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Warming up

3.1 Least Squares Estimation

3.2 Weighted Least Squares Estimation

Assessment

Graded Assignment due Feb 8, 2017 17:30 IST



Q&amp;A Forum

3.© Geometry of Least Squares (optional topic)

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## Exercises: Least Squares Estimation

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### Truth about least squares

2/2 points (ungraded)

Which of the following statements is correct? *Select all correct statements*

- ☐ Least squares Estimation takes the minimum of the squared observations.
- ☐ Least squares Estimation takes the minimum of the unknowns.
- ☐ The least squares solution of a system of observation equations minimizes the differences between the observations and the unknowns.

☒ The least squares solution of a system of observation equations minimizes the differences between the observations  $y$  and the adjusted observations  $\hat{y}$ .

☒ The adjusted observations  $\hat{y}$  always fit perfectly to the  $y = Ax$  model.
Which of the following statements is correct? *Select all correct statements*

## Mid-survey

## Feedback

- ▶ 4. Best Linear Unbiased Estimation (BLUE)
- ▶ 5. How precise is the estimate?
- ▶ Pre-knowledge Mathematics
- ▶ MATLAB Learning Content

☒ If a system of observation equations has  $m$  observations, then  $e^T e = e_1^2 + e_2^2 + \dots + e_m^2$ .

☒ The norm of a vector represents the length of that vector.

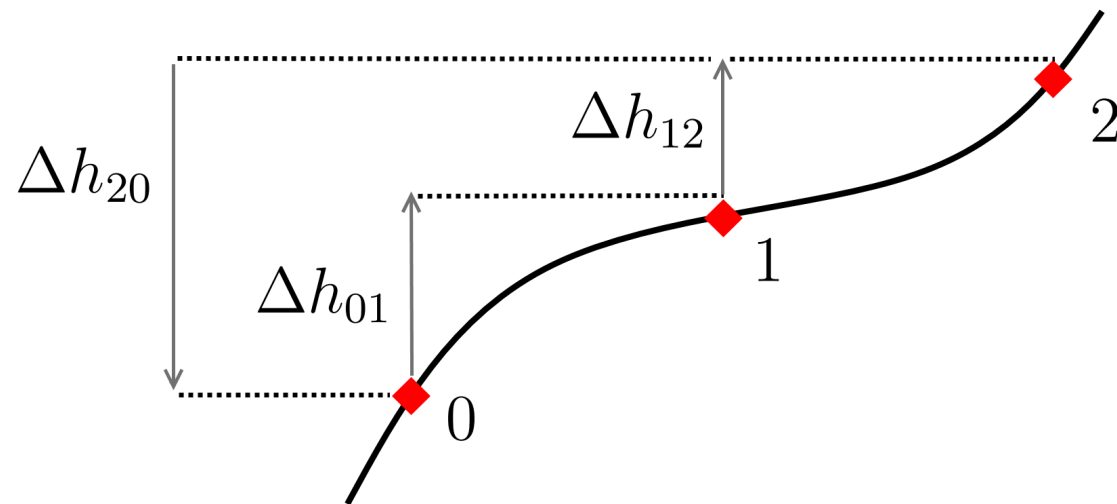
☐ The norm of a vector is the squared length of that vector.

☒ The normal matrix is always a square matrix.



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✓ Correct (2/2 points)



The above figure shows the scheme of a leveling campaign. The observed height difference between locations  $i$  and  $j$  is given by:

$$h_{ij} = h_j - h_i$$

In this case assume that  $h_0$  is known and equal to zero ( $h_0 = 0$ ).

### Design matrix

1/1 point (ungraded)

For the given observation vector  $\mathbf{y} = [h_{01} \quad h_{12} \quad h_{20}]^T$ , which of the following matrices is the correct design matrix?

☒  $\begin{bmatrix} 1 & 0 \\ -1 & 1 \\ 0 & -1 \end{bmatrix}$  ✓

☐  $\begin{bmatrix} 0 & 1 & 0 \\ 0 & -1 & 1 \\ 0 & 0 & -1 \end{bmatrix}$

☐  $\begin{bmatrix} 1 & 0 \\ -1 & 1 \\ 0 & 1 \end{bmatrix}$

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✓ Correct (1/1 point)

### Least square solution

4/4 points (ungraded)

For the same leveling campaign the following observation vector is given:  $\mathbf{y} = [2.2 \ 4.3 \ -6.7]^T$

Is the system of equations consistent?

✓ Answer: no

**Explanation**

No, we cannot find a solution for  $h_1$  and  $h_2$  such that all 3 observed height differences are obtained. For that we would need e.g. that  $y_1 = 2.2 = h_1$  and  $y_3 = -6.7 = -h_2$ . But then  $h_2 - h_1 = 6.7 - 2.2 = 4.5 \neq y_2 = 4.3$ .

Apply least squares estimation to estimate the two unknown heights,  $\hat{x} = [\hat{h}_1 \ \hat{h}_2]^T$ . [Give your answer to 2 decimal places, e.g. 1.00]

 $\hat{h}_1 =$ 

✓ Answer: 2.27

 $\hat{h}_2 =$ 

✓ Answer: 6.63

Which of the following is the correct vector with residuals?

☒  $\hat{e} = [-0.07 \ -0.07 \ -0.07]^T$  ✓

☐  $\hat{e} = [2.27 \ 4.37 \ -6.63]^T$

☐  $\hat{e} = [-0.20 \ -0.20 \ -0.20]^T$

☐  $\hat{e} = [0.33 \ 0.33 \ -0.67]^T$

#### Explanation

We have that  $\hat{x} = [2.27 \ 6.63]^T$ ,  $\hat{y} = A\hat{x} = [2.27 \ 4.37 \ -6.63]^T$ , and  $\hat{e} = y - \hat{y} = y - A\hat{x} = [-0.07 \ -0.07 \ -0.07]^T$ .

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✓ Correct (4/4 points)

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