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NPTEL

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

Announcements Course Ask a Question Progress

Unit 4 - Week 3 - Cramer-Rao Bound (CRB), Vector Parameter Estimation, Multi-Antenna Downlink Mobile Channel Estimation



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

- Lecture 11 - Cramer Rao Bound (CRB) for Parameter Estimation
- Lecture 12 - Cramer Rao Bound CRB Example – Wireless Sensor Network
- Lecture 13 - Vector Parameter Estimation – System Model for Multi Antenna Downlink Channel Estimation
- Lecture 14 - Likelihood Function and Least Squares

Assignment-3

The due date for submitting this assignment has passed. **Due on 2017-08-15, 23:59 IST.**
As per our records you have not submitted this assignment.

1) Given the log-likelihood $\ln p(\mathbf{y}; h)$ of the parameter h and unbiased estimator \hat{h} , the quantity $\left(\int_{-\infty}^{\infty} \hat{h} \frac{\partial}{\partial h} \ln p(\mathbf{y}; h) p(\mathbf{y}; h) dy \right)^2$ equals **1 point**

2

1

0

 $I(h)$

No, the answer is incorrect.

Score: 0

Accepted Answers:

1

2) Given the log-likelihood $\ln p(\mathbf{y}; h)$ of the parameter h , the quantity $\left(E \left\{ \frac{\partial}{\partial h} \ln p(\mathbf{y}; h) \right\} \right)^2$ equals, **1 point**

2

1

0

 $I(h)$

No, the answer is incorrect.

Score: 0

Accepted Answers:

0

3) The Cramer-Rao Bound for parameter h is derived as, **1 point**

Cost Function for Vector Parameter Estimation

- Lecture 15 - Least Squares Cost Function for Vector Parameter Estimation Vector Derivative Gradient
- Quiz : Assignment-3
- Assignment-3 Solution

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 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

$E \left\{ \frac{\partial}{\partial h} \ln p(\mathbf{y}; h) \right\}$

$E \left\{ \left(\frac{\partial}{\partial h} \ln p(\mathbf{y}; h) \right)^2 \right\}$

$\frac{1}{E \left\{ \left(\frac{\partial}{\partial h} \ln p(\mathbf{y}; h) \right)^2 \right\}}$

$E \left\{ \left(\frac{\partial}{\partial h} \ln p(\mathbf{y}; h) \right)^2 \right\}$

No, the answer is incorrect.

Score: 0

Accepted Answers:

$\frac{1}{E \left\{ \left(\frac{\partial}{\partial h} \ln p(\mathbf{y}; h) \right)^2 \right\}}$

4) Consider now a slightly modified version of the wireless sensor network (WSN) 1 point estimation scenario described in class with each observation $y(k) = kh + v(k)$, for $1 \leq k \leq N$. Let the noise samples be IID Gaussian with mean zero and variance σ^2 each. The quantity $\frac{\partial}{\partial h} \ln p(\mathbf{y}; h)$ is

$\frac{1}{\sigma^2} \sum_{k=1}^N (y(k) - kh)^2$

$\frac{\sigma^2}{\sum_{k=1}^N k(y(k) - kh)^2}$

$\frac{\sigma^2}{\sum_{k=1}^N (y(k) - kh)^2}$

$\frac{1}{\sigma^2} \sum_{k=1}^N k(y(k) - kh)$

No, the answer is incorrect.

Score: 0

Accepted Answers:

$\frac{1}{\sigma^2} \sum_{k=1}^N k(y(k) - kh)$

5) Consider now a slightly modified version of the wireless sensor network (WSN) 1 point estimation scenario described in class with each observation $y(k) = kh + v(k)$, for $1 \leq k \leq N$. Let the noise samples be IID Gaussian with mean zero and variance σ^2 each. The Fisher information for the parameter h is,

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

$\frac{N}{\sigma^2}$

$\frac{\sigma^2}{N}$

None of the above

No, the answer is incorrect.

