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

Announcements Course Ask a Question Progress



Unit 9 - Week 8 - Sequential Least Squares (SLS) Estimation – Scalar/ Vector Cases, Applications - Wireless Fading Channel Estimation, SLS 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-8

The due date for submitting this assignment has passed. **Due on 2017-09-18, 23:59 IST.** As per our records you have not submitted this assignment.

1) Consider an $N = 4$ subcarrier OFDM system with **conventional** channel estimation i.e. pilot symbols transmitted on all the carriers, given as, $X(0) = 3 - j$, $X(1) = 2 + 3j$, $X(2) = -1 - 2j$, $X(3) = -2 + j$. The ISI channel has $L = 2$ taps, denoted by $h(0)$, $h(1)$. Let the corresponding received samples in the time domain be $y(0) = 2 + j$, $y(1) = 3 + 2j$, $y(2) = -1 - j$, $y(3) = 2 - 3j$. Let the noise samples $v(k)$, $0 \leq k \leq 3$ be zero-mean IID Gaussian with variance σ^2 . Also, let the cyclic prefix be of length one symbol. The estimate of the channel coefficient $H(3)$ across subcarrier 3 is, **1 point**



$$\frac{7}{5} - \frac{4}{5}j$$



$$\frac{19}{13} - \frac{22}{13}j$$



$$\frac{19}{10} + \frac{3}{10}j$$



$$\frac{2}{5} - \frac{9}{5}j$$

No, the answer is incorrect.

Score: 0

Accepted Answers:

$$\frac{7}{5} - \frac{4}{5}j$$

2) Consider an $N = 4$ subcarrier OFDM system with **comb** type channel estimation and transmitted symbols **1 point**

$X(0) = 3 - j$, $X(1) = 2 + 3j$, $X(2) = -1 - 2j$, $X(3) = -2 + j$. The ISI channel has $L = 2$ taps, denoted by $h(0)$, $h(1)$. Let $l = 0, 3$ denote the pilot subcarriers. Let the corresponding received samples in the time domain be $y(0) = 2 + j$, $y(1) = 3 + 2j$, $y(2) = -1 - j$, $y(3) = 2 - 3j$. Let the noise samples $v(k)$, $0 \leq k \leq 3$ be zero-mean IID Gaussian with variance σ^2 . Also, let the cyclic prefix be of length two symbols. The estimate of the channel tap $h(0)$ is,



$$-\frac{22}{10} - \frac{5}{10}j$$



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

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

- Lecture 35 - Example Frequency Domain Equalization FDE for Inter Symbol Interference ISI Removal in Wireless Channels
- Lecture 36 - Example Frequency Domain Equalization FDE for Inter Symbol Interference ISI Removal in Wireless Channels
- Lecture 37 - Introduction to Sequential Estimation - Application in Wireless Channel Estimation
- Lecture 38 - Sequential Estimation of Wireless Channel Coefficient -

$\frac{22}{10} + \frac{5}{10}j$

$\frac{22}{10} - \frac{5}{10}j$

$-\frac{22}{10} + \frac{5}{10}j$

No, the answer is incorrect.

Score: 0

Accepted Answers:

$\frac{22}{10} - \frac{5}{10}j$

3) Consider a Frequency Domain Equalization system with block length N . Let 1 point $Y(l)$ and $H(l)$ denote respectively the output and channel coefficient corresponding subcarrier N . The estimate of the transmitted symbol $x(k)$ is given as,

$\sum_{l=0}^{N-1} \frac{Y(l)}{H(l)} e^{-j2\pi \frac{lk}{N}}$

$\frac{1}{N} \sum_{l=0}^{N-1} \frac{Y(l)}{H(l)} e^{j2\pi \frac{lk}{N}}$

$\frac{1}{N} \sum_{l=0}^{N-1} \frac{H(l)}{Y(l)} e^{j2\pi \frac{lk}{N}}$

$\sum_{l=0}^{N-1} \frac{H(l)}{Y(l)} e^{-j2\pi \frac{lk}{N}}$

No, the answer is incorrect.

