EE-668: Massive MIMO for 5G Communications: Design and Analysis

Programming assignment 2

Question 1. Consider a zero mean real signal x embedded in independent additive real Gaussian noise $w \sim \mathcal{N}(0,1)$. Let $\hat{x}$ be the linear minimum mean square error (MMSE) estimate. Let observations be

$$y_i = \sqrt{P}x + w_i,$$

abd mean square error (MSE) $= E[(x-\hat{x})^2]$ be obtained by averaging the error over 10^5 realizations. Plot the MSE as function of P.

Question 2. Let signals received over AWGN and Rayleigh fading channels be

$$\begin{aligned} y_a &= x + w, \\ y_f &= hx + w, \end{aligned}$$

respectively, where $w \sim \mathcal{CN}(0,\sigma^2)$ and $h \sim \mathcal{CN}(0,1)$ and $x \in \{-1,1\}$. Plot average bit error rate (BER) as a function of signal-to-noise ratio (SNR). You can vary σ^2 to get different SNRs. For Rayleigh fading plot fading averaged BER.

Question 3. Consider a SIMO system having a single antenna at the transmitter and N_r antennas at the receiver. Let $x \in \{-1,1\}$, $\mathbf{y} = [y_1,\ldots,y_{N_r}]^t, \mathbf{h} = [h_1,\ldots,h_{N_r}]^t, \mathbf{w} = [w_1,\ldots,w_{N_r}]^t$. Then the received signal is given by

$$\mathbf{y} = \mathbf{h}x + \mathbf{w}.$$

Assume that $h_1,\ldots,h_{N_r}$ are i.i.d., $\mathcal{CN}(0,1)$ and $w_1,\ldots,w_{N_r}$ are i.i.d., $\mathcal{CN}(0,\sigma^2)$. For a maximal ratio combining (MRC) receiver, plot the fading averaged error probability as a function of SNR for $N_r = 2,4,8$.