Homework 2 - Robot Dynamics and Control

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Preliminary steps

1. Determine the slight difference between Matlab'satan2and the function shown inAppendix A of SHV.

1 Problem

Find the Euler angles equivalent to the following sequence ofrotations: Rotx($\frac{\pi}{2}$), Roty($-\pi$) (relative to y_0), Roty($\frac{\pi}{2}$) (relative to the current frame) and Rotz(-$\frac{\pi}{2}$) (relative toz0). Sketch all frames and verify that the Euler angles for the composite rotation work (if there are multiple solutions, show them all).

The following figure illustrate the rotation by step-by-step:

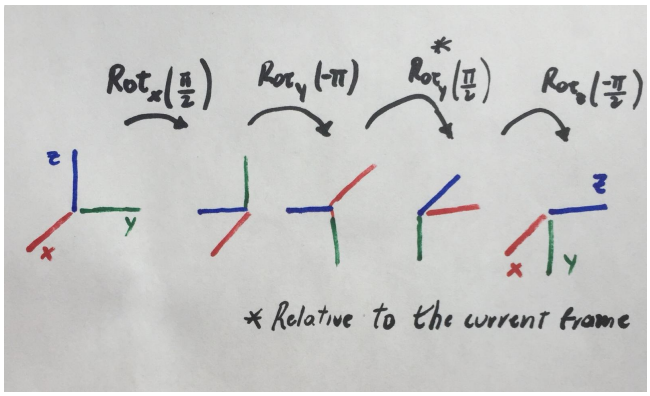

Figure 1: Snapshot of frames.

It is clearly that the last frame correspond to:

$$\begin{pmatrix} x' \\ y' \\ z' \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & -1 & 0 \end{pmatrix} \begin{pmatrix} x \\ y \\ z \end{pmatrix} = \begin{pmatrix} x \\ z \\ -y \end{pmatrix}$$

```
%% Problem 1
R04 = ...
      Rotz(-sym(pi/2))*Roty(-sym(pi))*Rotx(sym(pi)/2)*Roty(sym(pi/2))
```

```
3
4  function out = Rotx(alpha)
5  %Rot_x: Basic rotation matrix about the x-axes
6  out = [1 0 0 ; ...
7      0 cos(alpha) -sin(alpha); ....
8      0 sin(alpha) cos(alpha)];
9  end
10
11 function out = Roty(alpha)
12 %Rot_y: Basic rotation matrix about the y-axes
13 out = [cos(alpha) 0 sin(alpha); ...
14     0 1 0; ...
15     -sin(alpha) 0 cos(alpha)];
16 end
17
18 function out = Rotz(alpha)
19 %Rot_z: Basic rotation matrix about the z-axes
20 out = [cos(alpha) -sin(alpha) 0; ...
21     sin(alpha) cos(alpha) 0; ...
22     0 0 1];
23 end
```

2 Problem

Consider the PP robot with spherical wrist shown in Fig. 2. Consider all 3 d.o.f. of the spherical wrist to be concentric (zero lengths betweenjoints)

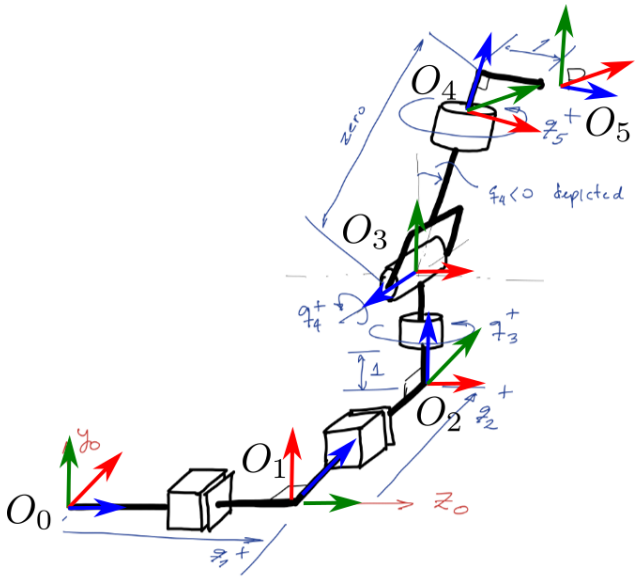

Figure 2: 5-DOF robot with spherical wrist.

Table 1: DH parameters for the 5-DOF manipulator.

