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Goal

- Analysis & Performance of the p-norm detector for the case of Gaussian Mixture Noise.
- Analysis of Receiver Diversity for p-law selection and p-law Combining

Contributions

- Expressions for P_F and P_D in series-form using an analysis based on the moment generating function for No fading; Nakagami-m, κ-μ, and η-μ fading channels

System Model:

$$y_i = \lambda h_i s_i + x_i,\ \ i = 1, \ldots, n$$

$$\mathcal{H}_0 : \lambda = 0 \ vs.\ \mathcal{H}_1 : \lambda = 1$$

$$Noise : x_i = \sum_{v=1}^{V} b_v \cdot \mathcal{N}\left(0, \sigma_v^2\right)$$

$$\Rightarrow x_i \sim \mathcal{N}\left(0, \sigma_n^2\right)$$

$$Decision\ Rule : S \gtrless T$$

p-norm detector: $S_p = \sum_{i=1}^{n} \left(\frac{|y_i|}{\sigma_n}\right)^p$

Energy detector: $S_2 = \sum_{i=1}^{n} \left(\frac{|y_i|}{\sigma_n}\right)^2$

$$P_F = P\left(S > T|\mathcal{H}_0\right) = 1 - F_S\left(T|\mathcal{H}_0\right)$$

$$P_D = P\left(S > T|\mathcal{H}_1\right) = 1 - F_S\left(T|\mathcal{H}_1\right)$$

$$F_S\left(T|\mathcal{H}_j\right) = Inv.\ Laplace\ \left[\frac{M_S\left(s|\mathcal{H}_j\right)}{s}\right]$$

$$M_{S_p}\left(s|\mathcal{H}_j\right) = \left(\int exp\left(-s\left(x/\sigma_n\right)^p\right) f(x|\mathcal{H}_j)dx\right)^n$$

Receiver Diversity:

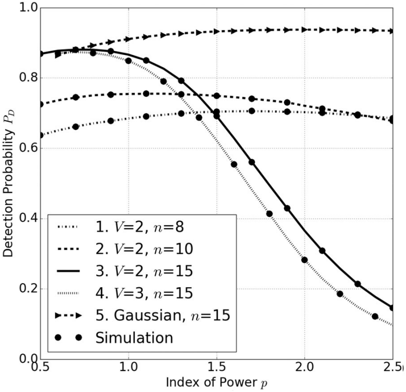
1. p-law Combining: $S_p = \sum_{l=1}^{L} \sum_{i=1}^{n} \left(\frac{|y_{i,l}|}{\sigma_n}\right)^p$
2. p-law Selection: $S_p = \max_{l=1,\dots,L} \sum_{i=1}^{n} \left(\frac{|y_{i,l}|}{\sigma_n}\right)^p$

Results:

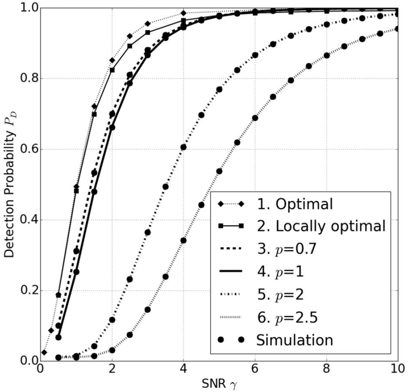
Case 1: No Fading - $M_{S_p}\left(s|\mathcal{H}_j\right) = \left(\frac{2}{\pi}\right)^{\frac{n}{2}} \sum_{k=0}^{\infty} C_k \cdot s^{-\frac{2k+n}{p}}$

$$\Rightarrow F_S\left(T|\mathcal{H}_j\right) = \left(\frac{2}{\pi}\right)^{\frac{n}{2}} \sum_{k=0}^{\infty} \frac{C_k \cdot T^{\frac{2k+n}{p}}}{\Gamma\left(\frac{2k+n}{p+1}\right)}$$