Score: 0

Accepted Answers:

$\frac{1}{N} \sum_{l=0}^{N-1} \frac{Y(l)}{H(l)} e^{j2\pi \frac{lk}{N}}$

4) Consider a sequential fading channel estimation problem where the output 1 point symbol $y(k)$ is $y(k) = hx(k) + v(k)$, with $h, x(k), v(k)$ denoting the real channel coefficient, pilot symbol and noise sample respectively. Let $\mathbf{x} = [-2 \ 3 \ 2]^T$ denote the pilot vector of transmitted pilot symbols at $N = 3$ and $\mathbf{y} = [3 \ 2 \ -1]^T$ denote the corresponding received symbol vector at $N = 3$. Let the transmitted and received symbols respectively at $N + 1 = 4$ be $x(4) = -1, y(4) = -2$ respectively. Let $v(k)$ be IID Gaussian noise with zero-mean and dB variance $\sigma^2 = -3dB$. Let $p(N)$ denote the variance at time N . The expression for the gain $K(N + 1)$ at time $N + 1$ is,

$\frac{p(N)x(N+1)}{\sigma^2 + p(N)x(N+1)}$

$\frac{p(N)x^2(N+1)}{\sigma^2 + p(N)x^2(N+1)}$

$\frac{p(N)x^2(N+1)}{\sigma^2 + p(N)x(N+1)}$

$\frac{p(N)x(N+1)}{\sigma^2 + p(N)x^2(N+1)}$

No, the answer is incorrect.

Score: 0

Accepted Answers:

$\frac{p(N)x(N+1)}{\sigma^2 + p(N)x^2(N+1)}$



Estimate and
Variance
Update
Equation

Lecture 39 -
Example
Sequential
Estimation of
Wireless
Channel
Coefficient

Quiz :
Assignment-8

Assignment-8
Solution

5) Consider a sequential fading channel estimation problem where the output **1 point**
symbol $y(k)$ is $y(k) = hx(k) + v(k)$, with $h, x(k), v(k)$ denoting the *real* channel
coefficient, pilot symbol and noise sample respectively. Let $\mathbf{x} = [-2 \ 3 \ 2]^T$ denote the
pilot vector of transmitted pilot symbols at $N = 3$ and $\mathbf{y} = [3 \ 2 \ -1]^T$ denote the
corresponding received symbol vector at $N = 3$. Let the transmitted and received
symbols respectively at $N + 1 = 4$ be $x(4) = -1, y(4) = -2$ respectively. Let $v(k)$
be IID Gaussian noise with zero-mean and dB variance $\sigma^2 = -3dB$. Let $p(N)$ denote
the variance at time N . The gain $K(N + 1)$ at time $N + 1 = 4$ is,

- $-\frac{1}{16}$
- $-\frac{1}{17}$
- $-\frac{1}{18}$
- $-\frac{1}{19}$

No, the answer is incorrect.

Score: 0

Accepted Answers:

$-\frac{1}{18}$

6) Consider a sequential fading channel estimation problem where the output **1 point**
symbol $y(k)$ is $y(k) = hx(k) + v(k)$, with $h, x(k), v(k)$ denoting the *real* channel
coefficient, pilot symbol and noise sample respectively. Let $\mathbf{x} = [-2 \ 3 \ 2]^T$ denote the
pilot vector of transmitted pilot symbols at $N = 3$ and $\mathbf{y} = [3 \ 2 \ -1]^T$ denote the
corresponding received symbol vector at $N = 3$. Let the transmitted and received
symbols respectively at $N + 1 = 4$ be $x(4) = -1, y(4) = -2$ respectively. Let $v(k)$
be IID Gaussian noise with zero-mean and dB variance $\sigma^2 = -3dB$. Let $p(N)$ denote
the variance at time N . The prediction error at time $N + 1 = 4$ is,

- $-\frac{38}{17}$
- $-\frac{36}{17}$
- $-\frac{34}{17}$
- $-\frac{32}{17}$

No, the answer is incorrect.

