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Courses » Estimation for Wireless Communications – MIMO/OFDM Cellular and Sensor Networks

Announcements Course Ask a Question Progress

# Unit 7 - Week 6 - Introduction to Orthogonal Frequency Division Multiplexing (OFDM) and Pilot Based OFDM Channel Estimation, Example



## Course outline

How to Access the Portal ?

Week 1 - Basics of Estimation, Maximum Likelihood (ML)

Week 2 - Vector Estimation

Week 3 - Cramer-Rao Bound (CRB), Vector Parameter Estimation, Multi-Antenna Downlink Mobile Channel Estimation

Week 4 - Least Squares (LS) Principle, Pseudo-Inverse, Properties of LS Estimate, Examples – Multi-Antenna Downlink and MIMO Channel Estimation

Week 5 - Inter Symbol Interference, Channel Equalization, Zero-forcing equalizer, Approximation error of equalizer

Week 6 - Introduction to

## Assignment - 6

The due date for submitting this assignment has passed. **Due on 2017-09-04, 23:59 IST.** As per our records you have not submitted this assignment.

1) Consider an Inter Symbol Interference channel

1 point

$y(k) = x(k) + \frac{1}{3}x(k-1) + v(k)$ . Let an  $r = 2$  tap channel equalizer be designed for this scenario based on symbols  $y(k), y(k+1)$  to detect  $x(k)$ . Let the equalizer vector be denoted by  $\mathbf{c}$ . The least squares problem for estimation of  $\mathbf{c}$  is,

$$\left\| \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} - \begin{bmatrix} 1 & 0 \\ \frac{1}{3} & 1 \\ 0 & \frac{1}{3} \end{bmatrix} \mathbf{c} \right\|^2$$

$$\left\| \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} - \begin{bmatrix} 1 & 0 \\ \frac{1}{3} & 1 \\ 0 & \frac{1}{3} \end{bmatrix} \mathbf{c} \right\|^2$$

$$\left\| \begin{bmatrix} 0 \\ 1 \end{bmatrix} - \begin{bmatrix} \frac{1}{3} & 1 & 0 \\ 0 & \frac{1}{3} & 1 \end{bmatrix} \mathbf{c} \right\|^2$$

$$\left\| \begin{bmatrix} 0 \\ 1 \end{bmatrix} - \begin{bmatrix} 1 & \frac{1}{3} \\ 1 & \frac{1}{3} \end{bmatrix} \mathbf{c} \right\|^2$$

No, the answer is incorrect.

Score: 0

Accepted Answers:

$$\left\| \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} - \begin{bmatrix} 1 & 0 \\ \frac{1}{3} & 1 \\ 0 & \frac{1}{3} \end{bmatrix} \mathbf{c} \right\|^2$$

2) Consider an Inter Symbol Interference channel

1 point

$y(k) = x(k) + \frac{1}{3}x(k-1) + v(k)$ . Let an  $r = 2$  tap channel equalizer be designed for this scenario based on symbols  $y(k), y(k+1)$  to detect  $x(k)$ . Let the equalizer vector be denoted by  $\mathbf{c}$ . The zero-forcing (ZF) equalizer vector  $\mathbf{c}$  is,

**Orthogonal Frequency Division Multiplexing (OFDM) and Pilot Based OFDM Channel Estimation, Example**

- Lecture 26 - Introduction to Orthogonal Frequency Division Multiplexing OFDM – Cyclic Prefix CP and Circular Convolution
- Lecture 27 - Introduction to Orthogonal Frequency Division Multiplexing OFDM – FFT at Receiver and Flat Fading
- Lecture 28 - Channel Estimation Across Each Subcarrier in Orthogonal Frequency Division Multiplexing OFDM
- Lecture 29 - Example Orthogonal Frequency Division Multiplexing OFDM – Transmission of Samples with Cyclic Prefix
- Lecture 30 - Example Orthogonal Frequency Division Multiplexing OFDM – FFT at Receiver and Channel Estimation
- Quiz : Assignment - 6
- Assignment-6 Solution

