

MATLAB_Exercise_1

Michael White 3/26/2021

```
clear; clc; close all;

% PART A
% Define symbolic parameters
syms theta1 theta2 theta3 L1 L2 L3;

% Define link parameter table
linkParamTable = ...
    [0 0 0 theta1;
     0 L1 0 theta2;
     0 L2 0 theta3];

% PART B
% Identify transformation matrices for each link (I will append the
% functions I use to the end of this pdf)
StepTransforms.Transform_01 = functions.links.Link2Transform(linkParamTable(1,:));
StepTransforms.Transform_12 = functions.links.Link2Transform(linkParamTable(2,:));
StepTransforms.Transform_23 = functions.links.Link2Transform(linkParamTable(3,:));

% The transform to point H requires another row to the parameter table,
% which I will append here:
linkParamTable(4,:) = [0 L3 0 0];

% Take new row and find appropriate transform:
StepTransforms.Transform_3H = functions.links.Link2Transform(linkParamTable(4,:));

% PART C
% For this part, I can use symbolic MATLAB in my functions to solve for the
% symbolic transforms, then substitute the actual functions with the
% replacement symbolics of ci and si with the subs function

% Derive the Transform_03 and Transform_0H
Transform_03.trig = functions.links.Link2Transform(linkParamTable(1:3,:));
Transform_0H.trig = functions.links.Link2Transform(linkParamTable(1:4,:));

% Convert trig functions to simplified syms
syms c1 c2 c3 s1 s2 s3;
Transform_03.simple = subs(Transform_03.trig,...
    [cos(theta1), cos(theta2), cos(theta3),...
     sin(theta1), sin(theta2), sin(theta3)],...
    [c1, c2, c3, s1, s2, s3]);
Transform_0H.simple = subs(Transform_0H.trig,...
    [cos(theta1), cos(theta2), cos(theta3),...
     sin(theta1), sin(theta2), sin(theta3)],...
    [c1, c2, c3, s1, s2, s3]);

% Convert trig combinations from angle sum formula to simplified versions
syms c12 c23 s12 s23;
Transform_03.simple = subs(Transform_03.simple,...
    [c1*c2-s1*s2, c2*c3-s2*s3, c1*s2+s1*c2, c2*s3+s2*c3],...
    [c12, c23, s12, s23]);
Transform_0H.simple = subs(Transform_0H.simple,...
    [c1*c2-s1*s2, c2*c3-s2*s3, c1*s2+s1*c2, c2*s3+s2*c3],...
    [c12, c23, s12, s23]);

% Convert trig combinations from angle sum formula to simplified versions
syms c123 s123;
Transform_03.simple = subs(Transform_03.simple,...
    [c3*c12-s3*s12, c3*s12+s3*c12],...
    [c123, s123]);
Transform_0H.simple = subs(Transform_0H.simple,...
    [c3*c12-s3*s12, c3*s12+s3*c12],...
    [c123, s123]);

% Display results from simplified transforms
disp('The simplified transform 03:'); disp(Transform_03.simple);
disp('The simplified transform 0H:'); disp(Transform_0H.simple);

% Creating quantified transforms for 03 for scenario i, ii, and iii
% Also: converting degrees to radians
Transform_03.i = subs(Transform_03.trig, ...
    [theta1, theta2, theta3, L1, L2, L3], [0 0 0 4 3 2]);
Transform_03.ii = subs(Transform_03.trig, ...
    [theta1, theta2, theta3, L1, L2, L3], [pi*10/180 pi*20/180 pi*30/180 4 3 2]);
Transform_03.iii = subs(Transform_03.trig, ...
    [theta1, theta2, theta3, L1, L2, L3], [pi/2 pi/2 pi/2 4 3 2]);

% Creating quantified transforms for 0H for scenario i, ii, and iii
Transform_0H.i = subs(Transform_0H.trig, ...
    [theta1, theta2, theta3, L1, L2, L3], [0 0 0 4 3 2]);
Transform_0H.ii = subs(Transform_0H.trig, ...
    [theta1, theta2, theta3, L1, L2, L3], [pi*10/180 pi*20/180 pi*30/180 4 3 2]);
Transform_0H.iii = subs(Transform_0H.trig, ...
    [theta1, theta2, theta3, L1, L2, L3], [pi/2 pi/2 pi/2 4 3 2]);
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% Display results for i, ii, and iii
disp('The Transforms for i'); disp(Transform_03.i); disp(Transform_0H.i);
disp('The Transforms for ii'); disp(Transform_03.ii); disp(Transform_0H.ii);
disp('The Transforms for iii'); disp(Transform_03.iii); disp(Transform_0H.iii);

% Plot the 03 and 0H transforms for i
functions.visual.plotTransform(double(Transform_03.i),1);
functions.visual.plotTransform(double(Transform_0H.i),1);
title('Transforms for i');

% Plot the 03 and 0H transforms for ii
functions.visual.plotTransform(double(Transform_03.ii),2);
functions.visual.plotTransform(double(Transform_0H.ii),2);
title('Transforms for ii');

% Plot the 03 and 0H transforms for iii
functions.visual.plotTransform(double(Transform_03.iii),3);
functions.visual.plotTransform(double(Transform_0H.iii),3);
title('Transforms for iii');

% PART D: Testing with Corke (compare these to my 3d plots)
% Scenario i
L01_i = Link('d',0,'a',0,'alpha',0);
L12_i = Link('d',0,'a',4,'alpha',0);
L23_i = Link('d',0,'a',3,'alpha',0);
L3H_i = Link('d',0,'a',2,'alpha',0);
bot_i = SerialLink([L01_i L12_i L23_i L3H_i],'name','Scenario i');
figure;
bot_i.plot([0 0 0 0]); %Looks good!

% Scenario ii
L01_ii = Link('d',0,'a',0,'alpha',0);
L12_ii = Link('d',0,'a',4,'alpha',0);
L23_ii = Link('d',0,'a',3,'alpha',0);
L3H_ii = Link('d',0,'a',2,'alpha',0);
bot_ii = SerialLink([L01_ii L12_ii L23_ii L3H_ii],'name','Scenario ii');
figure;
bot_ii.plot([0 pi/180*10 pi/180*20 pi/180*30]); %Looks good!

% Scenario iii
L01_iii = Link('d',0,'a',0,'alpha',0);
L12_iii = Link('d',0,'a',4,'alpha',0);
L23_iii = Link('d',0,'a',3,'alpha',0);
L3H_iii = Link('d',0,'a',2,'alpha',0);
bot_iii = SerialLink([L01_iii L12_iii L23_iii L3H_iii],'name','Scenario iii');
figure;
bot_iii.plot([0 pi/2 pi/2 pi/2]); %Looks good!

