Modern Robotics practical

EXERCISE 1

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This first exercise for the Modern Robotics practical focuses on the kinematics of the robot arm. You will find proper unit twists, reference configurations and an expression for the Jacobian of the robot.

Study figures 1 and 2. We define joint 1 to rotate around the z-axis and both joint 2 and 3 around the x axis. Until you have the robot, use L_1 for the length of the first link (between joints 1 and 2), L_2 for the second link and L_3 for the length of the third link.

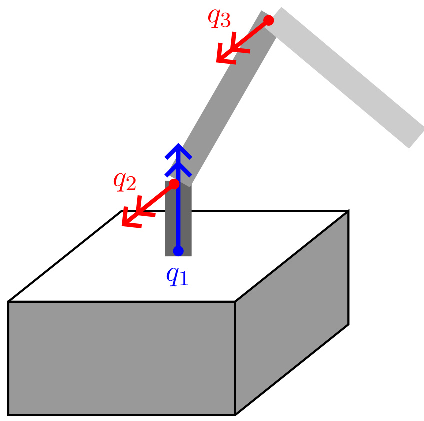

Figure 1: Drawing showing the robot's three rotational joints: one in the vertical direction (q_1) and two parallel in the horizontal direction.

1 Brockett's formula

A. Define an easy reference configuration $q_i = 0$.

B. Find the initial homogeneous transformation matrix $H^0_{\text{ee}}(0)$.

C. Find the unit twist for each joint.

D. Use these to write Brockett's exponential formula to obtain a direct expression for $H^0_{\text{ee}}(\boldsymbol{q})$.

E. Try implementing the equations in MATLAB (using some realistic numbers for the lengths) and test the kinematics by filling in some joint angles.

2 Geometric Jacobian

A. Find the (joint angle-dependent!) unit twists for the Geometric Jacobian.

B. Try implementing the Geometric Jacobian in MATLAB and test the differential kinematics by filling in some joint angles and speeds.

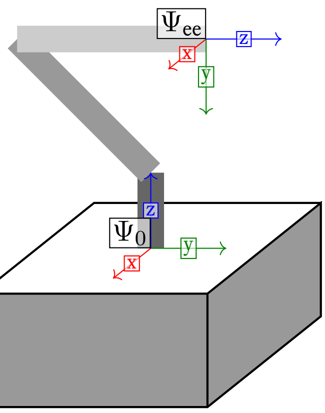

Figure 2: The reference frame Ψ_0 sits at the base of the first joint. The end-effector frame Ψ_{ee} is at the tip of the last link. In this drawing, $q = (0, 45°, -135°)^\top$.

Deliverables

Your implementations of question one and two should be handed in at the end of the course.

Please use the following function signature for question one:

$$[H_1^0, \ldots, H_{\text{ee}}^0] = \texttt{getHmatrices(q, L)}$$

The argument `q` should be a vector of three elements with the three joint positions. The `L` argument is a vector of three elements representing the lengths of each link in the robot. The origin of the frames should be placed right at the end of the link (Ψ_0 at the base, Ψ_1 at the second joint location (but attached to link 1), Ψ_2 at the third joint location (attached to link 2), and Ψ_3 at the tip of the last link.)

For question two, please stick to the following function signature:

```
J = getJacobian(q, L)
```

Where `J` should be a matrix where the columns represent the unit twists.

Put both functions (and any other required functions) into a folder named after your university abbreviation and student number (`{UT,TUD,TUe}s{0123456}`). Later, after completing the final exercise, you will have to hand in these functions.

The folder structure should look like this:

```
UTs1234567\
UTs1234567\getHmatrices.m
UTs1234567\getJacobian.m
UTs1234567\any_other_helper_functions.m
```