**Week 7 - OFDM – Comb Type Pilot (CTP) Transmission, Channel Estimation in Time/ Frequency**

$$\frac{1}{3} \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

$$\frac{1}{91} \begin{bmatrix} 23 \\ 11 \end{bmatrix}$$

$$\frac{1}{3} \begin{bmatrix} 9 \\ 13 \end{bmatrix}$$

$$\frac{3}{91} \begin{bmatrix} 1 \\ 27 \end{bmatrix}$$

**No, the answer is incorrect.**

**Score: 0**

**Accepted Answers:**

$$\frac{3}{91} \begin{bmatrix} 1 \\ 27 \end{bmatrix}$$

3) Consider an Inter Symbol Interference channel

**1 point**

$y(k) = x(k) + \frac{1}{3}x(k - 1) + v(k)$ . Let an  $r = 2$  tap channel equalizer be designed for this scenario based on symbols  $y(k)$ ,  $y(k + 1)$  to detect  $x(k)$ . Let the equalizer vector be denoted by  $\mathbf{c}$ . The zero-forcing equalizer is,

$$\hat{x}(k) = \frac{1}{3}y(k + 1) + \frac{1}{3}y(k)$$

$$\hat{x}(k) = \frac{11}{91}y(k + 1) + \frac{23}{91}y(k)$$

$$\hat{x}(k) = 3y(k + 1) + \frac{13}{3}y(k)$$

$$\hat{x}(k) = \frac{3}{91}y(k + 1) + \frac{81}{91}y(k)$$

**No, the answer is incorrect.**

**Score: 0**

**Accepted Answers:**

$$\hat{x}(k) = \frac{3}{91}y(k + 1) + \frac{81}{91}y(k)$$

4) Consider an Inter Symbol Interference channel

**1 point**

$y(k) = x(k) + \frac{1}{3}x(k - 1) + v(k)$ . Let an  $r = 2$  tap channel equalizer be designed for this scenario based on symbols  $y(k)$ ,  $y(k + 1)$  to detect  $x(k)$ . Let the equalizer vector be denoted by  $\mathbf{c}$ . Let the effective channel matrix for this scenario be denoted by  $\mathbf{H}$ . The approximation error for the zero-forcing equalizer (counting elements starting with 0) is,

$$1 - \left[ \mathbf{H}^T (\mathbf{H}\mathbf{H}^T)^{-1} \mathbf{H} \right]_{1,1}$$

$$1 - \left[ \mathbf{H}^T (\mathbf{H}\mathbf{H}^T)^{-1} \mathbf{H} \right]_{2,2}$$

$$1 - \left[ (\mathbf{H}\mathbf{H}^T)^{-1} \right]_{1,1}$$

$$1 - \left[ (\mathbf{H}\mathbf{H}^T)^{-1} \right]_{1,1}$$

**No, the answer is incorrect.**

**Score: 0**



Domain, CTP  
Example,  
Frequency  
Domain  
Equalization  
(FDE), Example-  
FDE

Week 8 -  
Sequential Least  
Squares (SLS)  
Estimation -  
Scalar/ Vector  
Cases,  
Applications -  
Wireless Fading  
Channel  
Estimation, SLS  
Example

Accepted Answers:

$$1 - \left[ \mathbf{H}^T (\mathbf{H}\mathbf{H}^T)^{-1} \mathbf{H} \right]_{1,1}$$

5) Consider an Inter Symbol Interference channel

1 point

$y(k) = x(k) + \frac{1}{3}x(k-1) + v(k)$ . Let an  $r = 2$  tap channel equalizer be designed for this scenario based on symbols  $y(k)$ ,  $y(k+1)$  to detect  $x(k)$ . Let the equalizer vector be denoted by  $\mathbf{c}$ . The approximation error for the zero-forcing equalizer is,



$$\frac{1}{3}$$



$$\frac{5}{91}$$



$$\frac{9}{91}$$



$$\frac{27}{91}$$



No, the answer is incorrect.

