Control Systems - 7 Semester DCSE

Simulation of observer-based state feedback controller

December 13, 2024

Controller Design Techniques

Recalling again, we know that there are 3 types of techniques to design controllers which are:

- Full-state feedback controller or state feedback controller
- Observer-based state feedback controller
- PID Controller

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We have studied (and then simulated) the design of full-state feedback controller and its pre-requisites.

Today, we will simulate observer-based state feedback controller.

Example

Check whether do we need to design a controller for the following system:

$$\begin{bmatrix} \frac{dx_1}{dt} \\ \frac{dx_2}{dt} \end{bmatrix} = \begin{bmatrix} 2 & 3 \\ 0 & 5 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 2 \end{bmatrix} u(t)$$

$$y = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

If we need a controller, identify which controller to design, and then design it and place the eigenvalues at $(-3, -5)$. If you need observer, then place observer eigen values at $(-10, -20)$.

Solution - Do we need a controller

First, we check stability of this system. The MATLAB code is as follows:

```
clear;

clc;

A=[2 3; 0 5 ];

disp('The eigenvalues of matrix A are')

eig(A)
```

Solution - Which controller to design

Now, which controller to choose?

$$\begin{bmatrix} \frac{dx_1}{dt} \\ \frac{dx_2}{dt} \end{bmatrix} = \begin{bmatrix} 2 & 3 \\ 0 & 5 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 2 \end{bmatrix} u(t)$$

$$y = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

Solution - Which controller to design

Now, which controller to choose?

$$\begin{bmatrix} \frac{dx_1}{dt} \\ \frac{dx_2}{dt} \end{bmatrix} = \begin{bmatrix} 2 & 3 \\ 0 & 5 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 2 \end{bmatrix} u(t)$$
$$y = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

As matrix C is NOT identity matrix, we proceed to design of observer based state feedback controller and check the next 2 pre-requisites.

Solution - Pre requisites Computations

```
A=[2 3; 0 5 ];

B=[1; 2];

C=[1 0];

P=[B A*B];

Q=[C; C*A];

disp('The rank of matrix P is ')

rank(P)

disp('The rank of matrix Q is ')

rank(Q)
```

Solution - Design of controller using MATLAB

```
desired_ob_egnvalues=[-10 -20];

L=place(A',C',desired_ob_egnvalues)'
```

```
desired_egnvalues=[-3 -5];

K=place(A,B,desired_egnvalues)
```

Solution - Constructing the observer based controller

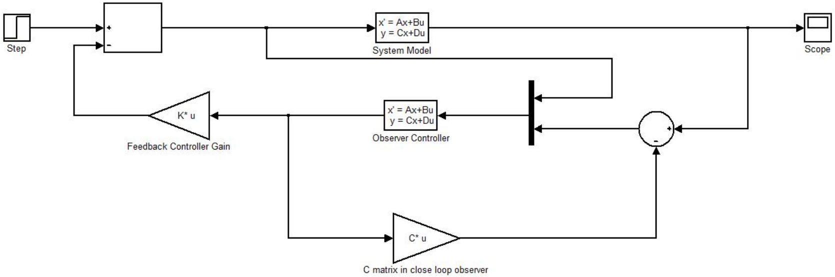

Figure: Schematic of observer based state feedback controller

Solution - Constructing the observer based controller

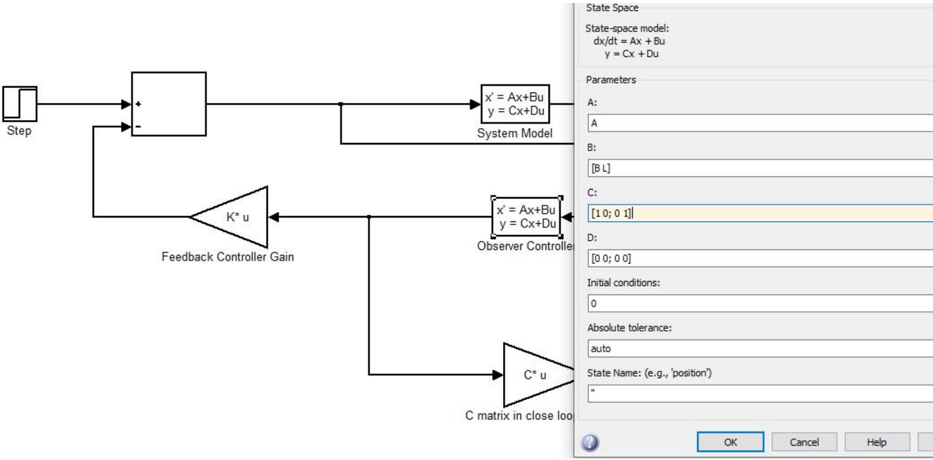

Figure: Putting values in observer block

Solution - Constructing the observer based controller

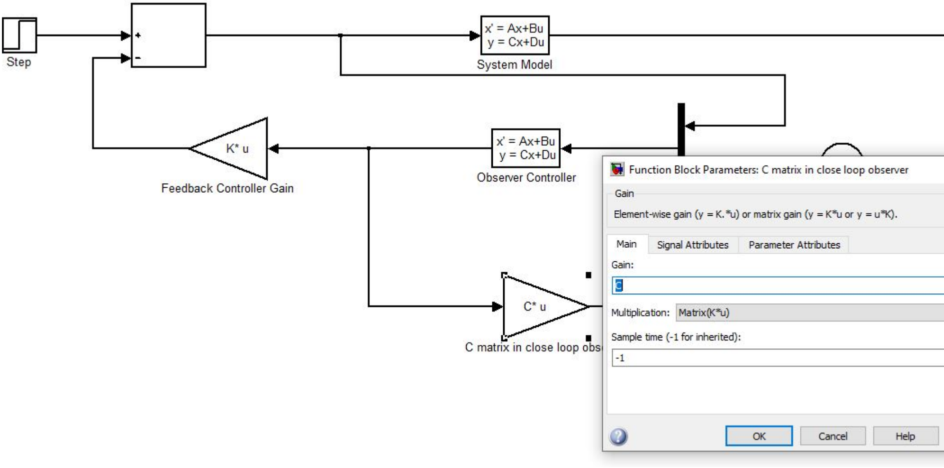

Figure: Putting values in feedback gain block of observer

Solution - Constructing the observer based controller

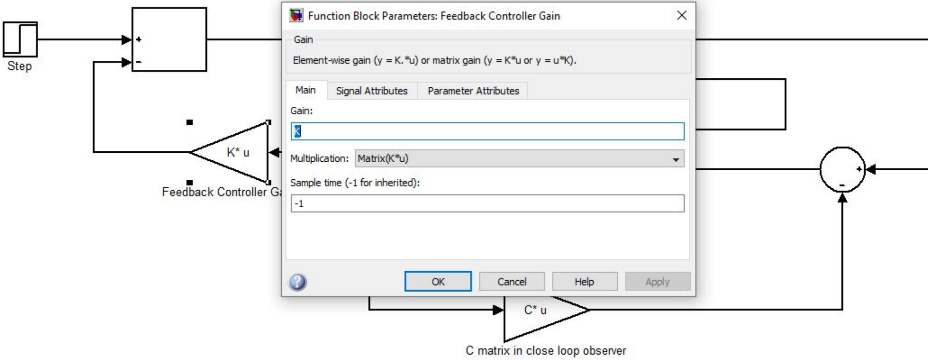

Figure: Substituting values in feedback controller block