Problem Statements - 7/12/2021

Controls

October 2021

1 Questions

1. Consider the following system dynamic equation,

$$x_{true}(k+1) = x_{true}(k) + v\Delta T$$

Choose appropriate initial values of $'x_{true}(0)'$ and $'v'$ of your choice. Consider that 3 sensors with the same refresh rates are employed to measure the true state and the measurements represented as the variables. z_1, z_2, z_3

   (a) In Scenario - 1, select appropriate values noise variances for the sensors such that, $R_1 < R_2 < R_3$. Design a Kalman filter to estimate the true states.

   (b) When simulating sensor fusion, try any structure for measurement updates of your own choice.

   (c) In an entirely different scenario (Scenario - 2), consider that there is only one measurement - z_2 whose noise variance is R_2 as same as that in the earlier scenario. Design a Kalman Filter for estimating the true states for this scenario.

   (d) Compare and comment on the nature of estimates obtained between the scenarios. Give your reasoning based on the results.

2. Consider the same system dynamic equation as in the previous question.

   Choose appropriate initial values of $'x_{true}(0)'$ and $'v'$ of your choice. Consider that 3 sensors with the same refresh rates and same noise variances are employed to measure the true state and the measurements represented as the variables. z_1, z_2, z_3.

   (a) Consider that the probability that each sensor can **fail/give a bad measurement** (in which case, it cannot be used for updating the estimates) is uniformly distributed.

   Hint : To simulate this, define a uniformly distributed random variable (that has an equal probability of returning any value between 0 and 1) for each sensor in MATLAB. If during a particular iteration, the sampled value of the random variable is greater than 0.5, then that specific sensor associated with it can be considered for updating, else it cannot be considered. You're supposed have 3 such uniform random variables since there are 3 sensors.

   Note : This uniformly distributed random variable is different from the random variable that is used for sensor noise, and this is only used to simulate sensor failing scenarios based on the condition given in the hint.

   (b) Design a Kalman Filter with the structure shown below to estimate the true state.

      i. Predict
      ii. Update Sensor - 1
      iii. Update Sensor - 2
      iv. Update Sensor - 3
      v. Repeat

   Compare the true states and the estimates using appropriate plots in MATLAB.

3. Consider the same system dynamic equation as in question-1.

   Choose appropriate initial values of $'x_{true}(0)'$ and $'v'$ of your choice. Consider that 5 sensors with the same refresh rates and noise variances are employed to measure the true state and the measurements represented as the variables. z_1, z_2, z_3, z_4, z_5.

(a) Suppose if during any k^{th} time interval, the on-board controller has a limitation that only 3 values of measurements can handled, Implement a kalman filter with the appropriate update structure of your choice.

(b) Suppose if sensor failure can happen as in question - 2, how would you modify your update structure(along with the sensor handling limitation) to improve the robustness of the estimator. Simulate the same, compare and provide your reasoning on the results between these two scenarios in (a) and (b).