ECSE 403 lab assignment
Fall 2018 , assignment 5
Instructor: Prof. P. E. Caines
Due 30^{th} November 2018

Lab TA: Borna Sayedana

1 Objective

The main goal of this assignment is to design and implement controller for inverted pendulum system using state feedback controller and dominant pole method.

2 Your responsibility

Your responsibility is to answer all questions which have been asked throughout this assignment and submit all your answers in addition to Matlab codes and Simulink results.

3 Questions

1. Using the linearized model introduced in previous lab, and coefficients in the lab manual, find matrices A, B, C, D of state space representation of the system, and define them in matlab.
2. Using matlab find the transfer function of the system.
3. Using system's transfer function and the command *pzmap*, find the place of poles of the system. Is the system stable?
4. Using *eig(A)* compare the place of eigen values of matrix A with poles of the system.
5. Check, whether or not your system is controllable.

6. Describe whether or not we should check observability conditions.
7. Choose your design parameters (maximum overshoot and settling time), determine the place of two dominant poles of your desired system using following set of equations.

$$P_{D_1,D_2} = \zeta.\omega_n \pm \omega_n\sqrt{1-\zeta^2}$$
$$t_s = \frac{3.9}{\zeta.\omega_n}$$
$$\zeta = \sqrt{\frac{\ln(M_p)^2}{\pi^2 + \ln(M_p)^2}}$$

8. Using the place of dominant poles, determine the place of non-dominant poles of your desired system.(choose non-dominant poles 5 to 15 times further than dominant poles from the origin.)
9. Using the command *place*, find state feedback gains.
10. Using calculated gains, implement a state feedback controller in the Simulink for the physical system which uses cart's position, cart's velocity, angel of pendulum, and angular velocity. (**Hint**: You should use low pass filter after derivative blocks).
11. Using the switch block in Simulink, design a mechanism to disconnect the controller when the angle exceeds 10°.
12. Is your system able to stabilize pendulum around zero degree? If not, change your design parameters and iterate over the steps until you achieve a proper controller.
13. You can fine tune your controller(manually), if you don't change a gain by more than 5% of its initial value.
14. Include all of the gains and parameters of your final controller. Using the scope, show the performance of your controller. (and all four states)
15. Changing each of the 4 different gains individually, describe intuitively the effect of each of these gains on the performance of your controller.