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| **Started on** | Thursday, 23 November 2023, 10:47 PM |
| **State** | Finished |
| **Completed on** | Thursday, 23 November 2023, 10:56 PM |
| **Time taken** | 8 mins 53 secs |
| **Grade** | **10.00** out of 10.00 (**100**%) |

Question **1**

Correct

Mark 1.00 out of 1.00

Flag question

Consider the multiple transmit antenna channel estimation model given by $\bar{\mathbf{y}} = \mathbf{X}\bar{\mathbf{h}} + \bar{\mathbf{v}}$, with, $\mathbf{X}, \bar{\mathbf{y}}$ denoting the pilot matrix, output vector, respectively and $\bar{\mathbf{v}}$ denoting the additive noise vector comprising of zero-mean i.i.d. Gaussian noise samples of variance $\sigma^2$. The channel coefficients are zero-mean i.i.d. Gaussian with variance $\sigma_h^2$. The error covariance of the MMSE estimate of the channel vector $\bar{\mathbf{h}}$ is

Select one:

- $\left(\frac{\mathbf{X}^T\mathbf{X}}{\sigma_h^2} + \frac{1}{\sigma^2}\right)^{-1}$
- $\left(\frac{\mathbf{X}\mathbf{X}^T}{\sigma_h^2} + \frac{1}{\sigma^2}\right)^{-1}$
- $\left(\frac{\sigma^2}{\sigma_h^2}\mathbf{X}\mathbf{X}^T + \mathbf{I}\right)^{-1}$
- $\left(\frac{\mathbf{X}^T\mathbf{X}}{\sigma^2} + \frac{1}{\sigma_h^2}\right)^{-1}$ ✔

Your answer is correct.

The correct answer is: $\left(\frac{\mathbf{X}^T\mathbf{X}}{\sigma^2} + \frac{1}{\sigma_h^2}\right)^{-1}$

Question **2**

Correct

Mark 1.00 out of 1.00

Flag question

The expression for the

**MMSE estimate** $\hat{\mathbf{h}}$ is

Select one:

- $E\{\bar{\mathbf{h}}\}$
- $E\{\bar{\mathbf{y}}|\bar{\mathbf{h}}\}$
- $E\{\bar{\mathbf{h}}|\bar{\mathbf{x}}\}$
- $E\{\bar{\mathbf{h}}|\bar{\mathbf{y}}\}$ ✔

Your answer is correct.

The correct answer is: $E\{\bar{\mathbf{h}}|\bar{\mathbf{y}}\}$

Question **3**

Correct

Mark 1.00 out of 1.00

Flag question

For

$\bar{\mathbf{h}}, \bar{\mathbf{y}}$, jointly Gaussian, zero-mean, MMSE estimate can be simplified as

Select one:

- $\mathbf{R}_{yy}^{-1}\mathbf{R}_{hy}\bar{\mathbf{y}}$
- $\mathbf{R}_{hy}\mathbf{R}_{yy}\ \bar{\mathbf{y}}$
- $\mathbf{R}_{hy}\mathbf{R}_{yy}^{-1}\bar{\mathbf{y}}$ ✔
- $\mathbf{R}_{hy}^{-1}\mathbf{R}_{yy}\ \bar{\mathbf{y}}$

Your answer is correct.

The correct answer is: $\mathbf{R}_{hy}\mathbf{R}_{yy}^{-1}\bar{\mathbf{y}}$

Question **4**

Correct

Mark 1.00 out of 1.00

Flag question

The covariance matrix $\mathbf{R}_{yy}$ is defined as

Select one:

- $E\{\bar{\mathbf{y}}^T\bar{\mathbf{y}}\}$
- $E\{\bar{\mathbf{y}}^2\}$
- $E\{\bar{\mathbf{y}}\bar{\mathbf{y}}^T\}$ ✔
- $E\left\{\frac{\bar{\mathbf{y}}}{\bar{\mathbf{y}}^T}\right\}$

Your answer is correct.

The correct answer is: $E\{\bar{\mathbf{y}}\bar{\mathbf{y}}^T\}$

Question **5**

Correct

Mark 1.00 out of 1.00

Flag question

The matrix $\mathbf{R}_{hy}$ is

Select one:

- cross-covariance matrix ✔
- covariance matrix
- variance
- standard deviation

Your answer is correct.

