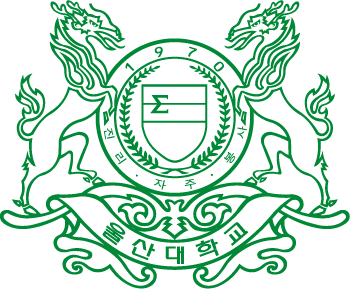
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| **R E P O R T** | |
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| **학 과** | **전기전자정보시스템공학전공** |
| **교수님 (Professor)** | **KANG, HEE-JUN 교수님** |
| **학 번 (Student ID)** | **20175308** |
| **이 름 (Name)** | **La Phuong Ha** |
| **제출일 (Times)** | **20191201** |



La Phuong Ha – ID: 20175308 – Assignment 6: Robot Manipulators

ECCL | #7-429 | Email: [laphuongha@gmail.com](mailto:laphuongha@gmail.com)

1. The trajectory planning

Matlab code:

%% Initial conditions:

m1 = 10;

m2 = 5;

l1 = 0.5;

l2 = 0.5;

%% Trajectory planning

tf = 1;

theta1\_0 = pi/6;

theta1\_f = 5\*pi/6;

dtheta1\_0 = 0;

dtheta1\_f = 0;

theta2\_0 = 5\*pi/6;

theta2\_f = pi/6;

dtheta2\_0 = 0;

dtheta2\_f = 0;

a10 = theta1\_0;

a11 = dtheta1\_0;

a12 = (3/tf^2)\*(theta1\_f - theta1\_0) - (2/tf)\*dtheta1\_0 - (2/tf)\*dtheta1\_f;

a13 = -(2/tf^3)\*(theta1\_f - theta1\_0) + (1/tf^2)\*(dtheta1\_f + dtheta1\_0);

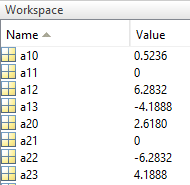
a20 = theta2\_0;

a21 = dtheta2\_0;

a22 = (3/tf^2)\*(theta2\_f - theta2\_0) - (2/tf)\*dtheta2\_0 - (2/tf)\*dtheta2\_f;

a23 = -(2/tf^3)\*(theta2\_f - theta2\_0) + (1/tf^2)\*(dtheta2\_f + dtheta2\_0);

The output of the code:



1. The PD control simulation.

Matlab code:

% PD Simulation

ts = 1e-3; % Sampling time

Ns = tf/ts;

theta1 = zeros(1,Ns+1);

theta2 = zeros(1,Ns+1);

dtheta1 = zeros(1,Ns+1);

dtheta2 = zeros(1,Ns+1);

% Initial state

theta1(1) = theta1\_0;

theta2(1) = theta2\_0;

dtheta1(1) = 0;

dtheta2(1) = 0;

g = 9.8;

for k = 1:1:Ns

th1r = a10 + a11\*(k-1)\*ts + a12\*((k-1)\*ts)^2 + a13\*((k-1)\*ts)^3;

dth1r = a11 + 2\*a12\*((k-1)\*ts) + 3\*a13\*((k-1)\*ts)^2;

th2r = a20 + a21\*(k-1)\*ts + a22\*((k-1)\*ts)^2 + a23\*((k-1)\*ts)^3;

dth2r = a21 + 2\*a22\*((k-1)\*ts) + 3\*a23\*((k-1)\*ts)^2;

M11 = l2^2\*m2 + 2\*l1\*l2\*m2\*cos(theta2(k)) + l1^2\*(m1+m2);

M12 = l2^2\*m2+l1\*l2\*m2\*cos(theta2(k));

M21 = M12;

M22 = l2^2\*m2;

M = [M11 M12; M21 M22];

V1 = - m2\*l1\*l2\*sin(theta2(k))\*dtheta2(k)^2 ...