Link	a_i	α_i	d_i	θ_i
1	0	$\frac{\pi}{2}$	q_1	$\frac{\pi}{2}$
2	0	$\frac{\pi}{2}$	q_2	$\frac{\pi}{2}$
3	0	$\frac{\pi}{2}$	q_3	q_3
4	0	$\frac{-\pi}{2}$	0	q_4
[a]	d_5	0	0	q_5
5	0	$\frac{\pi}{2}$	0	$\frac{\pi}{2}$

[a] Intermediate frame.

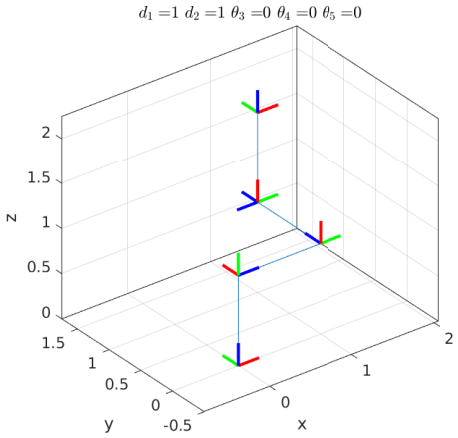

Figure 3: Zero angle configuration.

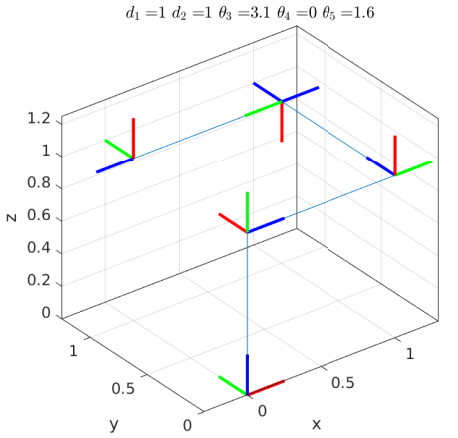

Figure 4: "Easy" configuration test #1.

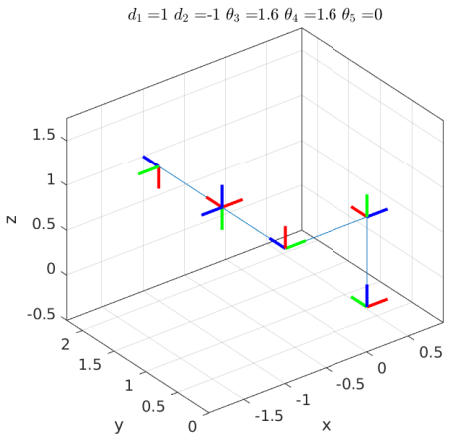

Figure 5: "Easy" configuration test #2.

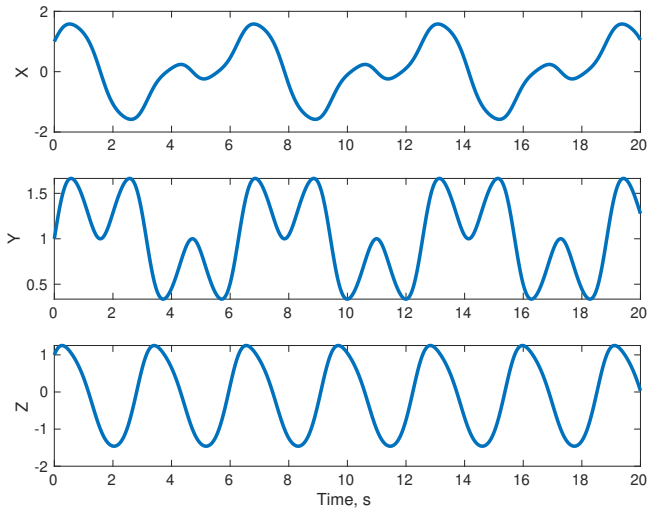

Figure 6: Position of End-Effector along the time.

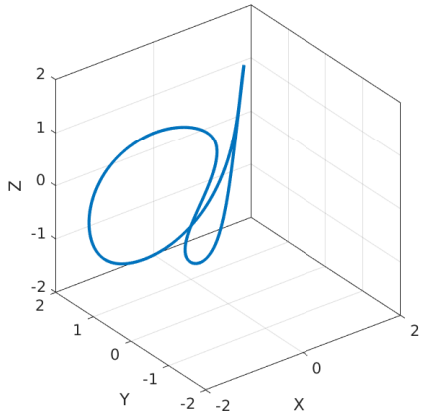

Figure 7: End-Effector trajectory on Space.