MESISI473424: Cobotics
TP-1 & 2

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Trajectory planning on a SCARA robot: Joint space simulation

The TP sessions 1 & 2 focuses exclusively on the trajectory planning of a SCARA robot. To recollect, SCARA is the acronym for **Selective Compliance Articulated Robot Arm**. It is an industrial robot that is extensively used for pick and place operations. A 3D view of the robot is provided below in Figure 1. You can download the MATLAB files **Scara3D.m** and **Robot.m** from DVL.

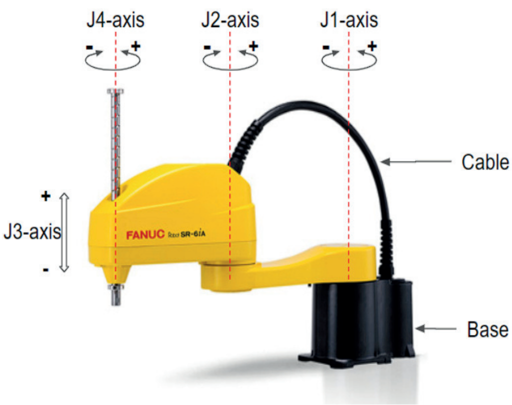

Figure 1: An overview of the SCARA robot

We will be working on MATLAB to perform a joint space simulation on the robot.

1. Consider link lengths of L_1= 70 mm and L_2= 70 mm. Call the file **robot.m** in the main script for the given link lengths. What do you observe from the plot obtained? What are the joint limits for this plot?

2. Propose a script **Main.m** and call the function **Scara3D.m** for the input values of $\theta_1 = \theta_2 = \pi/6$, $\theta_4 = 0$ and $\rho = 5$ mm. Observe the plot and add a snapshot of the plot generated on your report. This posture will be the home-pose or departure point of robot.

3. Use the function **DenaHart.m** to solve the Direct Kinematics Problem (DKP) for the robot end-effector. What are the X,Y and Z values of the end-effector at the home-pose. Refer to Figure 2 and compare it with MATLAB file **Scara3D.m** to identify the numerical values of link lengths (d), the link offsets (r), the joint variables (θ) and the link twist (α).

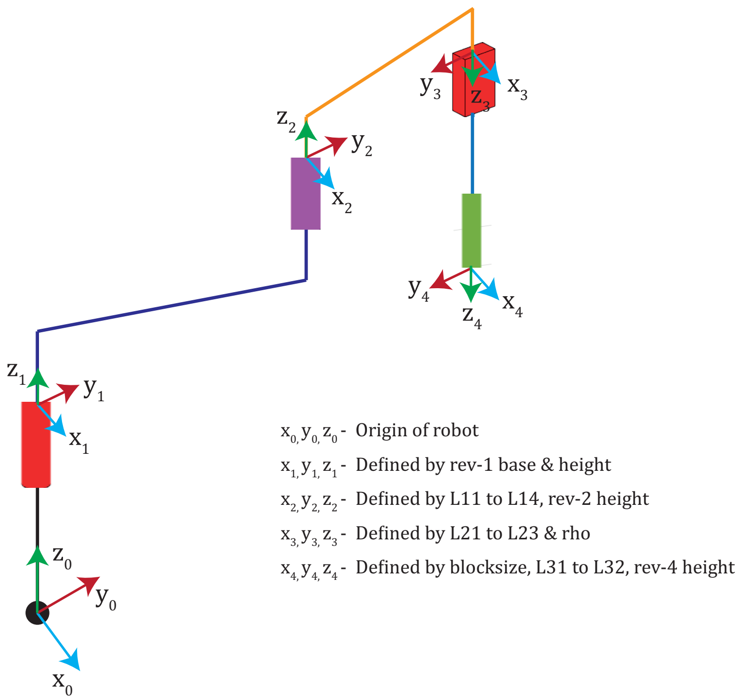

Figure 2: The SCARA robot generated by MATLAB file **Scara3D.m** with the offsets

4. We are now going to perform the Joint-Space simulation on this robot (from the home-pose). What do you understand by Joint-Space simulation?

5. In order to perform the simulation, we are going to set a simulation time t_f of 20 seconds for each task of the robot. Consider that the robot is connected to a controller with a frequency of 2.85 Hz. Determine the step size for the trajectory. After determining the step size, the position, velocity and acceleration profiles can be estimated for each joint using the fifth-order polynomial equations:

$$r(t) = 10 * \left(\frac{t}{t_f}\right)^3 - 15 * \left(\frac{t}{t_f}\right)^4 + 6 * \left(\frac{t}{t_f}\right)^5 \tag{1}$$

$$\dot{r}(t) = \frac{dr(t)}{dt} \quad \& \quad \ddot{r}(t) = \frac{d^2r(t)}{dt^2} \tag{2}$$

   Here are the joint movements to be achieved by the robot:

   - $\theta_1 = [\pi/6 \rightarrow 2\pi/3]$
   - $\theta_2 = [\pi/6 \rightarrow 5\pi/6]$
   - $\theta_4 = [0 \rightarrow 2\pi]$
   - $\rho = [5 \rightarrow 15]$

   The above sequences can be performed either at the same time or one joint after the other.

6. For each movement of the robot, calculate and extract the results of the DKP. Generate two subplots, one with the 3D view of the robot and the other from top-view.

7. Generate the plots of joint-positions, velocities and accelerations for the simulation.

!! Submission for this TP will be along with TP-3 & 4 !!