Problem Set 3

Robotics & Automation
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Instructions. Please write legibly and do not attempt to fit your work into the smallest space possible. It is important to show all work, but basic arithmetic can be omitted. You are encouraged to use Matlab when possible to avoid hand calculations, but print and submit your commented code for non-trivial calculations. You can attach a pdf of your code to the homework, use live scripts or the publish feature in Matlab, or include a snapshot of your code. Do not submit .m files — we will not open or grade these files.

1 Implementing Forward Kinematics

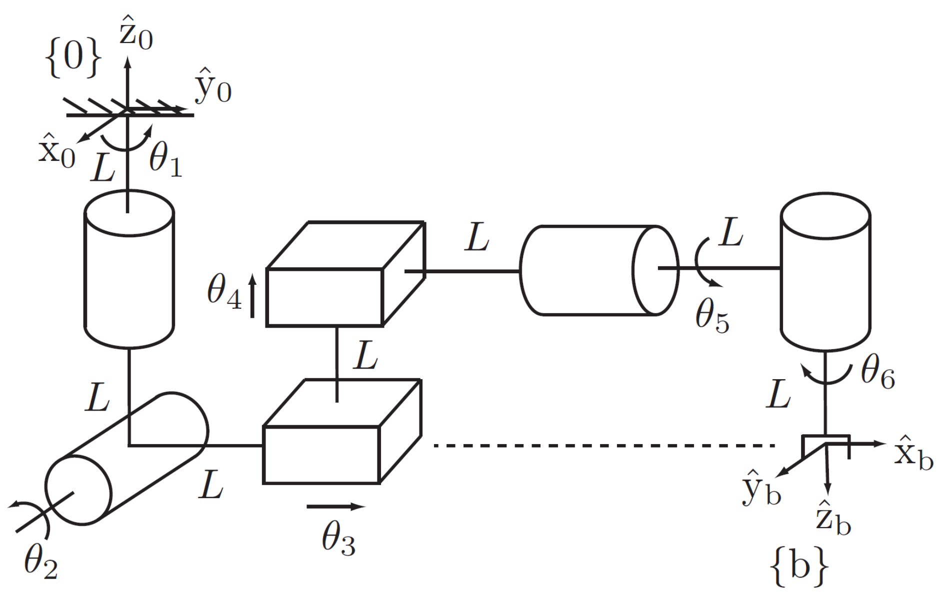
1.1 (25 points)

Write a general forward kinematics function in Matlab: `T = fk(M, S, theta)`

- $M = T(0)$ is the forward kinematics when the robot is in its home position
- $S = [S_1, \dots, S_n]$ is a matrix composed of n screw axes. The i-th column is S_i, the screw axis for the i-th joint
- $\theta = [\theta_1, \dots, \theta_n]$ a vector of n joint values
- T is the transformation matrix from the fixed frame to the body frame

You can double check your code by testing it with our in-class examples.

2 Finding Forward Kinematics



In this problem you will get the forward kinematics of the robot shown above. Frame $\{0\}$ is our fixed frame and we want the pose of frame $\{b\}$.

2.1 (20 points)

Find the home transformation matrix $M = T_{sb}(0)$ and write the screw axes $S_1, \ldots, S_6$.

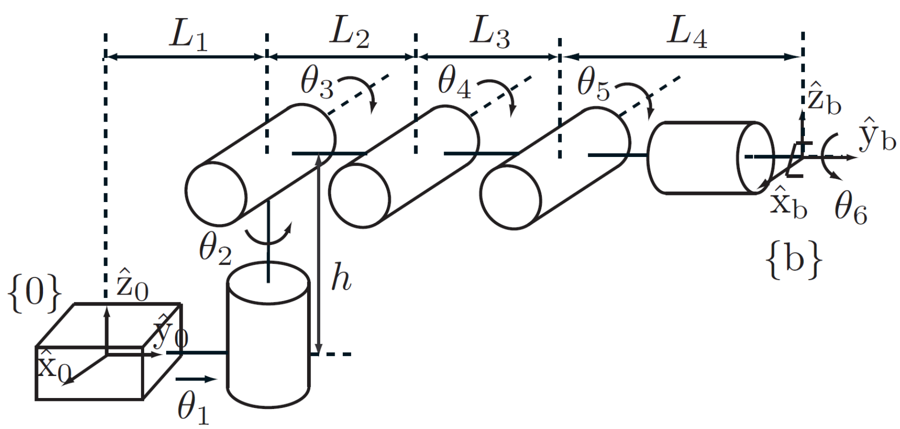
2.2 (5 points)

