EECS 489, Spring 2012

Problem Set 6: Tracking Control

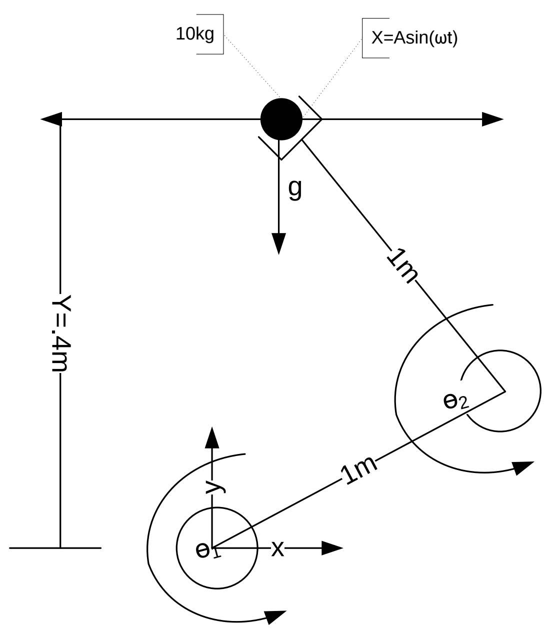
Due 4/24/12

Consider a 2 link planar robot with the following DH parameters:

a	α	d	ϴ
1	0	0	Θ_1
1	0	0	Θ_2

For simplicity, we will model the robot's inertia (including payload) as constant and diagonal, and we will ignore centrifugal and Coriolis effects. (This approximation may hold if the inertias of the motors, reflected through a high transmission ratio, dominate the total inertia). Assume an inertia matrix of: $H = \begin{bmatrix} 10 & 0 \\ 0 & 5 \end{bmatrix}$.

We have attached a 2kg mass to the end effecter and would like to wave this mass along a straight line in a sinusoidal fashion with $x(t) = 0.5\cos\omega t$:



The arm dynamics can be modeled as: $\tau = H \cdot \ddot{q} + g(q)$ where τ is a vector of motor torques, H is the diagonal matrix inertia tensor (specified above) and g is the gravity load on each joint. Assume that the only contribution to g(q) is the payload (with force of weight acting in the –y direction).

When we turn the robot on, the end effector will be at $\underline{X} = \begin{bmatrix} 0.5 \\ 0.4 \end{bmatrix}$ and $\dot{\underline{X}} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$

To simplify your task, a dynamic simulation of the robot has been provided. Functions are provided for desired hand motion, forward and inverse kinematics, Jacobian computations and gravity-load computation. Your task is to write variations on the function:

```
function tau= controller(H, DH, qdes, qdot_des, qddot_des, q, qdot)
```
and evaluate its performance.

1) Feedforward controller:

Use a controller of the form: $\tau(t) = GravityCompensate(t) + \ B \cdot \ddot{q}_{des}(t)$

Run the simulation at omega=1. Include plots of the results (per the providing plotting functions).

2) Feedback controller:

Use a controller of the form: $\tau = K_p \cdot \left(q_{des}(t) - q(t)\right) + K_v \cdot (\dot{q}_{des}(t) - \dot{q}(t))$ Recommend maximum values for Kp and Kv. Can you make the robot track y=0.4 within 1mm? If so, up to what frequency of omega?

3) Feedback plus Feedforward controller:

Use a controller of the form:
$\tau = K_p \cdot \left(q_{des}(t) - q(t)\right) + K_v \cdot \left(\dot{q}_{des}(t) - \dot{q}(t)\right) + GravityCompensate(q) + B \cdot \ddot{q}_{des}(t).$

Recommend values of Kp and Kv. Can you make the robot hand track y=0.4 within 1mm? If so, up to what frequency of omega?

Include your controller code with your solution.

Include plots of your best results (e.g. tracking to within 1mm at max frequency). Comment on values of Kp, Kv, omega and performance