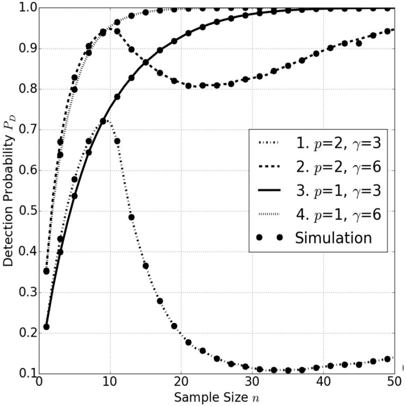
Case 2: Nakagami-m Fading - $\overline{M_{S_p}}\left(s|\mathcal{H}_j\right) = \left(\frac{2}{\pi}\right)^{\frac{n}{2}} \left(\frac{m}{\overline{\gamma}}\right)^{mn} \sum_{k=0}^{\infty} C_k^{Nak} \cdot s^{-\frac{2k+n}{p}}$

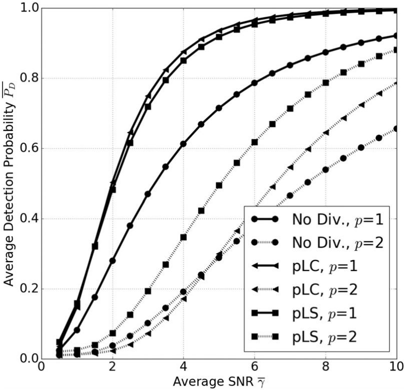


Detection Probability P_D
Index of Power p
1.0
0.8
0.6
0.4
0.2
0.0
0.5
1.0
1.5
2.0
2.5
1. V=2, n=8
2. V=2, n=10
3. V=2, n=15
4. V=3, n=15
5. Gaussian, n=15
Simulation



Detection Probability P_D
SNR γ
1.0
0.8
0.6
0.4
0.2
0.0
0
2
4
6
8
10
1. Optimal
2. Locally optimal
3. p=0.7
4. p=1
5. p=2
6. p=2.5
Simulation


Detection Probability P_D
Sample Size n
1. p=2, γ=3
2. p=2, γ=6
3. p=1, γ=3
4. p=1, γ=6
Simulation


Average Detection Probability $\overline{P_D}$
Average SNR $\overline{\gamma}$
No Div., p=1
No Div., p=2
pLC, p=1
pLC, p=2
pLS, p=1
pLS, p=2

Structured Turbo Compressed Sensing for Massive MIMO Channel Estimation Using a Markov Prior

Goal:

Design and Analysis of Structured Turbo Compressed Sensing Framework for Structured Sparse Channel Estimation

Contributions:

Algorithm for Structured Sparse Channel Estimation using Message Passing

System Model: BS has ULA transmit array with N antennas

$$\hat{h} = \underset{h}{argmax}\ p(h|y)$$

$$\hat{h} = \underset{h}{argmax}\ p(y|h)\, p(h)$$

$$y = X\tilde{h} + n = XF^H h + n$$

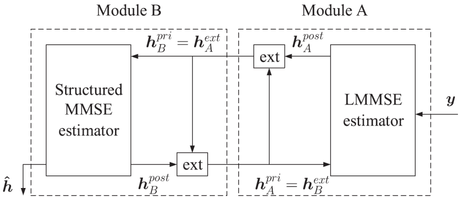
$$\Rightarrow y = Ah + n$$

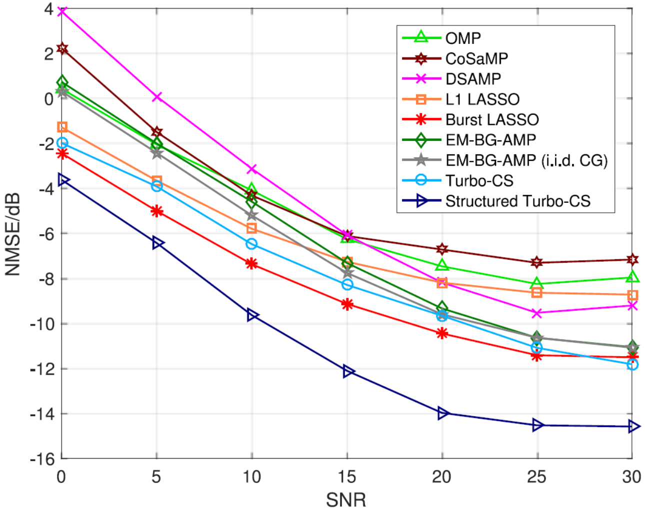
$$n \sim \mathcal{CN}\left(0, \sigma^2 I\right)$$

