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**Homework #3**

*Mechanics and Control of Robot Manipulators*

Program Forward Kinematics for Puma 560 Robots using Matlab.

Diagram

Description automatically generated

Choose [a2, a3, d3, d4] as [1 0.3 0.5 1] and 6PT = [0 0 0.3]T.

1. When θ1 = 30o, θ2 = 30o, θ3 = 30o, θ4 = 30o, θ5 = 30o, θ6 = 30o, find .

Matlab code:

clear all;

clc;

%DH parameter

alpha = [0 -90 0 -90 90 -90] ; %link twist

a = [0 0 1 0.3 0 0]; %link length

d = [0 0 0.5 1 0 0]; %link offset

theta = [30 30 30 30 30 30]; % joint variable

P6\_T = [0 0 0.3 1];

%Apply forward kinematics joints

T = [];

for n = 1:6

matT = [cosd(theta(n)) -sind(theta(n)) 0 a(n);

sind(theta(n))\*cosd(alpha(n)) cosd(theta(n))\*cosd(alpha(n)) -sind(alpha(n)) -sind(alpha(n))\*d(n);

sind(theta(n))\*sind(alpha(n)) cosd(theta(n))\*sind(alpha(n)) cosd(alpha(n)) cosd(alpha(n))\*d(n);

0 0 0 1];

T = [T; {matT}];

end

T0\_6 = T{1}\*T{2}\*T{3}\*T{4}\*T{5}\*T{6}

P0\_T = T0\_6.\*P6\_T

The result of T0\_6.

Graphical user interface, text

Description automatically generated

And the result of P0\_T.

A picture containing table

Description automatically generated

1. Find 8 sets of solutions from Inverse Kinematics with the . Confirm that one of 8 solution sets is the joint angle set in a).

Matlab code.

%calulate T0\_T, T06 with the code in a.

%problem b: 8 set parameter

px = T0\_6(1,4);

py = T0\_6(2,4);

pz = T0\_6(3,4);

r = T0\_6(1:3,1:3);

th = zeros(6,8);

th(1,1:4) = atan2d(px,py) - atan2d(d(3), sqrt(px^2 + py^2 -d(3)^2));

th(1,5:8) = atan2d(py,px) - atan2d(d(3), sqrt(px^2 + py^2 -d(3)^2));

K = (px^2 + py^2 + pz^2 - a(2)^2 - a(3)^2 - d(3)^2 - d(4)^2)/(2\*a(2));

th(3,[1,2,5,6]) = atan2d(a(3),d(4)) - atan2d(K, sqrt(a(3)^2 + d(4)^2 + K^2));

th(3,[3,4,7,8]) = atan2d(a(3),d(4)) - atan2d(K, -sqrt(a(3)^2 + d(4)^2 + K^2));

th23 = atan2d((-a(3)-a(2)\*cosd(th(3,:)))\*pz + (cosd(th(1,:))\*px + sind(th(1,:))\*py).\*(d(4)-a(2)\*sind(th(3,:))),(a(2)\*sind(th(3,:))-d(4))\*pz+(a(3)+a(2)\*cosd(th(3,:))).\*(cosd(th(1,:))\*px + sind(th(1,:))\*py));

th(2,:) = th23 - th(3,:);

th(4,:) = atan2d(-r(1,3)\*sind(th(1,:))+r(2,3)\*cosd(th(1,:)),-r(1,3)\*cosd(th(1,:)).\*cosd(th23) + r(3,3)\*sind(th23));

s5 = -r(1,3)\*(cosd(th(1,:)).\*cosd(th23).\*cosd(th(4,:)) + sind(th(1,:)).\*sind(th(4,:))) - r(2,3)\*(sind(th(1,:)).\*cosd(th23).\*cosd(th(4,:)) - cosd(th(1,:)).\*sind(th(4,:))) + r(3,3)\*sind(th23).\*cosd(th(4,:));

c5 = -r(1,3)\*cosd(th(1,:)).\*sind(th23) - r(2,3)\*sind(th(1,:)).\*sind(th23) - r(3,3)\*cosd(th23);

th(5,:) = atan2d(s5,c5);

s6 = -r(1,1)\*(cosd(th(1,:)).\*cosd(th23).\*sind(th(4,:)) - sind(th(1,:)).\*cosd(th(4,:))) - r(2,1)\*(sind(th(1,:)).\*cosd(th23).\*sind(th(4,:)) + cosd(th(1,:)).\*cosd(th(4,:))) + r(3,1)\*sind(th23).\*sind(th(4,:));

c6 = r(1,1)\*((cosd(th(1,:)).\*cosd(th23).\*cosd(th(4,:)) + sind(th(1,:)).\*sind(th(4,:))).\*cosd(th(5,:)) - cosd(th(1,:)).\*sind(th23).\*sind(th(5,:))) + r(2,1)\*((sind(th(1,:)).\*cosd(th23).\*cosd(th(4,:)) - cosd(th(1,:)).\*sind(th(4,:))).\*cosd(th(5,:)) - sind(th(1,:)).\*sind(th23).\*sind(th(5,:))) - r(3,1)\*(sind(th23).\*cosd(th(4,:)).\*cosd(th(5,:)) + cosd(th23).\*sind(th(5,:)));

th(6,:) = atan2d(s6,c6);

th(4,[2 4 6 8]) = th(4,[2 4 6 8]) + pi;

th(5,[2 4 6 8]) = -th(5,[2 4 6 8]);

th(6,[2 4 6 8]) = th(6,[2 4 6 8]) + pi;

th

The result is obtained.

Text

Description automatically generated