Score: 0

Accepted Answers:

$$\frac{9}{91}$$

6) Consider an Inter Symbol Interference channel

1 point

$y(k) = \frac{3}{4}x(k) - \frac{1}{4}x(k-1) + v(k)$ . Let an  $r = 2$  tap channel equalizer be designed for this scenario based on symbols  $y(k+1)$ ,  $y(k)$  to detect  $x(k)$ . What is the effective channel matrix  $\mathbf{H}$  for this scenario?



$$\mathbf{H} = \begin{bmatrix} \frac{3}{4} & -\frac{1}{4} \\ -\frac{1}{4} & \frac{3}{4} \end{bmatrix}$$



$$\mathbf{H} = \begin{bmatrix} \frac{3}{4} & -\frac{1}{4} & 0 \\ 0 & \frac{3}{4} & -\frac{1}{4} \end{bmatrix}$$



$$\mathbf{H} = \begin{bmatrix} \frac{3}{4} & -\frac{1}{4} & 0 & 0 \\ 0 & \frac{3}{4} & -\frac{1}{4} & 0 \\ 0 & 0 & \frac{3}{4} & -\frac{1}{4} \end{bmatrix}$$



$$\mathbf{H} = \begin{bmatrix} 0 & 0 & \frac{3}{4} & -\frac{1}{4} \\ 0 & \frac{3}{4} & -\frac{1}{4} & 0 \\ \frac{3}{4} & -\frac{1}{4} & 0 & 0 \end{bmatrix}$$

No, the answer is incorrect.

Score: 0

Accepted Answers:



$$\mathbf{H} = \begin{bmatrix} \frac{3}{4} & -\frac{1}{4} & 0 \\ 0 & \frac{3}{4} & -\frac{1}{4} \end{bmatrix}$$

7) Consider an Inter Symbol Interference channel

1 point

$y(k) = \frac{3}{4}x(k) - \frac{1}{4}x(k-1) + v(k)$ . Let an  $r = 2$  tap channel equalizer be designed for this scenario based on symbols  $y(k+1)$ ,  $y(k)$  to detect  $x(k)$ . Let the effective channel matrix  $\mathbf{H}$  for this scenario. The equalizer is,

- $\hat{x}(k) = -\frac{4}{91}y(k+1) - \frac{108}{91}y(k)$
- $\hat{x}(k) = \frac{4}{91}y(k+1) + \frac{108}{91}y(k)$
- $\hat{x}(k) = \frac{4}{91}y(k+1) - \frac{108}{91}y(k)$
- $\hat{x}(k) = -\frac{4}{91}y(k+1) + \frac{108}{91}y(k)$

No, the answer is incorrect.

Score: 0

Accepted Answers:

$$\hat{x}(k) = -\frac{4}{91}y(k+1) + \frac{108}{91}y(k)$$

8) Consider an Inter Symbol Interference channel

1 point

$y(k) = \frac{3}{4}x(k) - \frac{1}{4}x(k-1) + v(k)$ . Let an  $r = 2$  tap channel equalizer be designed for this scenario based on symbols  $y(k+1)$ ,  $y(k)$  to detect  $x(k)$ . Let the effective channel matrix  $\mathbf{H}$  for this scenario. The approximation error is,

- $\frac{9}{91}$
- $\frac{10}{91}$
- $\frac{11}{91}$
- $\frac{12}{91}$

No, the answer is incorrect.

Score: 0

Accepted Answers:

$$\frac{9}{91}$$

9) Consider an Inter Symbol Interference channel

1 point

$y(k) = \frac{3}{4}x(k) - \frac{1}{4}x(k-1) + v(k)$ . Let an  $r = 2$  tap channel equalizer be designed for this scenario based on symbols  $y(k+1)$ ,  $y(k)$  to detect  $x(k+1)$ . Let the effective channel matrix  $\mathbf{H}$  for this scenario. The approximation error is,

- $\frac{4}{91}$
- $\frac{3}{91}$
- $\frac{2}{91}$
- $\frac{1}{91}$

No, the answer is incorrect.

Score: 0

Accepted Answers:

$\frac{1}{91}$

10 OFDM is a technology which is used in

1 point

- 4G LTE
- 4G WiMAX
- WiFi
- All of the above

No, the answer is incorrect.

Score: 0

Accepted Answers:

All of the above



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