Use your forward kinematics function from Problem 1 to find T_{0b} when:

Case 1: $L = 1, \quad \theta = [\pi/2, 0, 2, -0.5, 2\pi/3, -\pi/4]^T$
Case 2: $L = 2, \quad \theta = [-\pi/2, -\pi/4, 0, 1, \pi/3, \pi/2]^T$

Your answers should be two transformation matrices with numerical values.

3 Finding More Forward Kinematics



In this problem you will get the forward kinematics of the robot shown above. Frame $\{0\}$ is our fixed frame and we want the pose of frame $\{b\}$.

3.1 (20 points)

Find the home transformation matrix $M = T_{sb}(0)$ and write the screw axes $S_1, \ldots, S_6$.

3.2 (5 points)

Use your forward kinematics function from Problem 1 to find T_{0b} when:

- $h = 2, \quad L_1 = L_2 = L_3 = L_4 = 1, \quad \theta = [1, \pi/4, -\pi/4, 0, \pi/4, \pi/2]^T$

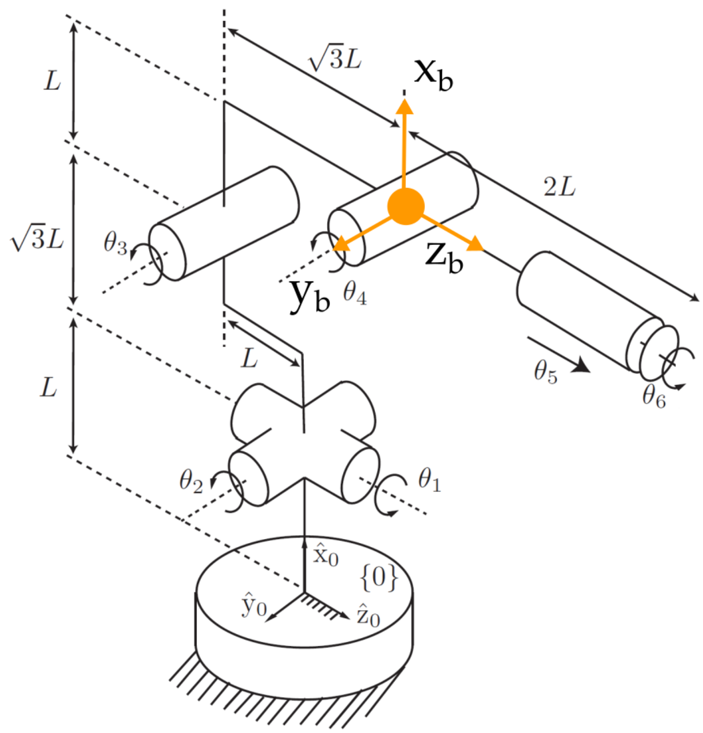
Your answer should be a transformation matrix with numerical values.

4 Arbitrary Point of Interest

Although we generally use forward kinematics to get the pose of the end-effector, sometimes there are other points we are interested in. For instance, perhaps we want to check that the elbow of our robot arm is not going to collide with an object. Here you will get the forward kinematics of the marked frame $\{b\}$ with respect to fixed frame $\{0\}$.

4.1 (5 points)

If you change θ_5 and θ_6 for this robot while leaving all other joints fixed, does T_{0b} change?



4.2 (20 points)

Find the forward kinematics T_{0b} for the following cases:

Case 1: $L = 1, \quad \theta = [\pi/4, \pi/4, 0, \pi/2, 2, -\pi/4]^T$
Case 2: $L = 1, \quad \theta = [-\pi/2, 0, \pi/6, -\pi/3, 1, \pi/2]^T$