NPTEL Online Certification Courses

Indian Institute of Technology Kharagpur

Course: Signal Processing for mm Wave communication for 5G and beyond

Assignment:

Week -5

TYPE OF QUESTION: MCQ/MSQ

Number of questions: 10 **Total mark: 10 X 1 = 10**

Q.1 The signal model in a communication system is described as follow:
$y = Hx + w$, where the input vector $x = As$, **(**$H \in C^{m*n}$ is the channel matrix, and A is the precoder matrix). To estimate the transmitted signal $\hat{s}$, which of the below method is an incorrect choice?

a. Use Least square method with cost function $||x - \hat{x}||^2$.
b. Use SVD of $H = U\Sigma V^*$, and design $A = V$.
c. Use $W = H^{-1}$ to obtain $Wy = \hat{x} + Ww$.
d. Use LMMSE and get $\hat{x} = PR^{-1}$, with $P = E(xy^*), R = E(yy^*)$.

Answer: c. Use $W = H^{-1}$ to obtain $Wy = \hat{x} + Ww$.

Explanation: Here, H may be a rectangular matrix (for $m \neq n$), and H^{-1} may not be available.

Q.2 An antenna-architecture for data transmission is given below.

The above system is an example of

a. SISO system
b. SIMO system
c. MISO system
d. MIMO system

Answer: b. SIMO system

Explanation: At the Transmitter, only one data-stream can be sent with power boost-up by two antennas. At the receiver, two received data is obtained. Hence, it is Single-input and Multiple output system.

Q.3 For beam-steering in mm-wave channel approximation, which of the following assumptions is not made in general?

a. Antenna-element distance, $d_i \geq \frac{\lambda}{2}$, where λ is the wave-length.
b. Transmitter to receiver antenna distances, $D_i \gg \lambda$
c. Frequency flat fading and single tap channel
d. Channel parameters h_i are same approximately.

Answer: d. Channel parameters h_i are same approximately.

Explanation: The values of h_i cannot be assumed equal. See, lecture 27 and 28 for details.

Q.4 Assuming the antenna-element spacing $d = \lambda$, the correct expression for phase-difference in antenna-array manifold is given by

a. $\pi(i-1)sin\ (\theta_i)$
b. $2\pi(i-1)sin\ (\theta_i)$
c. $3\pi(i-1)sin\ (\theta_i)$
d. $\frac{\pi}{2}(i-1)sin\ (\theta_i)$

Answer: b. $2\pi(i-1)sin\ (\theta_i)$

Explanation: The expression for antenna-array manifold is $\Delta\phi_i = \frac{2\pi(i-1)dsinsin\ (\theta_i)}{\lambda}$
See, lecture 29 for details.

Q.5 6. A uniform linear array in a communication system contains

a. N elements placed at equidistance and signal is transmitted of non-equal magnitude and progressive phase shift
b. N elements at equidistant signal is transmitted of equal magnitude and progressive phase shift
c. N elements at non-equidistance and signal is transmitted of unequal magnitude and progressive phase shift
d. N elements at non-equidistance and signal is transmitted of unequal magnitude and equal phase shift

Answer: b.

Explanation: An array is said to be linear if N elements are spaced equally along the line and is a uniform array if the signal is transmitted with equal magnitude to all elements and progressive phase shift along the line.

Q.6 Suppose, in a communication system, the receiver has a ULA antenna with three antenna elements at the receiver and one transmitting antenna. The angle of arrival (AOA) at the ULA is $\frac{\pi}{3}$ radian, measured vertically with respect to ULA antennas. Assume that, antenna spacing in ULA, $d = \frac{\lambda}{2}$. The steering vector takes the form

a. $a = [1 \quad e^{\frac{j\pi}{2}} \quad e^{j\pi}]$
b. $a = [1 \quad e^{\frac{j\sqrt{3}\pi}{2}} \quad e^{j\sqrt{3}\pi}]$
c. $a = [1 \quad e^{j\pi} \quad e^{\frac{j\pi}{2}}]$
d. $a = [1 \quad e^{j\pi} \quad e^{j\pi/\sqrt{3}}]$

Answer: $a = [1 \quad e^{\frac{j\pi}{2}} \quad e^{j\pi}]$

Explanation: The expression for antenna-array manifold is $\Delta\phi_i = \frac{2\pi(i-1)dsinsin\,(\theta_i)}{\lambda}$. Here, AOA $\theta_i = \frac{\pi}{2} - \frac{\pi}{3} = \frac{\pi}{6}$ radian. See, lecture 30 for details. Put $i = 1, 2, 3$ and form the steering vector.

Q.7 The transmitter and receiver manifold vectors in a simple communication set up are given by $a^t = \left[1\ e^{j0.1}\right]$, $a^r = \left[1\ e^{-j0.1}\right]$. Assume that, the attenuation factor (α_i) is effectively 0.5. The trace of the channel matrix becomes

a. 0.5
b. 0
c. 1
d. 2

Answer: c. 1

Explanation: The channel matrix is given by $H = \alpha\ [a^r(a^t)^*]$. Hence, the trace of H = 0.5 x (1+1)=1.

Q.8 The rotation matrix for steering a beam angle of 30^0 (say anti-clockwise) for a data vector is given by

a. $R = [0.86 \; -0.50 \; 0.50 \; 0.86 \,]$

b. $R = [0.50 \; -0.86 \; 0.86 \; 0.50 \,]$

c. $R = [0.86 \; 0.50 \; 0.50 \; -0.86 \,]$

d. $R = [0.86 \; -0.50j \; 0.50 \; 0.86 \,]$

Answer: a. $R = [0.86 \; -0.50 \; 0.50 \; 0.86 \,]$

Explanation: The rotation matrix for anti-clockwise rotating a beam of angle θ is given by $R = [cos\,(\theta) \; -sin\,(\theta) \; sin\,(\theta) \; cos\,(\theta) \,]$.

Q.9 A channel matrix for a data model $y = Hx$ is given as follows

$$H = [0.95 \; 0 \; 0 \; 0.9 \,].$$

The zero-force equalizer, H^{-1} is equal to

a. $H^{-1} = [0.95 \; 0 \; 0 \; 0.9 \,]$

b. $H^{-1} = [1.05 \; 0 \; 0 \; 1.11 \,]$

c. $H^{-1} = [0.9 \; 0 \; 0 \; 0.95 \,]$

d. $H^{-1} = [1.11 \; 0 \; 0 \; 1.05 \,]$

Answer: b. $H^{-1} = [1.05 \; 0 \; 0 \; 1.11 \,]$
Explanation: Compute the inverse of H. It is in diagonal form, hence, the computation is just reciprocal of the singular values.

Q.10 The uniform linear array has its maximum radiation for the angle (with respect to normal to the axis of the array) of

a. 0 degree
b. 180 degrees
c. 45 degrees
d. 90 degrees

Answer: d. 90 degrees.
Explanation: The uniform linear array has its maximum radiation for the angle of 90 degrees.