Course outline

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Assignment 9

The due date for submitting this assignment has passed.

Due on 2021-03-24, 23:59 IST.

As per our records you have not submitted this assignment.

Problem 1: Pole Placement Observer

Consider the following system (which is similar to the one discussed in previous assignments). Since we are interested in state estimation, only the manipulated input part is ignored:

$$x(k+1) = \begin{bmatrix} 0.3 & -0.4 \\ 0.4 & 0.25 \end{bmatrix} x(k) + \begin{bmatrix} 0.25 \\ 1 \end{bmatrix} \varepsilon(k)$$
$$y(k) = \begin{bmatrix} 1 & 0 \end{bmatrix} x(k) + v(k)$$

Let $\mathrm{cov}(\varepsilon(k)) = 1$ and $\mathrm{cov}(v) = 0.64$

Please answer the following questions.

1) Compute the pole-placement design that gives a dead-beat observer. Please report the observer gain `K_db`.

No, the answer is incorrect.
Score: 0
Accepted Answers: (Type: Numeric Array)

0.55	0.244

0.5 points

2) Compute the pole-placement design that gives an observer with one pole at 0.25 and another pole at 0.5. Please report the observer gain `K_pp`.

No, the answer is incorrect.
Score: 0
Accepted Answers: (Type: Numeric Array)

-0.2	0.4

0.5 points

Problem 2: Steady State Kalman Filter

Design a steady state Kalman filter for the above system. This involves calculation of Kalman filter gain and error covariance (K^{∞}, P^{∞}) as well as Kalman predictor gain and predictor covariance $\left(\bar{K}^{\infty}, \bar{P}^{\infty}\right)$.

Please report the results below.

3) Compute and report the Kalman *filter* gain, K^{∞}.

No, the answer is incorrect.
Score: 0
Accepted Answers: (Type: Numeric Array)

0.26
0.175

0.4 points

4) Compute and report the one-step predictor gain, $\bar{K}^{\infty}$.

No, the answer is incorrect.
Score: 0
Accepted Answers: (Type: Numeric Array)

0.008
0.148

0.4 points

5) The MATLAB command `idare` or `Kalman` gives the predictor error covariance. Please compute and report this value, i.e., $\bar{P}^{\infty}$.

No, the answer is incorrect.
Score: 0
Accepted Answers: (Type: Numeric Array)

0.225	0.1514
0.1514	1.117

0.2 points

Problem 3: Effect of R1 and R2 (Not graded)

This question is not graded. Please try it for self-study.

- For the above problem, calculate the poles of the filter equation (i.e., eigenvalues of $A - \bar{K}^{\infty}C$)
- Repeat Problem 2 with the same state error but lower measurement noise, $cov(v) = 2.5 \times 10^{-5}$. How do $\bar{K}^{\infty}$ and $\lambda\left(A - \bar{K}^{\infty}C\right)$ change?
- Repeat Problem 2 with lower covariance of state noise, $cov(\varepsilon) = 2.5 \times 10^{-5}$. How do $\bar{K}^{\infty}$ and $\lambda\left(A - \bar{K}^{\infty}C\right)$ change?

Problem 4: Estimator Simulation

You may download and use `estimator_data.m` for this problem.

We will perform simulation case study to analyze the performance of Kalman Filter. The code `estimator_data.m` does the following tasks.

First, the realizations for the noise signals, $\varepsilon(k)$, $v(k)$, are obtained:

```
% Noise variances and realizations
rng(25);
epsilon=randn(1,200);   % Realization of state error
nu=0.8*randn(1,200);    % Realization of meas. noise
```

Next, $x(k)$ and $y(k)$ are obtained, starting with the initial value $x(0) = [1 \quad 1]^T$. These are stored in `XALL` and `YALL`.

The above calculations are already done for you. In this problem, starting with initial estimate $\hat{x}(0|0) = [0 \quad 0]^T$, run the Kalman filter and compute $\hat{x}(k|k)$. To do so, (i) compute $\hat{x}(k|k-1)$ from $\hat{x}(k-1|k-1)$ and (ii) compute $\hat{x}(k|k)$ from $\hat{x}(k|k-1)$ after Kalman filter.

6) Report the sum of square errors for the first variable.

No, the answer is incorrect.
Score: 0
Accepted Answers:
(Type: Range) 30,34

0.5 points

7) Report the sum of square errors for the second variable.

No, the answer is incorrect.
Score: 0
Accepted Answers:
(Type: Range) 198,208

0.5 points