Experimental Robotics (CS225A) Homework #1

(Spring 2016/2017) Due: **Tuesday, April 18**

In this homework assignment, you will implement joint space control for the PUMA and experiment with control gains in simulation.

To download the assignment, you'll have to pull the latest updates from `cs225a-dist.git`. If you want to keep your progress from HW0, first call `git status` to see what files you've modified, and then call `git add <filename>` for all the files you want to save (at this point, you'll probably only want to keep `src/hw0/hw0.cpp`). Next call `git commit -m "Your commit message here"` to commit the changes to these files. For the rest of the files you don't care about, call `git stash` to revert them back to the original version (if you ever decide you want to bring back the modified files, you can call `git stash pop`). At this point, `git status` should show no modified files (untracked files are fine).

Now, you are ready to download the assignment. Call `git pull`. This will likely ask you to save a commit message for merging `cs225a.git` with your local repository - you can simply save and exit. If there were merging issues, you'll have to go into the problem files, manually fix the merging, and then commit those changes again. Now you're ready to start Homework 1!

1. Let the joint positions and velocities of the robot be given by q and $\dot{q}$, respectively. Let q_d be the desired position of the robot. Implement the joint space control law:

$$\Gamma = k_p(q_d - q) - k_v\dot{q}$$

   where k_p and k_v are your control gains.

   (a) Tune your gains to achieve critical damping with $k_p = 400$ and report your chosen k_v.

   (b) Move the robot from its initial configuration to $q_d = (0.5, 0.5, 0.5, 0.5, 0.5, 0.5)$ and plot the joint trajectory, as well as the end effector trajectory in Cartesian space. Why do some joints converge closer to the desired position than others?

2. Now, implement the joint space control law:

$$\Gamma = k_p(q_d - q) - k_v\dot{q} + g(q)$$

   where $g(q)$ is the joint space gravity compensation vector.

   (a) Tune your gains to achieve critical damping with $k_p = 400$ and report your chosen k_v.

   (b) Again, move the robot from its initial configuration to $q_d = (0.5, 0.5, 0.5, 0.5, 0.5, 0.5)$ and plot the joint trajectory, as well as the end effector trajectory in Cartesian space. Compare these plots to the ones in Problem 1.

3. Now, implement the joint space control law that takes into account the dynamics of the robot:

$$\Gamma = A(q)(k_p(q_d - q) - k_v\dot{q}) + g(q)$$

   where $A(q)$ is the joint space mass matrix.

   (a) Tune your gains to achieve critical damping with $k_p = 400$ and report your chosen k_v.

(b) Again, move the robot from its initial configuration to $q_d = (0.5, 0.5, 0.5, 0.5, 0.5, 0.5)$ and plot the joint trajectory, as well as the end effector trajectory in Cartesian space. Compare these plots to the ones in Problem 2.

4. Attach your SAI code here.