```

The simplified transform 03:

```

[c123, -s123, 0, L1*c1 + L2*c12]
[s123, c123, 0, L1*s1 + L2*s12]
[ 0, 0, 1, 0]
[ 0, 0, 0, 1]

```

The simplified transform 0H:

```

[c123, -s123, 0, L1*c1 + L2*c12 + L3*c123]
[s123, c123, 0, L1*s1 + L2*s12 + L3*s123]
[ 0, 0, 1, 0]
[ 0, 0, 0, 1]

```

The Transforms for i

```

[1, 0, 0, 7]
[0, 1, 0, 0]
[0, 0, 1, 0]
[0, 0, 0, 1]

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[1, 0, 0, 9]
[0, 1, 0, 0]
[0, 0, 1, 0]
[0, 0, 0, 1]

```

The Transforms for ii

```

[(3^(1/2)*(cos(pi/9)*cos(pi/18) - sin(pi/9)*sin(pi/18)))/2 - (cos(pi/9)*sin(pi/18))/2 - (cos(pi/18)*sin(pi/9))/2, (sin(pi/9)*sin(pi/18))/2 - (cos(pi/9)*cos(pi/18))/2, (3^(1/2)*(cos(pi/9)*sin(pi/18) + cos(pi/18)*sin(pi/9)))/2 + (cos(pi/9)*cos(pi/18))/2 - (sin(pi/9)*sin(pi/18))/2, (3^(1/2)*(cos(pi/9)*cos(pi/18) - sin(pi/9)*sin(pi/18))/2,
[ 0,
[ 0,

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[(3^(1/2)*(cos(pi/9)*cos(pi/18) - sin(pi/9)*sin(pi/18)))/2 - (cos(pi/9)*sin(pi/18))/2 - (cos(pi/18)*sin(pi/9))/2, (sin(pi/9)*sin(pi/18))/2 - (cos(pi/9)*cos(pi/18))/2, (3^(1/2)*(cos(pi/9)*sin(pi/18) + cos(pi/18)*sin(pi/9)))/2 + (cos(pi/9)*cos(pi/18))/2 - (sin(pi/9)*sin(pi/18))/2, (3^(1/2)*(cos(pi/9)*cos(pi/18) - sin(pi/9)*sin(pi/18))/2,
[ 0,
[ 0,

```

The Transforms for iii

```

[ 0, 1, 0, -3]
[-1, 0, 0, 4]
[ 0, 0, 1, 0]
[ 0, 0, 0, 1]

```

```

[ 0, 1, 0, -3]
[-1, 0, 0, 2]
[ 0, 0, 1, 0]

```

[0, 0, 0, 1]



