Quiz 4
Graded Quiz • 30 min

Due Jun 15, 12:29 PM IST

Congratulations! You passed!

TO PASS 80% or higher

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GRADE
100%

Quiz 4

LATEST SUBMISSION GRADE

100%

1. Which of the following statements is correct?

1 / 1 point

- If a linear system is completely controllable, the state can be made to go between any two initial and final values.
- The eigenvalues to a general system $\dot{x} = Ax + Bu$ can always be placed anywhere using state-feedback.
- If a linear system is completely controllable, the state can be made to follow any trajectory.
- The separation principle tells us that the control design and the observer design **cannot** be done independently of each other.
- When designing observer-based controllers, the observer must be slower than the controller.

Correct
Pay careful attention to the wording of the statements, and review concepts from lecture this week.

2. Suppose you have a robot whose dynamics are

1 / 1 point

$$\dot{x} = \begin{bmatrix} 0 & 1 \\ 0 & 0 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u,$$

and you go to the sensor store to buy a sensor. Each sensor comes with a corresponding output matrix C, such that $y = Cx$. Which of the following sensors/C-matrices should you **not** buy? (Hint: Observability seems to be a useful property in a sensor...)

- $C = \begin{bmatrix} 0 & 1 \end{bmatrix}$
- $C = \begin{bmatrix} -1 & 0 \end{bmatrix}$
- $C = \begin{bmatrix} 1 & -1 \end{bmatrix}$
- $C = \begin{bmatrix} 1 & 0 \end{bmatrix}$
- $C = \begin{bmatrix} 1 & 1 \end{bmatrix}$

Correct
Notice that an A-matrix is given in the question. Then, check for which (A, C) pair is observable, i.e., ensures that the sensors collect enough information for the state to be figured out (possibly through an observer).

3. Consider the scalar system

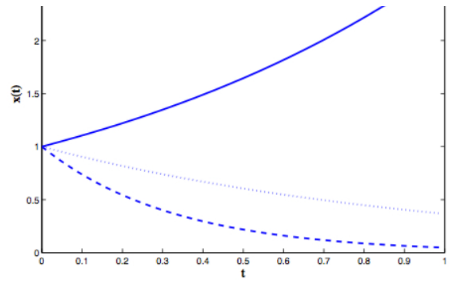
1 / 1 point

$$\dot{x} = 2x + u.$$

We decide to try three different state feedback controllers $u = -k_i x,\ i = 1, 2, 3$, where

$$k_1 = 1,\ \ k_2 = 3,\ \ k_3 = 5.$$

The different closed-loop system behaviors are shown in the figure below. Your job is to identify which feedback controller was used to produce which plot. (The upper trajectory is referred to as ``solid", the middle one as ``dotted", and the lower one as ``dashed".)



- (selected) k_1 solid, k_2 dotted, k_3 dashed
- k_1 dashed, k_2 solid, k_3 dotted
- k_1 dashed, k_2 dotted, k_3 solid
- k_1 dotted, k_2 solid, k_3 dashed
- k_1 solid, k_2 dashed, k_3 dotted

Correct

Plug in each value for k_i to the equation for $\dot{x}$. Then, this question harks back to Quiz 1 and differential equations. Go through and plot a few points (notice that $x(0) = 1$ from the plot) using a discretization of this continuous equation to see approximately how the behavior will vary for each different controller. (For example, if $k_i = 8$, then $\dot{x} = (2 - 8)x = -6x$. So at $t = .1$, $x = 1 + .1 * -6 = .4$.)

4. An attempt at a software implementation of an observer-based feedback controller is given below (in some sort of pseudo-code):

1 / 1 point

% Given: dt (sample time), A,B,C (system matrics), K,L (gains)

% At each iteration, compute the following:

y=read_in_output_value;

u=-K*x_tilde;

send_control_value(u);

x_tilde=update_estimator_value(x_tilde,u,y);

Which of the following versions of

update_estimator_value(x_tilde,u,y)

is correct?

- return x_tilde+A*x_tilde+B*u+L*(y-C*x_tilde);
- return x_tilde+dt*(A*x_tilde+B*u+L*(C*x-C*x_tilde));
- (selected) return x_tilde+dt*(A*x_tilde+B*u+L*(y-C*x_tilde));
- return A*x_tilde+B*u+L*(y-C*x_tilde);
- return A*x_tilde+L*(y-C*x_tilde);

Correct

This question boils down to finding the correct equation for how to numerically approximate the solutions to differential equations (using the Euler approximation). Don't forget which variables you have access to in this situation. You are trying to simulate x!

5. We have seen that when using pole-placement, the larger (in magnitude) the closed-loop eigenvalues are, the faster the response. So why not place all eigenvalues in $-10,000,000,000$ and be done with it? Well, there are problems with making the eigenvalues too large in magnitude.

1 / 1 point

Assume that we are designing a state-feedback, go-to-goal behavior for a mobile robot by stabilizing the system around the goal point using pole-placement. Which of the following is a valid concern when making the eigenvalues too large?

- Modeling errors get amplified by large control gains, which may deteriorate the performance.
- Fast and aggressive maneuvers lead to significant odometric drift.

- The actuators may saturate making the stability analysis invalid.
- (selected) They all are valid concerns.
- Fast and aggressive maneuvers increase the risk of not being able to detect obstacles in the environment quickly enough.

Correct

Think through each option, and review the concepts introduced in lecture. Remember how we achieve desired eigenvalues during pole-placement....