From Fig 2 shows if the signal to interference noise ratio increases then the error decreases and if the average SINR is 13 db the error will be minimum.

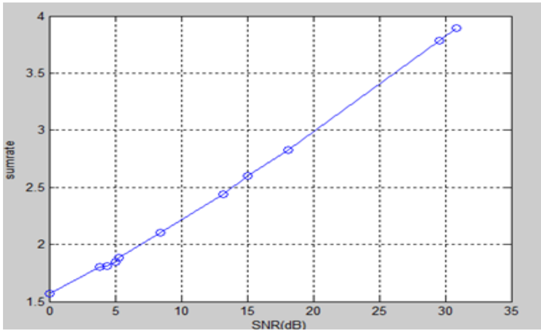

Fig.3.sum rate performance for receiver beamforming

4.2 BER Performance for different beamforming design

Beamforming means transmitting and receiving the signal in specific direction and it is used to reduce the interference and improve the communication quality.

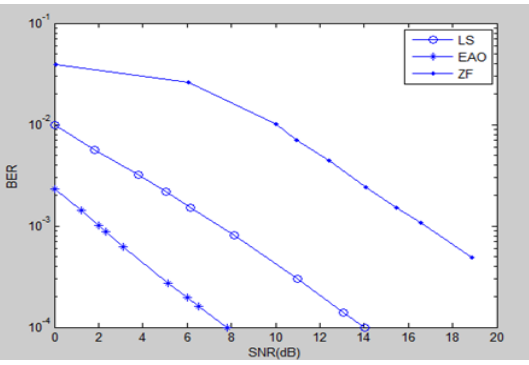

Fig. 4. Comparison of BER Performance

Fig 4 shows an BER performance for different beamforming design using Extended alternating optimization algorithm. From the graph, it is observed that if the signal to noise ratio increases then the bit error rate decreases and the extended alternating optimization algorithm provides better error performance than the least square and zero forcing beamforming design and it has less computation time compared to the least square design and zero forcing transmit beamforming design.

4.3 Sum rate Performance for different beamforming design

Sum rate is a maximum aggregation of all user data rate.From this graph it is observed that if the signal to noise ratio increases then the sum rate increases and the extended alternating optimization algorithm provides better sum rate than the least square and the zero forcing transmitter beamforming design.

At 20 db SNR the extended alternating optimization algorithm provides the sum rate of 30.96 bits/s/Hz.The computation time of extended alternating optimization algorithm is observed to be approximately five times faster than the least square and zero forcing design for the same set of specification.

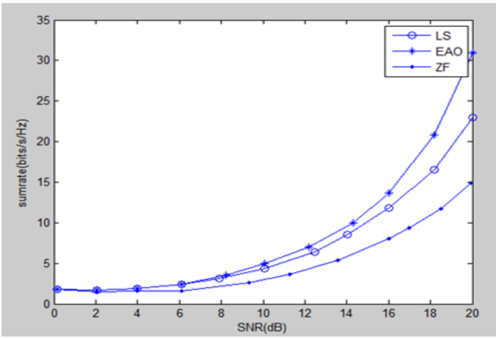

Fig. 4. Comparison of sum rate performance

V. CONCLUSION

Three beamforming designare performed for multiuser MIMO interference channels where transmit and receive beamformers are obtained iteratively. In first case the transmit beamformer are fixed and receive beamformer are calculated. The second case is jointly optimizing the transmit and receive beamformer for SNR maximization. Then the third case is joint transmit and receive beamformer for SNR and SINR maximization using Extended alternating optimization algorithm. The proposed optimization algorithm provides better sumrate and bit error rate performance and the computation time of EAO algorithm is less compared to the least square transmit beamforming design. At maximum SNR the extended alternating optimization algorithm provides better sum rate performance. The computation time of least square transmit beamforming is large compared to extended alternating optimization algorithm and the execution time of extended alternating optimization (EAO)algorithm simulation is observed to be approximately five times faster than the Least square design for the same set of specification. At 20 db SNR the extended alternating optimization algorithm provides the sum rate is 30.98 bits/s/Hz.

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