

Jacobian

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clear all; close all; clc;

% Symbolic Expressions
syms t1 t2 t3 t4 t5 t6 a2 a3 d2 d3 d4

DH = [
    0      0      0      t1;      %alpha, a, d, theta
    -pi/2   0      d2     t2;
    0      a2      d3     t3;
    pi/2    a3      d4     t4;
    -pi/2   0      0      t5;
    pi/2    0      0      t6
]

T_01 = transformationMatrix(DH(1,:));
T_12 = transformationMatrix(DH(2,:));
T_23 = transformationMatrix(DH(3,:));
T_34 = transformationMatrix(DH(4,:));
T_45 = transformationMatrix(DH(5,:));
T_56 = transformationMatrix(DH(6,:));

T_06 = T_01*T_12*T_23*T_34*T_45*T_56;
simplify(T_06)

[R_01, P_01] = tr2rt(T_01); R_10 = transpose(R_01);
[R_12, P_12] = tr2rt(T_12); R_21 = transpose(R_12);
[R_23, P_23] = tr2rt(T_23); R_32 = transpose(R_23);
[R_34, P_34] = tr2rt(T_34); R_43 = transpose(R_34);
[R_45, P_45] = tr2rt(T_45); R_54 = transpose(R_45);
[R_56, P_56] = tr2rt(T_56); R_65 = transpose(R_56);
[R_06, P_06] = tr2rt(T_06); R_60 = transpose(R_06);

T_02 = T_01*T_12;
T_03 = T_02*T_23;
T_04 = T_03*T_34;
T_05 = T_04*T_45;
T_06 = T_05*T_56;
[R_02, P_02] = tr2rt(T_02); R_20 = transpose(R_02);
[R_03, P_03] = tr2rt(T_03); R_30 = transpose(R_03);
[R_04, P_04] = tr2rt(T_04); R_40 = transpose(R_04);
[R_05, P_05] = tr2rt(T_05); R_50 = transpose(R_05);

J0_DD = sym(zeros(6,3));
J0_DD(:,1) = [cross(R_01(:, 3), (P_06 - P_01));R_01(:,3)];
J0_DD(:,2) = [cross(R_02(:, 3), (P_06 - P_02));R_02(:,3)];
J0_DD(:,3) = [cross(R_03(:, 3), (P_06 - P_03));R_03(:,3)];
J0_DD(:,4) = [cross(R_04(:, 3), (P_06 - P_04));R_04(:,3)];
J0_DD(:,5) = [cross(R_05(:, 3), (P_06 - P_05));R_05(:,3)];
J0_DD(:,6) = [cross(R_06(:, 3), (P_06 - P_06));R_06(:,3)];
J0_DD = simplify(J0_DD)

J0_det = det(J0_DD)

simplify(J0_det)

function [T] = transformationMatrix(DH_row)

    T = [cos(DH_row(4))      -sin(DH_row(4))      0      DH_row(2);
        sin(DH_row(4))*cos(DH_row(1))  cos(DH_row(4))*cos(DH_row(1))  -sin(DH_row(1))  -sin(DH_row(1))*DH_row(3);
        sin(DH_row(4))*sin(DH_row(1))  cos(DH_row(4))*sin(DH_row(1))  cos(DH_row(1))  cos(DH_row(1))*DH_row(3);
        0      0      0      1];
end

DH =

[ 0, 0, 0, t1]
[-pi/2, 0, d2, t2]
[ 0, a2, d3, t3]
[ pi/2, a3, d4, t4]
[-pi/2, 0, 0, t5]
[ pi/2, 0, 0, t6]

ans =

[- sin(t6)*(cos(t4)*sin(t1) - sin(t4)*(cos(t1)*sin(t2)*sin(t3) - cos(t1)*cos(t2)*cos(t3))) - cos(t6)*(cos(t5)*(sin(t1)*sin(t4) + cos(t4)*(cos(t1)*sin(t2)*sin(t3) -
[ sin(t6)*(cos(t1)*cos(t4) + sin(t4)*(sin(t1)*sin(t2)*sin(t3) - cos(t2)*cos(t3)*sin(t1))) + cos(t6)*(cos(t5)*(cos(t1)*sin(t4) - cos(t4)*(sin(t1)*sin(t2)*sin(t3) -
[
[
sin(
```

```
J0_DD =  
  
[a3*(sin(t1)*sin(t2)*sin(t3) - cos(t2)*cos(t3)*sin(t1)) - d4*(cos(t2)*sin(t1)*sin(t3) + cos(t3)*sin(t1)*sin(t2)) - d2*cos(t1) - d3*cos(t1) - a2*cos(t2)*sin(t1), -co  
[d4*(cos(t1)*cos(t2)*sin(t3) + cos(t1)*cos(t3)*sin(t2)) - a3*(cos(t1)*sin(t2)*sin(t3) - cos(t1)*cos(t2)*cos(t3)) - d2*sin(t1) - d3*sin(t1) + a2*cos(t1)*cos(t2), -si  
[  
[  
[  
[
```

```
J0_det =  
  
- a2^2*a3*sin(t2 + t3)^3*cos(t1)^4*cos(t2)^2*cos(t4)^2*sin(t5) - a2^2*a3*sin(t2 + t3)^3*cos(t2)^2*cos(t4)^2*sin(t1)^4*sin(t5) - a2^2*a3*sin(t2 + t3)^3*cos(t1)^4*cos
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```
ans =  
  
a2*sin(t5)*((a3^2*sin(t2))/2 + (d4^2*sin(t2))/2 - (a3^2*sin(t2 + 2*t3))/2 + (d4^2*sin(t2 + 2*t3))/2 + (a2*d4*cos(t2 - t3))/2 + a3*d4*cos(t2 + 2*t3) + (a2*a3*sin(t2
```