EE620 - MIMO Wireless Communications
Term Project

(Due at 10:00am, May 8, 2019, right before the final exam)
(Note: Final exam schedule: 10:00-11:20am, May 8, 2019, Baldy 108, UB North Campus)

1. **Survey (10 points)**: MIMO technology has been adopted in many communication standards including Wireless Local Area Network (WLAN) standards and cellular wireless communication standards. Prepare a survey regarding the emerging 5G cellular wireless communication standard and review MIMO technique specification adopted in the 5G standard. The purpose of this survey is to understand cutting-edge MIMO techniques used in the industry and to get familiar with the latest wireless cellular standards. (Note: Don't cut-and-paste from the internet and literature, summarizing by your own words.)

2. **Matlab Simulations (10 points)**: Consider a MIMO system with $M_t = 2$ transmit antennas and $M_r = 1$ or 2 receive antennas. The transceiver signal model at time τ is given by

$$Y_\tau = \sqrt{\frac{\rho}{M_t}}\, S_\tau H_\tau + N_\tau, \quad \tau = 1, 2, \cdots \tag{1}$$

where Y_τ is the received signal matrix of size $M_t \times M_r$, and S_τ is the transmitted signal matrix of size $M_t \times M_t$. H_τ is the channel coefficient matrix of size $M_t \times M_r$ which is unknown to both the transmitter and the receiver. N_τ is the noise matrix of size $M_t \times M_r$ whose each entry is a complex Gaussian random variable of mean zero and variance 1. Let us consider a differential space-time (ST) modulation scheme:

$$S_\tau = \frac{1}{\sqrt{M_t}}\, C_{l,\tau}\, S_{\tau-1}, \quad \tau = 1, 2, \cdots \tag{2}$$

where $S_0 = \sqrt{M_t} I_{M_t}$, and $C_{l,\tau}$ is chosen from the following cyclic ST signals

$$\left\{ C_l = \sqrt{2} \begin{pmatrix} e^{j\frac{l\pi}{2}} & 0 \\ 0 & e^{j\frac{l\pi}{2}} \end{pmatrix} : l = 0, 1, 2, 3 \right\}.$$

Assume that the fading channels are approximately the same over two adjacent transmission blocks, i.e., $H_{\tau-1} \approx H_\tau$. We consider a differential ST demodulation scheme such as:

$$Y_\tau = \frac{1}{\sqrt{M_t}}\, C_{l,\tau} Y_{\tau-1} + \tilde{N}_\tau, \tag{3}$$

where $\tilde{N}_\tau = N_\tau - \frac{1}{\sqrt{M_t}} C_{l,\tau} N_{\tau-1}$. The ML decoding/demodulation of $C_{l,\tau}$ is

$$\hat{C}_{l,\tau} = \arg \min_{l=0,1,2,3} ||Y_\tau - \frac{1}{\sqrt{M_t}}\, C_{l,\tau} Y_{\tau-1}||_F^2.$$

We assume that the MIMO system uses bandwidth of 30 KHz at the 800MHz frequency band, and a mobile user with moving velocity of 50 miles/hour. We also assume the slow fading channel experiences Rayleigh fading.

(i) Use Jakes' fading simulator (with M = 8 oscillators or N = 34) to generate four independent fading channels (to be used in simulations). Generate 10^5 channel samples for each channel (note: normalize channel coefficients such that the average power of each channel coefficient is 1). In one figure, plot the first 500 channel samples for the four channels (showing the channel amplitude, $|h(t)|$, in dB).

(ii) When $M_r = 1$, use two fading channels generated in (i) to simulate the differential MIMO system. Plot the symbol error rate curve vs SNR.

(iii) When $M_r = 2$, use four fading channels generated in (i) to simulate the differential MIMO system. Plot the symbol error rate curve vs SNR in the same figure in (ii). Compare the two curves and explain your observation.