CSE 4360/5364 - *Autonomous Robots*

Homework 2- Fall 2023

Due Date: 5:30pm, Oct. 10, 2023

Problems marked with * are mandatory only for students of CSE 5364 but will be graded for extra credit for students of CSE 4360.

Dynamics and Control

In this exercise you are going to perform system identification and implement a PD controller for a 1 degree-of-freedom robot manipulator.
Again you are provided with a C library containing a dynamic simulator and a file in which you should implement the controller. For this part of the assignment, download the corresponding code and uncompress it. The subdirectory *dyn* contains the following files:

Imakefile This file is used to create a machine specific Makefile by typing *xmkmf*.

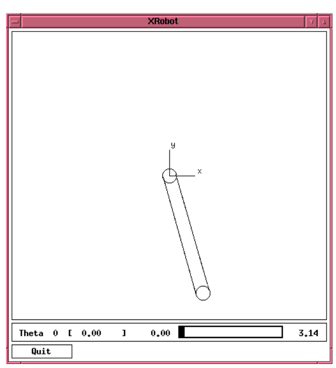
PD_control.c This is the file you have to edit in order to implement the controller and to perform the experiments required for system identification.

lib/libDyn.a This library contains the dynamic simulator.

In the file *PD_control.c* make sure that you fill in the *UTA_ID* variable with your UTA student ID number. The solution you will obtain depends on this number and thus submissions using a different a ID number will likely yield wrong answers. We will not accept answers derived from an incorrect student ID number.

The Dynamic Simulator

To generate the simulator you have to type *make*. This creates the simulator executable *Dynamics*. The simulator looks as follows:



The Slider on the bottom allows you to set the reference angle configuration for your controller (the reference velocity is always set to 0).

1. Determine the dynamic parameters of the robot.

   Here you are supposed to perform system identification to determine the parameters required later to perform model compensation in your PD control loop. The dynamic model of this single joint manipulator has the form

   $\tau = I\ddot{\Theta} + B\dot{\Theta} + G(\Theta)$

   These are caused by the inertia of the arm (I), the viscous friction in the joint (B) and by gravity (G).

   To determine these elements of the dynamics you have to perform experiments with the simulated robot. Your interface here is given in the function *PD_control()* which receives all relevant information from the robot system and is called at a rate of $500Hz$.

```
double PD_control(theta, theta_dot, theta_ref, theta_dot_ref)
double theta, theta_dot, theta_ref, theta_dot_ref;
{
...
return(...);
}
```

   This function receives the current joint angle (*theta*), the corresponding rotational velocity (*theta_dot*), the desired reference angle (*theta_ref*) set using the slider, and the reference velocity (*theta_dot_ref*). The output of this function should be the amount of torque you want to apply to the joint.

   (HINT: To perform system identification you want to collect this data and analyze it in order to determine the system parameters).

   For this part of the assignment you should hand in the system parameters found as well as a description of the method used to determine them.

2.* Implement a PD controller with model compensation for the 1 degree-of-freedom robot.

   Using the parameters found above you should implement a PD controller with model compensation for this robot. Use of the model will give the system the appearance of a unit-mass system without friction or gravity and critically damped behavior should therefore be achieved by a choice of gains where $K_v = 2\sqrt{K_p}$.

   For this part of the assignment you have to hand in the controller code you implemented in the function *PD_control* in the file *PD_control.c*.