EE 632: Advanced Topics in Communications

Homework 2

Question 1. Consider a single input single output system aided by N element IRS. The transmitter sends a unit power symbol x with transmit power P_t. The direct link from the transmitter to the receiver are blocked. Let h_{1n}, for $n \in \{1, 2, \ldots, N\}$, denote the complex channel gain from the the transmitter to the n^{th} IRS element. Similarly, h_{2n}, for $n \in \{1, 2, \ldots, N\}$, denote the complex channel gain from the n^{th} IRS element to the receiver. Let $e^{j\theta_n}$ denote the reflection coefficient programmed at the n^{th} IRS element.

1. Write down the signal received through IRS when there is no direct link.
2. Derive the optimal value of θ_n that maximizes the receive signal power.
3. Let K_1 and K_2 denote the Rician factors of the transmitter to IRS and the IRS to the receiver links. Derive the fading averaged signal power for the above optimal phase, considering Rician fading for the both the links. (Assume independence among all the channel gains.)

Question 2. Consider a multiple input single output system aided by N element IRS. The transmitter is equipped with N_t antennas. Let g_{nk}, for $k \in \{1, 2, \ldots, N_t\}$, $n \in \{1, 2, \ldots, N\}$, denote the complex channel gain from the the k^{th} transmit antenna to the n^{th} IRS element. Similarly, h_n, for $n \in \{1, 2, \ldots, N\}$, denote the complex channel gain from the n^{th} IRS element to the receiver. Let $\mathbf{w} \in \mathbb{C}^{N_t \times 1}$ denote the beamforming vector employed at the transmitter and $e^{j\theta_n}$ denote the reflection coefficient programmed at the n^{th} IRS element.

1. Write down the combined signal received through the direct and reflected links.
2. Derive the expression for the instantaneous receive signal power.
3. Propose an alternating optimization algorithm to optimize $\mathbf{w}$ and θ_n alternatively to maximize the above receive signal power. Derive the closed-form expressions for $\mathbf{w}$ and θ_n when other quantity is fixed.