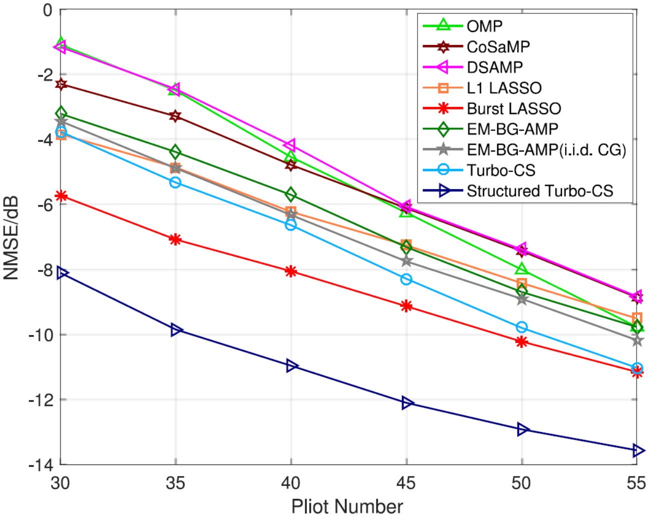
$$p(h_n|s_n) = \delta(s_n - 1)\,\mathcal{CN}\left(0, \sigma_h^2\right) + \delta(s_n)\,\delta(h_n)$$

$h \sim$ Bernoulli Gaussian Model

s forms a Markov chain




4
2
0
-2
-4
-6
-8
-10
-12
-14
-16
NMSE/dB
0
5
10
15
20
25
30
SNR
OMP
CoSaMP
DSAMP
L1 LASSO
Burst LASSO
EM-BG-AMP
EM-BG-AMP (i.i.d. CG)
Turbo-CS
Structured Turbo-CS



NMSE/dB
0
-2
-4
-6
-8
-10
-12
-14
30
35
40
45
50
55
Pliot Number
OMP
CoSaMP
DSAMP
L1 LASSO
Burst LASSO
EM-BG-AMP
EM-BG-AMP(i.i.d. CG)
Turbo-CS
Structured Turbo-CS

Contributions:

- Stage 1: Algorithm for Beam Search to reduce complexity
- Stage 2: Algorithms for Dynamic Beam Assignment based on a throughput metric

System Model:

- Base Station (BS) serves U users (U < L) with 1 stream per subcarrier to every user
- BS (Tx): L subarrays with N_t antennas each driven by separate RF chain
- User (Rx): 1 subarray with N_r atennas driven by 1 RF chain
- Received signal of user u at subcarrier c after processing is:

$$y_u^c = v_u^H H_u^c F_{RF} F_{BB}^c s^c + v_u^H n_u^c$$

$$H_u^c = \left[H_{u,1}^c, \ldots H_{u,L}^c \right]$$

$$H_{u,l}^c = \gamma \sum_{n=1}^{N_{cl}} \sum_{m=1}^{N_{ray}} \alpha_{nm} \; a_r\left(\theta_{nm}^r\right) \left(a_t\left(\theta_{nm}^t\right)\right)^H exp\left(\frac{-j2\pi\psi_n c}{C}\right)$$

Beam Search:

- Codeword Generation: $f_{k_t}^{beam} = a_t\left(2\pi k_t/2^q\right)$
  $f_{k_r}^{beam} = a_r\left(2\pi k_r/2^q\right); k_t, k_r \in [0, 2^q - 1]$
- Joint Precoder v_u and Combiner $w_{u,l}$ Design:

$$\underset{v_u, w_{u,l}}{argmax} \sum_{l=1}^{L} \sum_{c=1}^{C} \left| v_u^H H_{u,l}^c w_{u,l} \right|^2$$

$$st : v_u \in \left\{ f_{k_r}^{beam} \right\}_{k_r=0}^{2^q-1} \;\&\; w_{u,l} \in \left\{ f_{k_t}^{beam} \right\}_{k_t=0}^{2^q-1}$$