- 2\*m2\*l1\*l2\*sin(theta2(k))\*dtheta1(k)\*dtheta2(k);

V2 = m2\*l1\*l2\*g\*sin(theta2(k))\*dtheta1(k)^2;

V = [V1;V2];

G1 = m2\*l2\*g\*cos(theta1(k)+theta2(k)) + (m1+m2)\*l1\*g\*cos(theta1(k));

G2 = m2\*l2\*g\*cos(theta1(k)+theta2(k));

G = [G1;G2];

tau = [0;0];

% Controller

Kp = diag([300;300]);

Kd = diag([60;60]);

tau = Kp\*[th1r - theta1(k); th2r - theta2(k)] ...

+ Kd\*[dth1r - dtheta1(k); dth2r - dtheta2(k)];

f1 = [dtheta1(k); dtheta2(k)];

f2 = inv(M)\*(tau - V - G);

[t,x] = ode45(@(t,x) [f1;f2], [(k-1)\*ts, k\*ts], ...

[theta1(k);theta2(k);dtheta1(k);dtheta2(k)]);

theta1(k+1) = x(max(size(x)),1);

theta2(k+1) = x(max(size(x)),2);

dtheta1(k+1) = x(max(size(x)),3);

dtheta2(k+1) = x(max(size(x)),4);

end

%Plot the results

subplot(2,2,1);

plot(0:1:Ns,theta1);

xlabel('Ns');

ylabel('theta1');

grid on

subplot(2,2,2);

plot(0:1:Ns,theta2);

xlabel('Ns');

ylabel('theta2');

grid on

subplot(2,2,3);

plot(0:1:Ns,dtheta1);

xlabel('Ns');

ylabel('dtheta1');

grid on

subplot(2,2,4);

plot(0:1:Ns,dtheta2);

xlabel('Ns');

ylabel('dtheta2');

grid on

Output of Matlab:



c. PD + gravity controller

Matlab Code

% PD Simulation

Same with section b

% Initial state

Same with section b

% Controller

Kp = diag([300;300]);

Kd = diag([60;60]);

tau = Kp\*[th1r - theta1(k); th2r - theta2(k)] ...

+ Kd\*[dth1r - dtheta1(k); dth2r - dtheta2(k)] + G;

f1 = [dtheta1(k); dtheta2(k)];

f2 = inv(M)\*(tau - V - G);

[t,x] = ode45(@(t,x) [f1;f2], [(k-1)\*ts, k\*ts], ...

[theta1(k);theta2(k);dtheta1(k);dtheta2(k)]);

theta1(k+1) = x(max(size(x)),1);

theta2(k+1) = x(max(size(x)),2);

dtheta1(k+1) = x(max(size(x)),3);

dtheta2(k+1) = x(max(size(x)),4);

end

%plot the results

Same with section b

Output of Matlab:



d. Computed torque control simulation

Matlab code:

% PD Simulation

Same with section b

% Initial state

Same with section b

% Controller

Kp = diag([300;300]);

Kd = diag([60;60]);

ddth1r = 2\*a12 + 6\*a13\*((k-1)\*ts);

ddth2r = 2\*a22 + 6\*a23\*((k-1)\*ts);

ddth = [ddth1r;ddth2r];

tau = M\*(ddth + Kp\*[th1r - theta1(k); th2r - theta2(k)]...

+ Kd\*[dth1r - dtheta1(k); dth2r - dtheta2(k)]) + V + G;

f1 = [dtheta1(k); dtheta2(k)];

f2 = inv(M)\*(tau - V - G);

[t,x] = ode45(@(t,x) [f1;f2], [(k-1)\*ts, k\*ts], ...

[theta1(k);theta2(k);dtheta1(k);dtheta2(k)]);

theta1(k+1) = x(max(size(x)),1);

theta2(k+1) = x(max(size(x)),2);

dtheta1(k+1) = x(max(size(x)),3);

dtheta2(k+1) = x(max(size(x)),4);

end

%plot the results

Same with section b

Output of Matlab