The correct answer is: cross-covariance matrix

Question **6**

Correct

Mark 1.00 out of 1.00

Flag question

The MISO channel estimation problem can be formulated as

Select one:

- $\underbrace{\begin{bmatrix} y(1) \\ y(2) \\ \vdots \\ y(N) \end{bmatrix}}_{\bar{\mathbf{y}}} = \underbrace{\begin{bmatrix} \bar{\mathbf{x}}(1) \\ \bar{\mathbf{x}}(2) \\ \vdots \\ \bar{\mathbf{x}}(N) \end{bmatrix}}_{\mathbf{X}} \bar{\mathbf{h}} + \underbrace{\begin{bmatrix} v(1) \\ v(2) \\ \vdots \\ v(N) \end{bmatrix}}_{\bar{\mathbf{v}}}$
- $\underbrace{\begin{bmatrix} y(1) \\ y(2) \\ \vdots \\ y(N) \end{bmatrix}}_{\bar{\mathbf{y}}} = \underbrace{\begin{bmatrix} \bar{\mathbf{x}}(1) \\ \bar{\mathbf{x}}(2) \\ \vdots \\ \bar{\mathbf{x}}(N) \end{bmatrix}}_{\mathbf{X}} \bar{\mathbf{h}}^T + \underbrace{\begin{bmatrix} v(1) \\ v(2) \\ \vdots \\ v(N) \end{bmatrix}}_{\bar{\mathbf{v}}}$
- $\underbrace{\begin{bmatrix} y(1) \\ y(2) \\ \vdots \\ y(N) \end{bmatrix}}_{\bar{\mathbf{y}}} = \underbrace{\begin{bmatrix} \bar{\mathbf{x}}^T(1) \\ \bar{\mathbf{x}}^T(2) \\ \vdots \\ \bar{\mathbf{x}}^T(N) \end{bmatrix}}_{\mathbf{X}} \bar{\mathbf{h}}^T + \underbrace{\begin{bmatrix} v(1) \\ v(2) \\ \vdots \\ v(N) \end{bmatrix}}_{\bar{\mathbf{v}}}$
- $\underbrace{\begin{bmatrix} y(1) \\ y(2) \\ \vdots \\ y(N) \end{bmatrix}}_{\bar{\mathbf{y}}} = \underbrace{\begin{bmatrix} \bar{\mathbf{x}}^T(1) \\ \bar{\mathbf{x}}^T(2) \\ \vdots \\ \bar{\mathbf{x}}^T(N) \end{bmatrix}}_{\mathbf{X}} \bar{\mathbf{h}} + \underbrace{\begin{bmatrix} v(1) \\ v(2) \\ \vdots \\ v(N) \end{bmatrix}}_{\bar{\mathbf{v}}}$ ✔

Your answer is correct.

The correct answer is: $\underbrace{\begin{bmatrix} y(1) \\ y(2) \\ \vdots \\ y(N) \end{bmatrix}}_{\bar{\mathbf{y}}} = \underbrace{\begin{bmatrix} \bar{\mathbf{x}}^T(1) \\ \bar{\mathbf{x}}^T(2) \\ \vdots \\ \bar{\mathbf{x}}^T(N) \end{bmatrix}}_{\mathbf{X}} \bar{\mathbf{h}} + \underbrace{\begin{bmatrix} v(1) \\ v(2) \\ \vdots \\ v(N) \end{bmatrix}}_{\bar{\mathbf{v}}}$

Question **7**

Correct

Mark 1.00 out of 1.00

Flag question

Consider a multi-antenna channel estimation scenario with $N = 4$ pilot vectors, with the pilot matrix $\mathbf{X}$ and receive vector $\bar{\mathbf{y}}$ given below

$$\mathbf{X} = \begin{bmatrix} 1 & 1 \\ -1 & 1 \\ 1 & -1 \\ -1 & -1 \end{bmatrix}, \bar{\mathbf{y}} = \begin{bmatrix} -2 \\ 1 \\ -1 \\ -2 \end{bmatrix}$$

Let the channel coefficients be i.i.d. Gaussian with variance $\sigma_h^2 = 1$ and noise variance $\sigma^2 = 2$. The MMSE estimate of the channel vector $\bar{\mathbf{h}}$ is

Select one:

- $\begin{bmatrix} -\frac{4}{3} \\ -\frac{2}{3} \end{bmatrix}$
- $\begin{bmatrix} -\frac{1}{3} \\ \frac{1}{3} \end{bmatrix}$ ✔
- $\begin{bmatrix} \frac{2}{3} \\ -\frac{1}{3} \end{bmatrix}$

$\begin{bmatrix} -\frac{1}{2} \\ \frac{1}{4} \end{bmatrix}$

Your answer is correct.