- Algorithm proposed for finding Z most dominant Tx/Rx pairs based on largest effective power

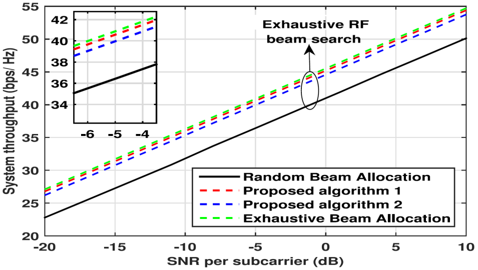
Beam Assignment:

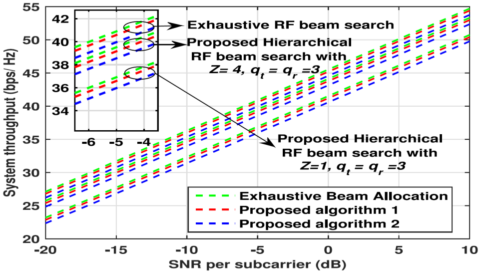
- Rate maximization:

$$\underset{\Lambda}{argmax} \sum_{l=1}^{L} \sum_{u=1}^{U} r_{u,l} \Lambda(u,l)$$

$$st : \Lambda(u,l) \in \{0,1\}, \sum_{u=1}^{U} \Lambda(u,l) = 1$$

- Two Algorithms proposed for beam assignment
- First algorithm assigns beams fairly to each user
- Second algorithm uses a greedy approach where higher rate channel can be assigned to the same user every time





Channel Estimation for Millimeter-Wave MIMO Communications With Lens Antenna Arrays

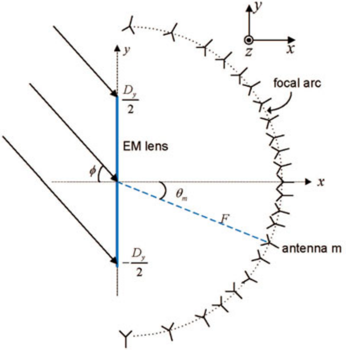
Contributions:

- Channel Estimation scheme for MIMO systems with limited RF chains

System Model:

- Base Station (BS) has M_B and Mobile Terminal (MT) has M_M antennas respectively

- There are only $Q_B < M_B$ & $Q_M < M_M$ RF chains
- $H_{UL}(t) = \sum_{l=1}^{L} \alpha_{UL}^{l} a_B(\psi_l) a_M^H(\phi_l) \delta(t-\tau_l)$
- $H_{DL}(t) = \sum_{l=1}^{L} \alpha_{DL}^{l} a_M(\phi_l) a_B^H(\psi_l) \delta(t-\tau_l)$
- No Channel Reciprocity, but, Path Reciprocity
- For Lens Arrays, $a_M(\phi) = e^{-j\phi_0}\sqrt{A} sinc(m - Dsin\phi)$, $m \in \{-\frac{M-1}{2}, \dots, 0, \dots, \frac{M-1}{2}\}$



Channel Estimation

(Block Fading assumption)

Stage 1: Energy Based Antenna Selection

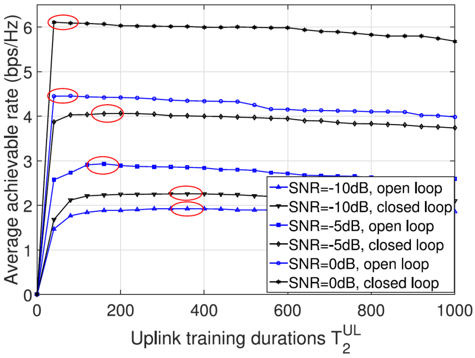
- BS sends pilots out for n symbols
- Energy Detector used at receiver to figure out strongest S_M channels at the MT

