Automation and robotic project 1

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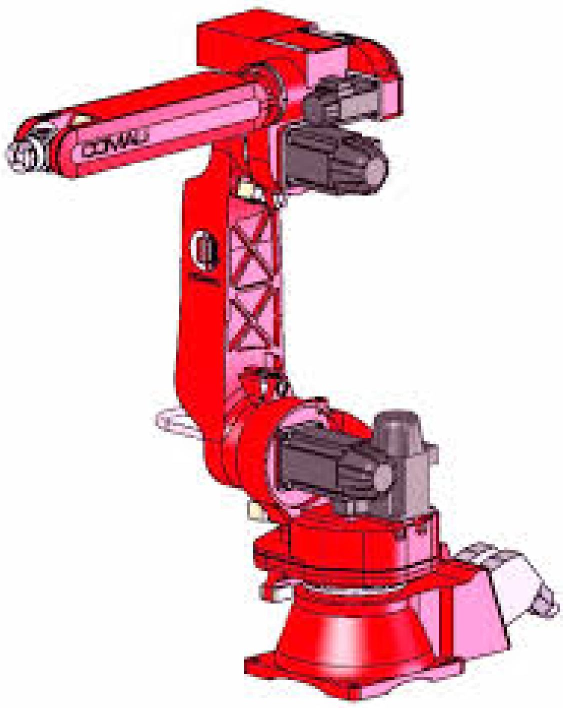

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Chapter 1

Introduction

In this project we apply the theory seen in automatic and robotic course. The aim is creating a function that returns the most important parameters for moving the end-effector of the robot. We can see it on the figure 1 with it's own axes “ANS”. Those parameters are the position and the orientation of the end-effector, the rotation matrix of the end-effector and the roto-translation matrices for the different input parameters (angles and translations of the junctions).

The function takes two parameters, the first is a vector values reprensenting the translation or the rotation of each axe. The type of representation we are in. It can be “ZYZ” or “RPY” (roll, pitch, yaw).

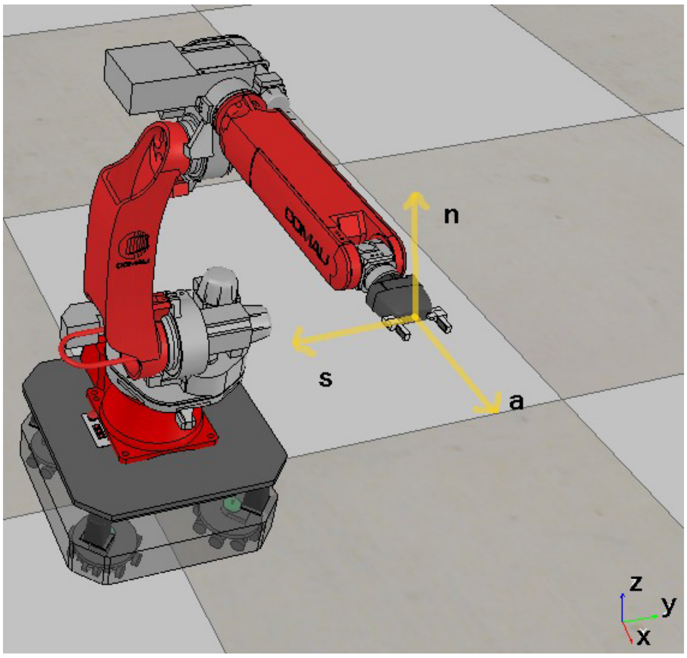

Figure 1.1: Robot smart5 six with a pince on the end-effector

Chapter 2

Work

2.1 Compute the roto-translation matrix

2.1.1 Required

To get the roto-translation matrix we need to multiply the different matrices for each junction and the A_0^b and A_e^n which are two constants matrix respectly represent the b to 0 transformation matrix and the n to e transformation matrix.
We also need the α angles for each junction. We put them in a vector called alpha_i detailed here $\begin{bmatrix} \frac{\pi}{2} & \frac{\pi}{2} & \frac{-\pi}{2} & 0 & \frac{-\pi}{2} & \frac{\pi}{2} & \frac{-\pi}{2} & 0 \end{bmatrix}$. We obtain this values by comparing the junction i's Z axis with the $(i-1)$'s Z axis.
On the figure 2.1.1 we can see the different axis of the robot. Each line corresponds to an axis and the Z vector corresponds to the rotation axis. Then, if we take the second line, we have to make a clockwise rotation of $\frac{\pi}{2}$ to get its Z axe.
We also need a vector that we will call a that stores the distances between the axis that have the same Z orientation 2 by 2. We get those values in on the figure 4 of the documentation of the project. With the same figure we fill the di vector which stores the distance of the axis that doesn't have the same Z orientation. Finally, we create the $teta\_i$ vector to store the angles of in parameter of the function.

