Servosystems & Robotics - Project *Lh*4 - Spring 2022

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

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 according to ISO 9946;
5. design a control structure to follow a trajectory (a standard decentralized control or a centralized controller of free choice (in the working space, inverse dynamics, precomputed torques,...));
6. simulation of the assigned task. When executing the assigned trajectory (and whenever advisable) assure the continuity in velocity and acceleration as well as the respect of maximum motor limits;

The report must include

1. description of the algorithms and the adopted notation;
2. results of the simulation (xyz trajectory of end-effector; position, velocity and acceleration of gripper and joint coordinates, motor trorques/forces versus time);
3. comparison between theoretical and simulated motion (effect of control);
4. description of methodology used for kinematics and dynamics debug (including graphs);

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. It moves to point P_2 with minimum actuation time.
3. It moves along a trajectory of linear and circular segments approximating the shape of the letter in the figure, until it reaches point P_3. The letter lies in a plane with inclination with respect to all xyz axes. The segments must be opportunely connected. For each segment define the maximum velocity and, for the whole trajectory, define suitable acceleration ramps (**Look-Ahead** algorithm).
4. Return to P_1 with minimum actuation time.

At the exam bring a PC with a working copy of the SW and a printed copy of the report. A pdf copy of the report must be also sent to the professor 5 days before the discussion of the project.

Note If the project is developed by a couple of students both of them must be able to answer any question during the exam.

For general information on the project, please write to giovanni.legnani@unibs.it, while for Simsape you can also refer to roberto.pagani@unibs.it

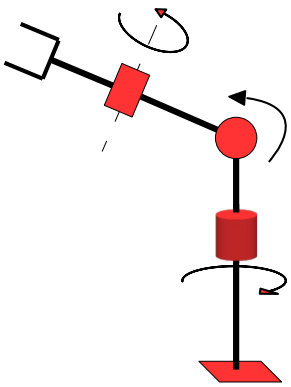

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Figure 1: Scheme of the manipulator and description of the movement.