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

Announcements Course Ask a Question Progress

Unit 2 - Week 1 - Basics of Estimation, Maximum Likelihood (ML)



Course outline

How to Access the Portal ?

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

- Lecture 01 - Basics – Sensor Network and Noisy Observation Model
- Lecture 02 - Likelihood Function and Maximum Likelihood (ML) Estimate
- Lecture 03 - Properties of Maximum Likelihood (ML) Estimate – Mean and Unbiasedness
- Lecture 04 - Properties of Maximum Likelihood (ML) Estimate – Variance and Spread Around Mean
- Lecture 05 - Reliability of the Maximum Likelihood (ML) Estimate – Number of Samples Required
- Quiz : Assignment-1
- Assignment-1 Solution

Assignment-1

The due date for submitting this assignment has passed. **Due on 2017-08-06, 23:59 IST.** As per our records you have not submitted this assignment.

1) In the context of estimation, the probability density function (PDF) of the observations, viewed as a function of the unknown parameter h is termed as the **1 point**

- Likelihood Function
- Estimation Function
- Objective Function
- Cost Function

No, the answer is incorrect.

Score: 0

Accepted Answers:

Likelihood Function

2) Consider the wireless sensor network (WSN) estimation scenario described in lectures with each observation $y(k) = h + v(k)$, for $1 \leq k \leq N$, i.e. number of observations is N . The ML estimate given by the sample mean has the following property. **1 point**

- It is biased
- Gaussian distributed
- Variance decreases as $\frac{1}{N^2}$, where N is number of observations
- All of the above

No, the answer is incorrect.

Score: 0

Accepted Answers:

Gaussian distributed

3) Consider the wireless sensor network (WSN) estimation scenario described in lectures with each observation $y(k) = h + v(k)$, for $1 \leq k \leq N$, i.e. number of observations is N and noise samples $v(k)$ are IID Gaussian noise samples with zero mean and variance σ^2 . For this scenario, what is the maximum likelihood estimate \hat{h} of the unknown parameter h . **1 point**

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

$\left(\prod_{k=1}^N y(k) \right)^{\frac{1}{N}}$

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 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

$$\min \{y(k), 1 \leq k \leq N\}$$

None of the above

No, the answer is incorrect.

Score: 0

Accepted Answers:

None of the above

4) Consider the wireless sensor network (WSN) estimation scenario described in lectures with **1 point** each observation $y(k) = h + v(k)$, for $1 \leq k \leq N$, i.e. number of observations is N and noise samples $v(k)$ are IID Gaussian noise samples with zero mean and variance σ^2 . For this scenario, what is the **variance** of the maximum likelihood estimate \hat{h} of the unknown parameter h

$$\sigma^2$$

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

$$\frac{\sigma}{N}$$

$$N\sigma^2$$

No, the answer is incorrect.

Score: 0

Accepted Answers:

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

5) Consider the wireless sensor network (WSN) estimation scenario described in lectures with **1 point** each observation $y(k) = h + v(k)$, for $1 \leq k \leq N$, i.e. number of observations is N and noise samples $v(k)$ are IID Gaussian noise samples with zero mean and variance σ^2 . For this scenario, what is the **mean** of the maximum likelihood estimate \hat{h} of the unknown parameter h

$$h$$

$$Nh$$

$$\frac{h}{N}$$

$$\frac{1}{N}$$

No, the answer is incorrect.

Score: 0

Accepted Answers:

$$h$$

6) Consider now a slightly modified version of the wireless sensor network (WSN) estimation **1 point** scenario described in class with each observation $y(k) = h + v(k)$, for $1 \leq k \leq N$. Let the noise samples be IID Gaussian with mean θ and variance σ^2 each. What is the maximum likelihood estimate \hat{h} ?

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

$$\frac{1}{N} \sum_{k=1}^N (y(k) - \theta)$$

$$\frac{1}{N} \sum_{k=1}^N (y(k) + \theta)$$



$$\frac{1}{N} \sum_{k=1}^N y(k)$$

No, the answer is incorrect.

Score: 0

Accepted Answers:

$$\frac{1}{N} \sum_{k=1}^N (y(k) - \theta)$$

7) Consider now a slightly modified version of the wireless sensor network (WSN) estimation scenario described in class with each observation $y(k) = h + v(k)$, for $1 \leq k \leq N$. Let the noise samples be IID Gaussian with mean θ and variance σ^2 each. What is **mean** of the maximum likelihood estimate \hat{h} ? **1 point**

-
- $$h + \frac{\theta}{N}$$
-
- $$\frac{h}{N} + \theta$$
-
- $$h + \theta$$
-
- $$h$$

No, the answer is incorrect.

Score: 0

Accepted Answers:

h

8) Consider now a slightly modified version of the wireless sensor network (WSN) estimation scenario described in class with each observation $y(k) = h + v(k)$, for $1 \leq k \leq N$. Let the noise samples be IID Gaussian with mean θ and variance σ^2 each. What is **variance** of the maximum likelihood estimate \hat{h} ? **1 point**

-
- $$\sigma^2 + \theta^2$$
-
- $$\frac{\sigma^2}{N} + \theta^2$$
-
- $$\frac{\sigma^2}{N}$$
-
- $$\frac{\sigma^2}{N} + \theta$$

No, the answer is incorrect.

Score: 0

Accepted Answers:

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

9) Consider now a slightly modified version of the wireless sensor network (WSN) estimation scenario described in class with each observation $y(k) = h + v(k)$, for $1 \leq k \leq N$. Let the noise samples be IID Gaussian with mean θ and variance σ^2 each. What is the distribution of the maximum likelihood estimate \hat{h} ? **1 point**

-
- Uniform
-
- Exponential
-
- Rayleigh
-
- None of the above

No, the answer is incorrect.

Score: 0



Accepted Answers:*None of the above*

10) Consider now a slightly modified version of the wireless sensor network (WSN) estimation **1 point** scenario described in class with each observation $y(k) = h + v(k)$, for $1 \leq k \leq N$. Let the noise samples be IID Gaussian with mean θ and variance $\sigma^2 = -6dB$ i.e. $10 \log_{10} \sigma^2 = -6$. What is the number of observations N required such that the probability that the maximum likelihood estimate \hat{h} lies within a radius of $\frac{1}{16}$ of the unknown parameter h is greater than 99.9%? Let Q denote the Gaussian Q function introduced in the lectures.

- $(2\sqrt{2}Q^{-1}(\theta + 10^{-3}))^2$
- $(8Q^{-1}(5 \times 10^{-4}))^2$
- $8Q^{-1}(5 \times 10^{-4})$
- $\theta + 2Q^{-1}(5\sqrt{2} \times 10^{-4})$

No, the answer is incorrect.**Score: 0****Accepted Answers:** $(8Q^{-1}(5 \times 10^{-4}))^2$ [Previous Page](#)[End](#)

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