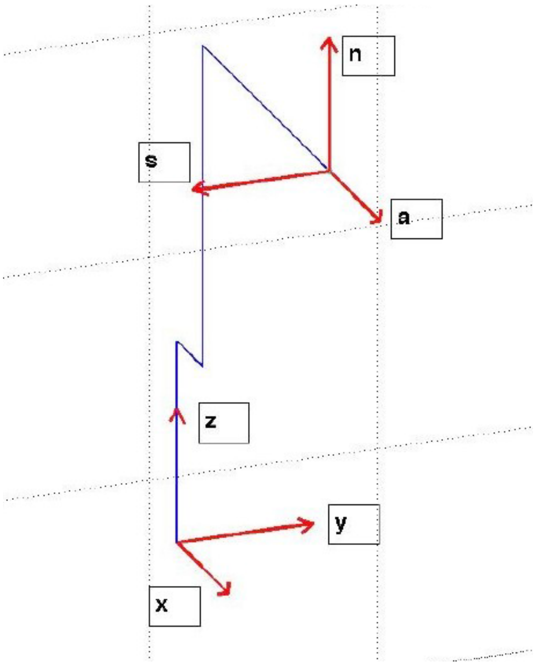

Figure 2.1: Stick view of the Smart5 Six

Link	α	θ	a	d	$\overline{q}$
1	$\frac{\pi}{2}$	0	0	d_1	d_1
2	$\frac{\pi}{2}$	0	0	d_2	d_2
3	$\frac{-\pi}{2}$	θ_3	0.15	0.45	θ_3
4	0	θ_4	0.59	0	θ_4
5	$\frac{-\pi}{2}$	θ_5	0.13	0	θ_5
6	$\frac{\pi}{2}$	θ_6	0	0.64707	θ_6
7	$\frac{-\pi}{2}$	θ_7	0	0	θ_7
8	0	θ_8	0	0.095	θ_8

Figure 2.2: DH parameter table for each junction

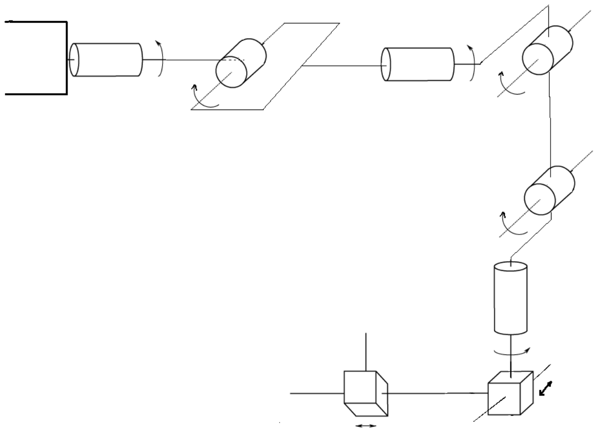

Figure 2.3: Direct kinematic of the robot

2.1.2 Compute the matrix

We learned during the lessons that : $A_i^{i-1}(q_i) = A_{i'}^{i-1} A_i^{i'} = \begin{bmatrix} c_{\theta_i} & -s_{\theta_i} c_{\alpha_i} & s_{\theta_i} s_{\alpha_i} & a_i c_{\theta_i} \\ s_{\theta_i} & c_{\theta_i} c_{\alpha_i} & -c_{\theta_i} s_{\alpha_i} & a_i s_{\theta_i} \\ 0 & s_{\alpha_i} & c_{\alpha_i} & d_i \\ 0 & 0 & 0 & 1 \end{bmatrix}$

To store efficiently the values, we use a tridimensionnal matrix $4 \times 4 \times 8$ which makes a 4×4 per each junction. Using a 'for' loop, we fill the matrix using the values of the a, di and $teta\_i$ vectors.

2.1.3 Get the position and the rotation matrix relative to the end-effector

To get the position of the end-effector and the rotation matrix, we have to compute the general transition matrix denoted T. The formula is : $A_0^b \times \prod_{i=1}^{n} A_n^{n-1} \times A_e^n$. It corresponds to the $A_e^b(\overline{q})$ which is equals to $\begin{bmatrix} R_e^b(\overline{q}) & O_e^b(\overline{q}) \\ \overline{O}^T & 1 \end{bmatrix}$ It last to extract the $R_e^b(\overline{q})$ and the $O_e^b(\overline{q})$ matrices of the $A_e^b(\overline{q})$ matrix by writing :

```
p = T([1 2 3], 4);
R = T([1 2 3], [1 2 3]);
```

There we have the A transition matrix of all the junctions, the matrix of rotation from the base to the end-effector and the position of the end-effector. Now, we will focus on the the Euler angles.

2.2 Get the Euler angles

2.2.1 Divide the different referentials

The two different referentials are 'ZYZ' and 'RPZ'. They are not axed the same way, this is why we differenciate 2 cases to extract the Euler angles ϕ, θ and ψ.

2.2.2 Extraction of the angles

In 'ZYZ' we have :

```
phi = atan2(R(2,3),R(1,3));
theta = atan2(sqrt(R(1,3)^2 + R(2,3)^2), R(3,3));
psi = atan2(R(3,2), -R(3,1));
```

and for 'RPY' referential we need :

```
phi = atan2(R(2,1),R(1,1));
theta = atan2(-R(3,1), sqrt(R(3,2)^2 + R(3,3)^2));
psi = atan2(R(3,2), -R(3,3));
```

There we compute the Euler angles in the good referential.

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