Score: 0

Accepted Answers:

None of the above



Cases,
Applications -
Wireless Fading
Channel
Estimation, SLS
Example

6) Consider now a slightly modified version of the wireless sensor network (WSN) **1 point** estimation scenario described in class with each observation $y(k) = kh + v(k)$, for $1 \leq k \leq N$. Let the noise samples be IID Gaussian with mean zero and variance σ^2 each. The Cramer Rao Bound for the parameter h is,

- $\frac{6}{N(N+1)(2N+1)} \sigma^2$
- $\frac{\sigma^2}{N}$
- $\frac{4}{N(N+1)} \sigma^2$
- $\frac{\sigma^2}{N^2}$

No, the answer is incorrect.

Score: 0

Accepted Answers:

$$\frac{6}{N(N+1)(2N+1)} \sigma^2$$

7) Consider now a slightly modified version of the wireless sensor network (WSN) **1 point** estimation scenario described in class with each observation $y(k) = kh + v(k)$, for $1 \leq k \leq N$. Let the noise samples be IID Gaussian with mean zero and variance σ^2 each. The Cramer Rao Bound for the parameter h is,

- Always Lower than the variance of the ML estimate
- Always Greater than the variance of the ML estimate
- Always Equal to the variance of the ML estimate
- None of the above

No, the answer is incorrect.

Score: 0

Accepted Answers:

Always Equal to the variance of the ML estimate

8) Consider the multiple antenna downlink channel estimation problem described in **1 point** class with $x_i(k)$ denoting the pilot symbol transmitted from the i^{th} antenna at time k , $y(k)$, h_i denoting the corresponding received symbol and fading channel coefficient for the i^{th} antenna respectively. Let number of antennas $M = 2$ and consider the transmission of $N = 3$ pilot vectors. The pilot matrix \mathbf{X} is of size

- 3×2
- 2×3
- 2×2
- 3×3

No, the answer is incorrect.

Score: 0

Accepted Answers:

$$3 \times 2$$

9) Consider the multiple antenna downlink channel estimation problem described in **1 point** class with $x_i(k)$ denoting the pilot symbol transmitted from the i^{th} antenna at time k , $y(k)$, h_i denoting the corresponding received symbol and fading channel coefficient for the i^{th} antenna respectively. Let number of antennas $M = 2$ and consider the transmission of $N = 3$ pilot vectors. Let the vector of received output symbols be



denoted by $\mathbf{y} = [y(1), y(2), \dots, y(N)]^T$. The equivalent cost function to be minimized to compute the estimate of the channel vector \mathbf{h} is,

$$\sum_{k=1}^N \sum_{i=1}^M (y(k) - h_i x(k))^2$$

$$\frac{1}{2\sigma^2} \sum_{k=1}^N (y(k) - \mathbf{h}^T \mathbf{x}(k))^2$$

$$\sum_{k=1}^N |\mathbf{y} - \mathbf{X}\mathbf{h}|$$

$$\sum_{k=1}^N \sum_{i=1}^M (y(k) - h_i)^2$$

No, the answer is incorrect.

Score: 0

Accepted Answers:

$$\frac{1}{2\sigma^2} \sum_{k=1}^N (y(k) - \mathbf{h}^T \mathbf{x}(k))^2$$

10 Consider a multi-antenna channel estimation scenario with $N = 3$ pilot vectors **1 point**
 $\mathbf{x}(1) = [1, 2]^T$, $\mathbf{x}(2) = [3, -1]^T$, $\mathbf{x}(3) = [1, 1]^T$. Let the corresponding received vector be $\mathbf{y} = [2, 1, 2]^T$. The corresponding pilot matrix \mathbf{X} is

- It is invertible
 It has orthogonal columns
 It has identical columns
 None of the above

No, the answer is incorrect.

Score: 0

Accepted Answers:

It has orthogonal columns

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