ECE 801 – Monitoring and Estimation

Assignment 3 (Due: 10/11/2019)

Report: Your report should be sent via email to course teaching assistant (cmenel02@ucy.ac.cy) prior the deadline and must include the usual cover page. In your report, include any comments and description you may want to add. Email subject line should only consist of "ECE801_2019". Naming format for the zip/rar file: lastName.zip/rar.

Note: Your solutions should **not** utilize any specialized MATLAB libraries that can solve the estimation problems.

1. **[30%]**

Assume that you run an experiment where you know that the underlying model is given by the linear input-output relation $y = g(x) = \theta_0 x + \theta_1$. After 100 experiments with $\boldsymbol{x}$ inputs you get $\boldsymbol{y}$ measured outputs, given in the file (xy.mat).

Using MATLAB:

I. Determine the optimum set of coefficients of $\theta^* = [\theta_0^*, \theta_1^*]$ that minimize Mean Square Error (MSE).

II. Given the file (xyb.mat) as input determine the optimum set of coefficients of $\theta^* = [\theta_0^*, \theta_1^*]$ that minimize MSE when the first 50 measurements are taken with a low precision sensor while the second 50 measurements are taken with a high precision sensor (the weight of the i_{th} observation i.e., x>50 is equal with 2).

III. Solve the problem from I. above using the recursive least square method assuming that the input signals arrive in First In First Out (FIFO).

2. **[70%]**

I. Assume that a vehicle is moving on a straight road and we want to estimate its true speed (denoted as v_x) that can be measured from the speedometer of vehicle. The vehicle's speedometer offers indirect measurements which may fluctuate due to external factors. Under this setting, the vehicle's measured speed is given by:

$$\mathrm{y}_\mathrm{n}^\mathrm{v} = v_x + w_n$$

where, w_n Gaussian White Noise with variance σ_w^2 and v_x is the constant vehicle speed. Assuming that the true speed is 60 km/h using MATALB generate a set of 100 sequential measurements (measured every 1s) when the noise variance $\sigma_w^2 = 0.1$. Design a Kalman Filter algorithm that accurately estimates the position and speed of vehicle. Your solution should provide the plots of the true, measured and estimated values of vehicle's **position** and **speed** as a function of time for different sensor noise scenarios (i.e., assume low, medium and high sensor noise scenarios). Furthermore, for every scenario you should plot the estimated uncertainty and the Kalman gain as a function of the number measurements, discuss your findings.

II. Repeat the problem I above when the vehicle starts with speed 60Km/h and is moving with constant acceleration $0.5m/s^2$ when the vehicle records only speed measurements.

III. Repeat the problem II above when your vehicle is equipped with a GPS sensor that can also measure the longitudinal position of the vehicle. The GPS measurements are given by

$$\mathrm{y}_{\mathrm{n}}^{\mathrm{x}} = x_n + \gamma_n$$

where, $x_n$is the true vehicle position and γ_n denotes Gaussian White Noise with zero mean and the variance σ_γ^2. Investigate your estimator accuracy in different scenarios including high σ_w^2 and low σ_γ^2 and vice versa.