

Statistical Signal Processing I

MATLAB Homework

Instructions (Please read carefully)

Return your solution to Moodle before 08.12.2023 16:15. Late returning will lead to deduction of points.

Upload your solutions to Moodle as ZIPPED file containing all files needed to run your codes. Your codes must be ready to run without any additional user configuration.

Use filename `MATLAB_Group.zip`. In addition to the well-commented program, make sure the report includes the following:

- The full name and the student number for each group member.
- Clear answers to the problems posted (including for example figures obtained by running the simulation program).
- Plagiarism is strictly forbidden and will lead to immediate rejection!
- You will get separate grade for each MATLAB exercise and you must need passing grade in order to pass the whole course.

Tasks

1. The data

$$x[n] = A \cos(2\pi f_o n + \phi) + w[n]$$

for $n = 0, 1, 2, \dots, N-1$ where $A > 0$ and $0 < f_o < 1/2$. Multiple parameters A , f_o and ϕ are unknown. Implement MLE estimator for $\theta = [A \ f_o \ \phi]^T$ by minimizing

$$J(A, f_o, \phi) = \sum_{i=0}^{N-1} (x[n] - A \cos(2\pi f_o n + \phi))^2$$

Implement Monte Carlo Simulation for MLE estimator to check their variance satisfies the CRLB.

Hint: See Example 3.14 and Example 7.16 for variance and estimator equations.

Use these parameter values:

$$N = 5;$$

$$A = 1;$$

$$\sigma^2 = 0.001;$$

$$f_o = 1/4;$$

$\phi = \pi/3$;
 $MC = 100000$; % number of Monte Carlo loops

2. For the same data

$$x[n] = A \cos(2\pi f_o n + \phi) + w[n]$$

with $n = -M, \dots, 0, \dots, M$.

Implement LSE estimator for frequency f_o and phase ϕ as a phase locked-loop with 10 times iteration.

Hint: See Example 8.14 for estimator equations.

Use these parameter values:

$$M = 2;$$

$$A = 1;$$

$$\sigma^2 = 0.001;$$

$$f_o = 1/4;$$

$$\phi = \pi/3;$$

$$Iteration = 10;$$