Computational Methods for Detection, Estimation and Identification

ASSIGNMENT 3

MsC in Electrical and Computer Engineering

DEEC - University of Coimbra

2022/2023

Experimental Work

As in the assignment 1 and 2, assume a robotic platform equipped with a sonar system that measures the distance to a wall. The goal of our experiment is to evaluate the performance of the vehicle's breaking system. The robot starts moving toward the wall with a constant velocity v_0. The break is actuated at a distance d_0 from the wall, in order to induce a constant acceleration a_0. The sonar measures the decreasing distance with a frequency of 10 Hz. The readings are collected during 10 seconds and stacked in a data vector $\mathbf{d}$ with dimension 100×1.

1. File *test3.mat* contains the data set $\mathbf{d}$ as well as the ground truth of the covariance matrix $\mathbf{CovM_{gt}}$ of the least square solution for the motion parameters. If you plot the sonar readings, you will observe that the noise has a strange behavior.

   (a) Compute the normal least square solution for the motion parameters.

   (b) Since the noise statistical parameters are unknown, there is no way to analytically estimate the estimation covariance matrix. Apply an alternative method to accomplish the task, and compare the results with the provided ground truth.

2. You can find enclosed a Matlab function named *SimulationRobotWall* (for details make *help SimulationRobotWall*). This function simulates sonar readings for a robotic platform moving towards a wall that suddenly breaks. You can define the standard deviation of the additive gaussian noise, as well as the percentage of outliers in the data set.

   In this work proposal we want you to use Monte Carlo Simulation to evaluate and compare the performance of three different estimation approaches: *(i)* normal least squares, *(ii)* robust M-estimation using the L1 norm, and *(ii)* RANSAC based approach with normal least squares. The performance must be evaluated for noise standard deviations between 0 and 5 (unitary increments). We want tests for data sets comprising 10, 30 and 50% of outliers.

For each combination method-noise-outlier the synthetic experiment must be ran 100 times. The estimation error of each run is kept in order to compute the root mean square (RMS) error at the end. You are supposed to show the graphics with the evolution of the RMS and discuss the results. The planning of the experiment and clarity of the presentation will be taken in account in the evaluation.

Write a **small report** (maximum 6 pages) of the assignment and submit it, with the **code scripts**, in the system until the deadline defined in the system. The report should show the theoretical derivations and provide explanations to the computed values and the comparisons made.