Stage 2: Reduced MIMO Channel Estimation:

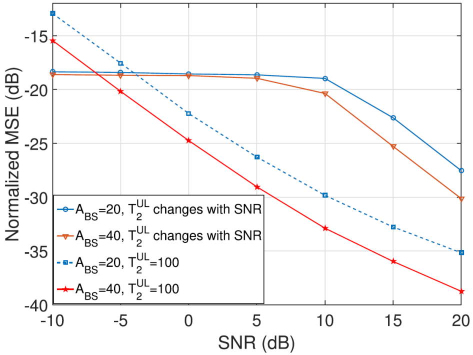
- Orthogonal Training Sequences sent from S_M antennas corresponding to the strongest channels from the receiver
- Sequences received at the transmitter are correlated with the orthogonal training sequence.
- Peak search is done as the correlation would be high for the strongest channels and low for the weakest.

Results

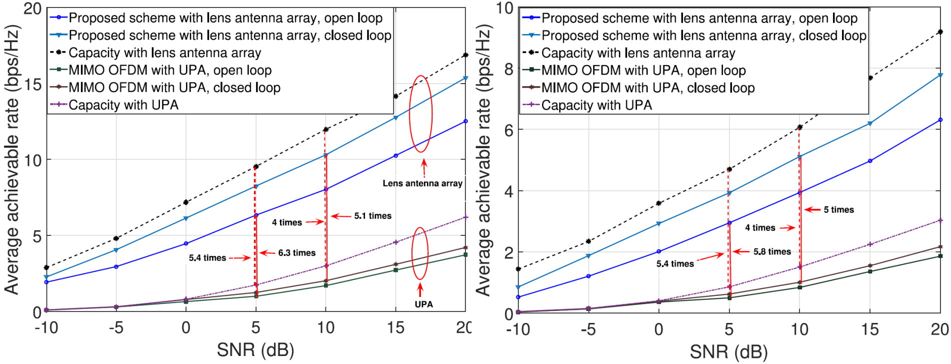
- V-Blast scheme used for simulation
- Closed Loop is a scheme with Perfect CSI at BS (via feedback from MT)
- Open Loop is a scheme with Estimated CSI at BS (no feedback from MT)



Average achievable rate (bps/Hz)
Uplink training durations T_2^{UL}
SNR=-10dB, open loop
SNR=-10dB, closed loop
SNR=-5dB, open loop
SNR=-5dB, closed loop
SNR=0dB, open loop
SNR=0dB, closed loop



Normalized MSE (dB)
SNR (dB)
A_{BS}=20, T_2^{UL} changes with SNR
A_{BS}=40, T_2^{UL} changes with SNR
A_{BS}=20, T_2^{UL}=100
A_{BS}=40, T_2^{UL}=100


Proposed scheme with lens antenna array, open loop
Proposed scheme with lens antenna array, closed loop
Capacity with lens antenna array
MIMO OFDM with UPA, open loop
MIMO OFDM with UPA, closed loop
Capacity with UPA
Average achievable rate (bps/Hz)
SNR (dB)
Lens antenna array
UPA
5.4 times
6.3 times
4 times
5.1 times
5 times
5.8 times

Other Interesting Papers

1. Downlink Precoding With Mixed Statistical and Imperfect Instantaneous CSI for Massive MIMO Systems
2. Antenna Selection for MIMO Nonorthogonal Multiple Access Systems
3. Millimeter Wave Analog Beamforming With Low Resolution Phase Shifters for Multiuser Uplink
4. Optimal Power Allocation and Active Interference Mitigation for Spatial Multiplexed MIMO Cognitive Systems
5. Resource Allocation and Admission Control for an Energy Harvesting Cooperative OFDMA Network
6. SBL-Based Joint Sparse Channel Estimation and Maximum Likelihood Symbol Detection in OSTBC MIMO-OFDM Systems
7. ON-OFF Analog Beamforming for Massive MIMO
8. Coverage, Capacity, and Energy Efficiency Analysis in the Uplink of mmWave Cellular Networks