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Middle Term Workshop
DH – IK – FK – DK

Contents

1. Objectives

- To evaluate the concepts learnt so far in Industrial manipulators.

2. Instructions

- This assignment is individual.
- Duration: 180 minutes.
- You might validate your results with the computational resources: Sympy, rtb, etc.

3. Question 1

The HRP-4C robot is a humanoid robot with female features. The figure 1 shows the bottom of this robot, with six degrees of freedom. Units shown are in millimeters. It is desired to model the right leg of this robot using the Denavit-Hartenberg (DH) convention standard. The base system 0 is shown in the figure and is at hip level. The end system 6 to be used as the "end effector" is also shown in the figure 1
Do the following

- Assign the missing reference frames to the right leg of the robot according to the convention Standard DH. The order of the joints is displayed as J_i, along with the direction of rotation. To facilitate the task, it is not necessary to indicate the y-axes. Note that the knee has some lateral displacement with regarding the waist.
- Determine the table with the DH parameters that describe this robot.

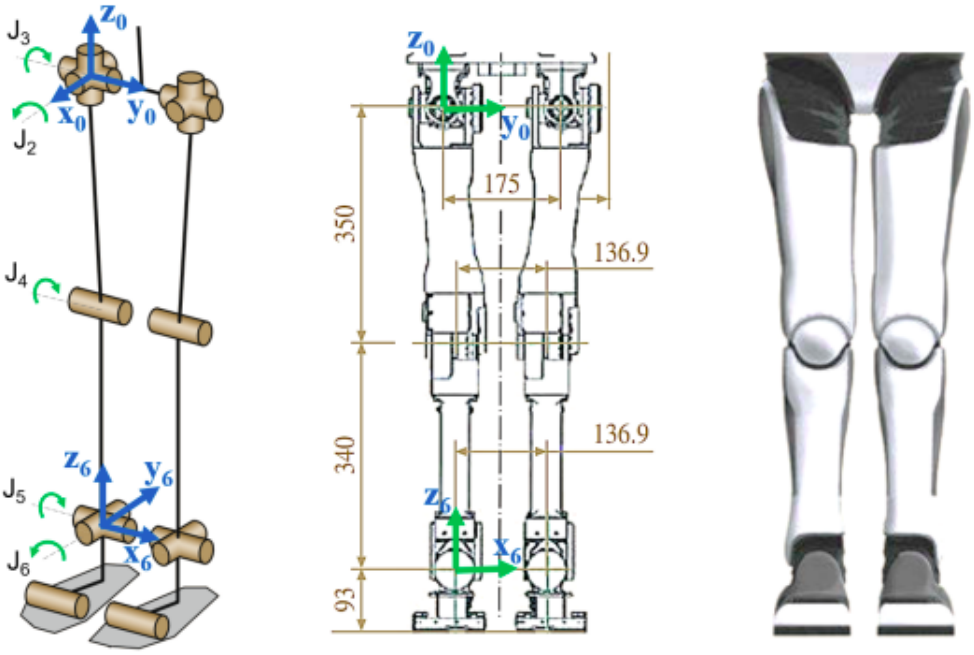

Figura 1: General measures of the HRP-4C

link	d_i	θ_i	a_i	α_i
1	0	q_1	0	0
2	q_2	$-\frac{\pi}{2}$	0	$\frac{\pi}{2}$
3	0	q_3	l_2	$\frac{\pi}{2}$

Tabla 1: DH configuration for the RPR robot

4. Question 2

The kinematic model of an RPR robot with three degrees of freedom is described by Denavit-Hartenberg parameters shown in the following table, where $l_2 = 0.7$m

- Find the linear velocity and the angular velocity of the end effector of this robot, when having joint configuration $q = [\frac{\pi}{4}, 0.5, \pi]$, the joints have a change ration with respect to at the time of $q = (0.4, 0.1, 0.4)$. Units are in rad, m, rad/s, m/s, as appropriate.
- Determine all the unique configurations of this robot, considering only the part corresponding to position, it means, at linear speed.
- The robot, with a quaternion configuration $q = [\frac{\pi}{4}, 0.5, \pi]$, is in contact with a table. It is desired the robot – maintaining this configuration – exerts a force (0.5, 0.5, 0.5) and a null moment on the table. Determine, if possible, the torques that should be applied to each motor to satisfy this restriction.

- The orientation of the end effector of this robot is represented using a quaternion. The relationship between the change rate of a quaternion and the angular velocity is given by:

$$\omega = 2 \begin{bmatrix} -\epsilon_x & w & -\epsilon_z & \epsilon_y \\ -\epsilon_y & \epsilon_z & w & -\epsilon_x \\ -\epsilon_z & -\epsilon_y & \epsilon_x & w \end{bmatrix} \dot{Q} \tag{1}$$

  Express the analitic Jacobian (you have not seen this, study for yourself.)