Score: 0

Accepted Answers:

$-\frac{36}{17}$

7) Consider a sequential fading channel estimation problem where the output **1 point**
symbol $y(k)$ is $y(k) = hx(k) + v(k)$, with $h, x(k), v(k)$ denoting the *real* channel
coefficient, pilot symbol and noise sample respectively. Let $\mathbf{x} = [1 \ -1 \ 1]^T$ denote the
pilot vector of transmitted pilot symbols at $N = 3$ and $\mathbf{y} = [2 \ \frac{1}{2} \ \frac{3}{2}]^T$ denote the
corresponding received symbol vector at $N = 3$. Let the transmitted and received
symbols respectively at $N + 1 = 4$ be $x(4) = -1, y(4) = -1$ respectively. Let $v(k)$
be IID Gaussian noise with zero-mean and dB variance $\sigma^2 = -3dB$. What is the
prediction error at time $N + 1 = 4$ is,

- 1
-



0

 $\frac{1}{2}$  $\frac{1}{4}$ **No, the answer is incorrect.****Score: 0****Accepted Answers:**

0

8) Consider a sequential fading channel estimation problem where the output symbol $y(k)$ is $y(k) = hx(k) + v(k)$, with $h, x(k), v(k)$ denoting the *real* channel coefficient, pilot symbol and noise sample respectively. Let $\mathbf{x} = [1 \ -1 \ 1]^T$ denote the pilot vector of transmitted pilot symbols at $N = 3$ and $\mathbf{y} = [2 \ \frac{1}{2} \ \frac{3}{2}]^T$ denote the corresponding received symbol vector at $N = 3$. Let the transmitted and received symbols respectively at $N + 1$ be $x(4) = -1, y(4) = -1$ respectively. Let $v(k)$ be IID Gaussian noise with zero-mean and dB variance $\sigma^2 = -3dB$. The gain $K(4)$ at time $N + 1$ is,



0

 $\frac{1}{4}$  $-\frac{1}{4}$  $\frac{1}{2}$ **No, the answer is incorrect.****Score: 0****Accepted Answers:** $-\frac{1}{4}$

9) Consider a sequential fading channel estimation problem where the output symbol $y(k)$ is $y(k) = hx(k) + v(k)$, with $h, x(k), v(k)$ denoting the *real* channel coefficient, pilot symbol and noise sample respectively. Let $\mathbf{x} = [1 \ -1 \ 1]^T$ denote the pilot vector of transmitted pilot symbols at $N = 3$ and $\mathbf{y} = [2 \ \frac{1}{2} \ \frac{3}{2}]^T$ denote the corresponding received symbol vector at $N = 3$. Let the transmitted and received symbols respectively at $N + 1 = 4$ be $x(4) = -1, y(4) = -1$ respectively. Let $v(k)$ be IID Gaussian noise with zero-mean and dB variance $\sigma^2 = -3dB$. The update i.e. quantity to be added to estimate $\hat{h}(3)$ at $N = 3$ to generate the estimate $\hat{h}(4)$ at time $N + 1 = 4$ is,

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

0

No, the answer is incorrect.**Score: 0****Accepted Answers:**

0

10)

1 point

Consider a sequential fading channel estimation problem where the output symbol $y(k)$ is $y(k) = hx(k) + v(k)$, with h , $x(k)$, $v(k)$ denoting the *real* channel coefficient, pilot symbol and noise sample respectively. Let $\mathbf{x} = [1 \ -1 \ 1]^T$ denote the pilot vector of transmitted pilot symbols at $N = 3$ and $\mathbf{y} = [2 \ \frac{1}{2} \ \frac{3}{2}]^T$ denote the corresponding received symbol vector at $N = 3$. Let the transmitted and received symbols respectively at $N + 1 = 4$ be $x(4) = -1$, $y(4) = -1$ respectively. Let $v(k)$ be IID Gaussian noise with zero-mean and dB variance $\sigma^2 = -3dB$. The variance of the estimate $\hat{h}(4)$ at time $N + 1 = 4$ is,



$$\frac{1}{4}$$



$$\frac{1}{8}$$



$$\frac{1}{10}$$



$$\frac{1}{16}$$

No, the answer is incorrect.

Score: 0

Accepted Answers:

$$\frac{1}{8}$$



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