

Project 1:
 Course Value: 250 points

Deadline: April 15, 2011

Fuzzy stick balancing.

a) [200 points] Design a fuzzy controller to balance the inverted pendulum. Pay careful attention to the coordinate definitions shown in the figure below, these are used in the Simulink model. Ignore the disk position dynamics for this part. Demonstrate that you can stabilize the virtual dynamics included in the simulink file: Provide plots of all four plant states, and the control effort.

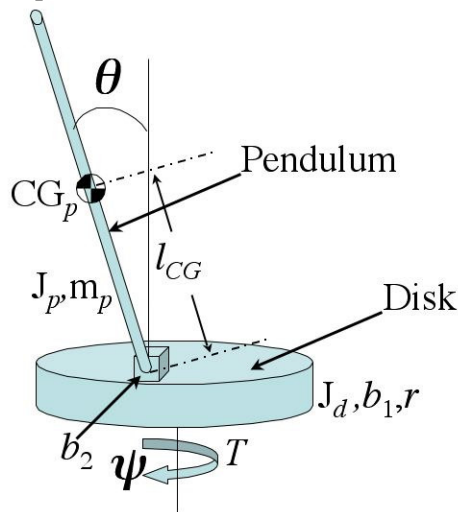


Figure 1: Furuta Pendulum

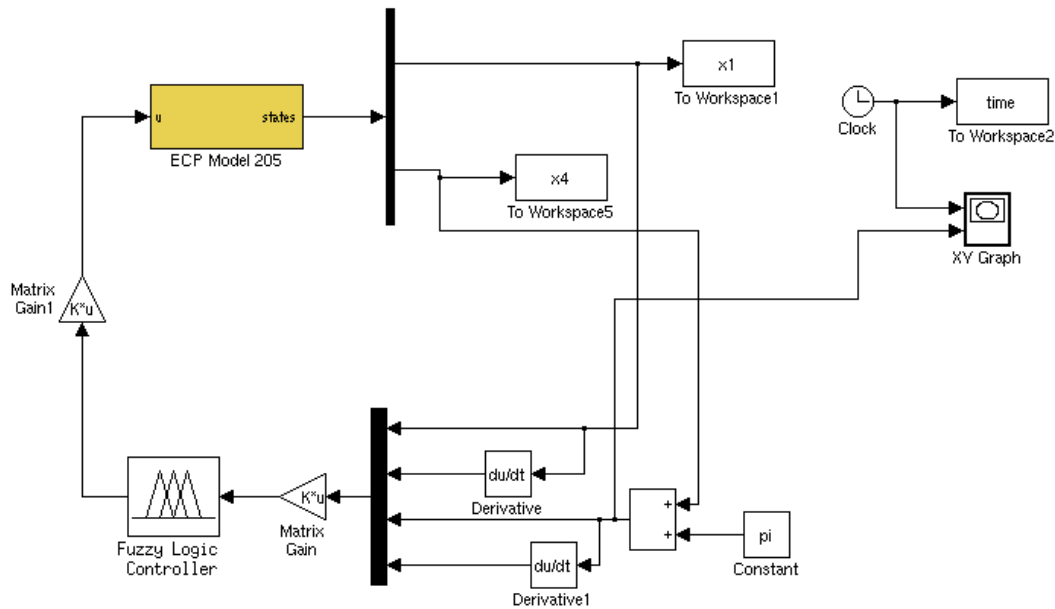


Figure 2: Furuta-Pendulum Simulink Laboratory Configuration

b) [25 points] Add disk position control to your stick balancing fuzzy controller. Demonstrate stability and improved disk position tracking on the simulink model. Provide plots of all four plant states, and the control effort.

c) [25 points] Implement your solution to parts a) and b) on the hardware in C-116. Provide plots of the hardware response compared to the model response. Position the disk (cart) and pendulum at zero (vertical hanging position) and run `ecpdspresetmdl`. In the model 'fuzzyrip.mdl' connect to target. Now lift the pendulum to the vertical inverted pendulum. Have your lab partner start the simulation (play button), and release the pendulum.

HINTS: If you use all four system states as inputs to your fuzzy controller, and allocate five membership functions to each input state, a 'full' rule set would consist of $5^4 = 625$ rules. This would be daunting, and frankly overkill. Part a) can be satisfied with 25 rules, considering only θ and $\dot{\theta}$ as inputs. If you consider the solution to part b) a 'separate' fuzzy controller, and try to limit the number of relevant inputs, you should be able to improve cart position tracking using 25 to 125 additional rules (less would be better from the standpoint of elegance and computational efficiency). Take advantage of the Fuzzy control property of automatically balancing conflicting objectives by designing a) and b) separately and implementing them simultaneously. The master's thesis "Three-Input Fuzzy Controller for a Cart and Inverted Pendulum System", by Hui Zhao is available at the library. You might find it helpful for parts a) and b) although the system used was the 'large scale' pendulum, and the sign conventions are different than those used in our model.

Be sure to iterate your design on Simulink only. I will provide a simulink model of the linearized pendulum dynamics in inverted mode. A snapshot of the model appears below.

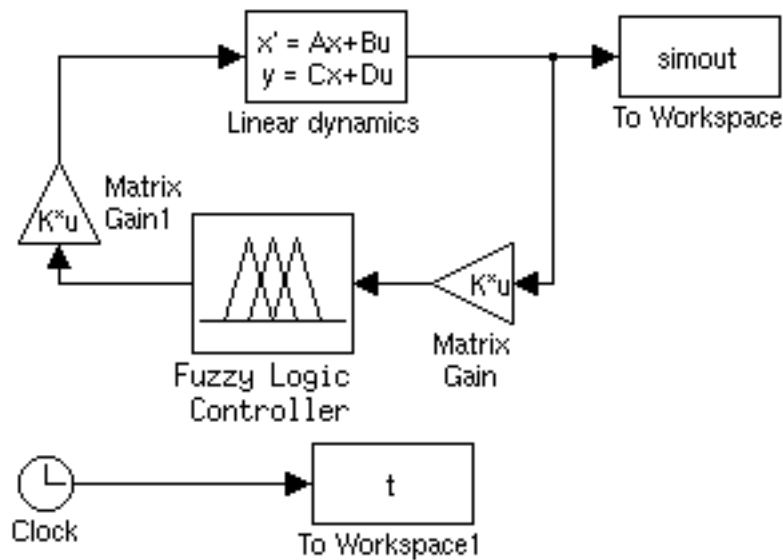


Figure 3: Simulink Model of Furuta Pendulum.