The correct answer is: $\begin{bmatrix} -\frac{1}{3} \\ \frac{1}{3} \end{bmatrix}$

Question **8**

Correct

Mark 1.00 out of 1.00

Flag question

Consider a multi-antenna channel estimation scenario with $N = 4$ pilot vectors, with the pilot matrix $\mathbf{X}$ given below

$$\mathbf{X} = \begin{bmatrix} 1 & 1 \\ -1 & 1 \\ 1 & -1 \\ -1 & -1 \end{bmatrix}$$

Let the channel coefficients be i.i.d. Gaussian with variance $\sigma_h^2 = 1$ and noise variance $\sigma^2 = 2$. The error covariance of the LMMSE estimate of $\bar{\mathbf{h}}$ is,

Select one:

- $\begin{bmatrix} \frac{1}{3} & 0 \\ 0 & \frac{1}{3} \end{bmatrix}$ ✔
- $\begin{bmatrix} \frac{1}{2} & 0 \\ 0 & \frac{1}{2} \end{bmatrix}$
- $\begin{bmatrix} 1 & \frac{1}{3} \\ \frac{1}{3} & 1 \end{bmatrix}$
- $\begin{bmatrix} 2 & 0 \\ 0 & 2 \end{bmatrix}$

Your answer is correct.

The correct answer is: $\begin{bmatrix} \frac{1}{3} & 0 \\ 0 & \frac{1}{3} \end{bmatrix}$

Question **9**

Correct

Mark 1.00 out of 1.00

Flag question

Consider a multi-antenna channel estimation scenario with $N = 4$ pilot vectors, with the pilot matrix $\mathbf{X}$ and receive vector $\bar{\mathbf{y}}$ given below

$$\mathbf{X} = \begin{bmatrix} 1 & 1 \\ -1 & 1 \\ 1 & -1 \\ -1 & -1 \end{bmatrix}, \bar{\mathbf{y}} = \begin{bmatrix} -2 \\ 1 \\ -1 \\ -2 \end{bmatrix}$$

Let the channel coefficients be i.i.d. zero-mean Gaussian with variance $\sigma_h^2 = 1$. The LMMSE estimate as the noise variance $\sigma^2 \longrightarrow 0$ is

Select one:

- $\begin{bmatrix} 1 \\ -\frac{1}{2} \end{bmatrix}$

- $\begin{bmatrix} -\frac{1}{2} \\ -1 \end{bmatrix}$
- $\begin{bmatrix} -\frac{1}{2} \\ \frac{1}{2} \end{bmatrix}$ ✔
- $\begin{bmatrix} -\frac{1}{4} \\ 1 \end{bmatrix}$

Your answer is correct.

The correct answer is: $\begin{bmatrix} -\frac{1}{2} \\ \frac{1}{2} \end{bmatrix}$

Question **10**

Correct

Mark 1.00 out of 1.00

Flag question

Consider the fading channel estimation problem where the output symbol 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 $\bar{\mathbf{x}} = [x(1) \quad x(2) \quad \ldots \quad x(N)]^T$ denote the pilot vector of transmitted pilot symbols and $\bar{\mathbf{y}} = [y(1) \quad y(2) \quad \ldots \quad y(N)]^T$ denote the corresponding received symbol vector. Let $v(k)$ be IID Gaussian noise with zero-mean and variance $\sigma^2$. Let the channel coefficient $h$ be Gaussian with mean $\mu_h$ and variance $\sigma_h^2$. The MMSE estimate $\hat{h}$ of the channel coefficient $h$ is

Select one:

- $\dfrac{\frac{\mathbf{x}^T\mathbf{y}}{\sigma^2}+\frac{\mu_h}{\sigma_h^2}}{\frac{\|\mathbf{x}\|^2}{\sigma^2}+\frac{1}{\sigma_h^2}}$ ✔
- $\dfrac{\frac{\mathbf{x}^T\mathbf{y}}{\sigma_h^2}+\frac{\mu_h}{\sigma^2}}{\frac{1}{\sigma^2}+\frac{1}{\sigma_h^2}}$
- $\dfrac{\frac{\mathbf{x}^T\mathbf{y}}{\sigma^2\|\mathbf{x}\|^2}+\frac{\mu_h}{\sigma_h^2}}{\frac{\|\mathbf{x}\|^2}{\sigma^2}+\frac{1}{\sigma_h^2}}$
- $\dfrac{\frac{\mathbf{x}^T\mathbf{y}}{\sigma^2}}{\frac{N}{\sigma^2}+\frac{1}{\sigma_h^2}}$

Your answer is correct.

The correct answer is: $\dfrac{\frac{\mathbf{x}^T\mathbf{y}}{\sigma^2}+\frac{\mu_h}{\sigma_h^2}}{\frac{\|\mathbf{x}\|^2}{\sigma^2}+\frac{1}{\sigma_h^2}}$

Finish review