Servosystems & Robotics - Project $\sigma\pi 1$ - Spring 2021

For the manipulator in the figure it is requested to develop and document the:

1. direct and inverse kinematics analysis (position, velocity, acceleration);
2. analysis of the singular configurations;
3. inverse dynamic analysis (evaluation of the actuators forces/torques);
4. working space determination;
5. design a control structure to follow a trajectory.
6. when following an assigned trajectory (and whenever advisable) continuity in velocity and acceleration must be assured.

It is possible to use analytical or numerical methods, and SimScape SW. The students will freely assign the geometrical dimensions, the joints ranges, their maximum velocities, accelerations (positive and negative), and torques. Inspiration for the data may be taken from real robot data that can be found in internet. The TASK to be simulated is:

1. The manipulator is in point P_1.
2. Then, it moves to point P_2 with minimum actuation time and cycloid acceleration profile.
3. Then, it moves along a trajectory approximating the shape of the letter in the figure, until it reaches point P_3. The trajectory must pass, at least, through 4 intermediate points to be connected using the spline algorithm. The letter lies in a plane with inclination with respect to all xyz axes.
4. Finally, it moves to point P_1 with minimum actuation time and cycloid acceleration profile.

The requests are[1]

1. plot the working space according to UNI ISO 29976 (if possible the exact one, an approximation as an alternative)
2. develop a SW to generate the correct trajectory
3. plot the motion of the end-effector (trajectory) and the motion of the actuators (position, velocity, acceleration)
4. plot the actuator forces/torques
5. guarantee the respect of the maximum joint velocity and acceleration values
6. simulate the control checking the trajectory error with a standard decentralized control or a centralized controller of free choice (in the working space, inverse dynamics, precomputed torques,...)

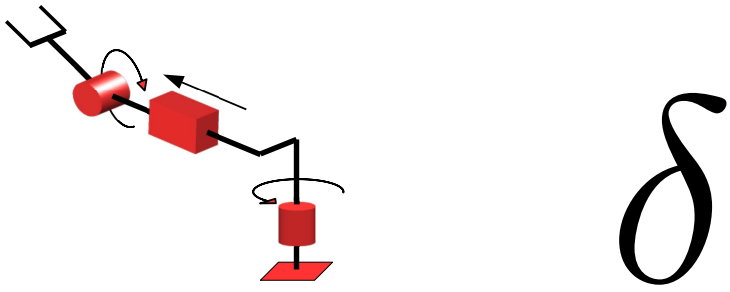

Figure 1: Scheme of the manipulator and description of the movement.

[1] *At the examination bring a PC with a working copy of the SW, plus a printed document which summaries: the adopted notation, the developed algorithms, the debug criteria, as well as the numerical results (numbers and graphs). The exam on this part will consists in a discussion about the project.*

For general information on the project, please write to giovanni.legnani@unibs.it, while for SimSimsape you can also refer to roberto.pagani@unibs.it; serena.ruggeri@stiima.cnr.it