MECH4000J/ELEC4010M Robotic Manipulation and Mobility 2018/2019 Spring
Project #1 - Baxter Kinematics DUE 3 Apr

Project policy: Work individually. This is not a group project. Upload your zip package to Canvas due 11:59pm, 3 Apr. Late packages can be turned in until 11:59pm on 8 Apr with a 25% penalty. After that, none will be accepted. Extensions are available for certain conflicts including illness (email the instructor). Collaboration with other students is allowed. But you MUST turn in your own work. Failure to do so constitutes plagiarism and may nullify your score.

The baxter robot system has two 7-DOF (degrees-of-freedom) arms. Each arm is composed of a 2-DOF shoulder (shoulder roll/pitch joints), a 2-DOF elbow (elbow roll/pitch joints), and a

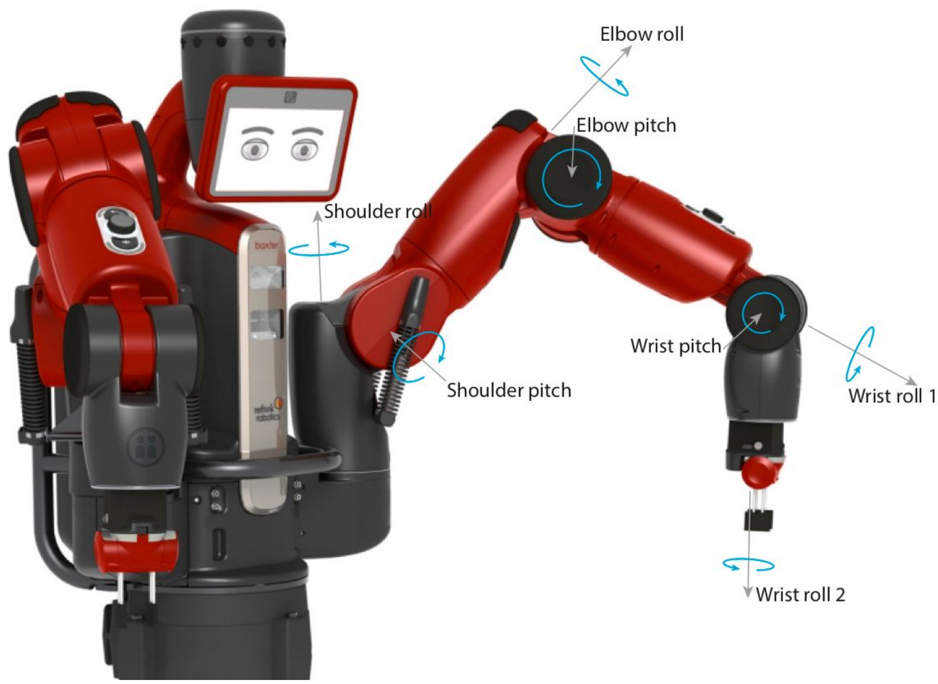

Fig. 1: The Baxter robot system. Each arm is composed of seven 1-DOF revolute joints. The names of the joints and the positive directions of the joint axes of the left arm are shown.

3-DOF wrist (wrist roll/pitch/roll joints). See Fig. 1. All the seven joints are single-DOF revolute joints. Fig. 2 shows the “home” configuration of the arm in which all the joint angles are zero. At the home configuration, the arm is represented as a planar chain (that is, a “stick figure”) as illustrated in the figure. Our project is to develop the kinematic simulator of the Baxter robot.

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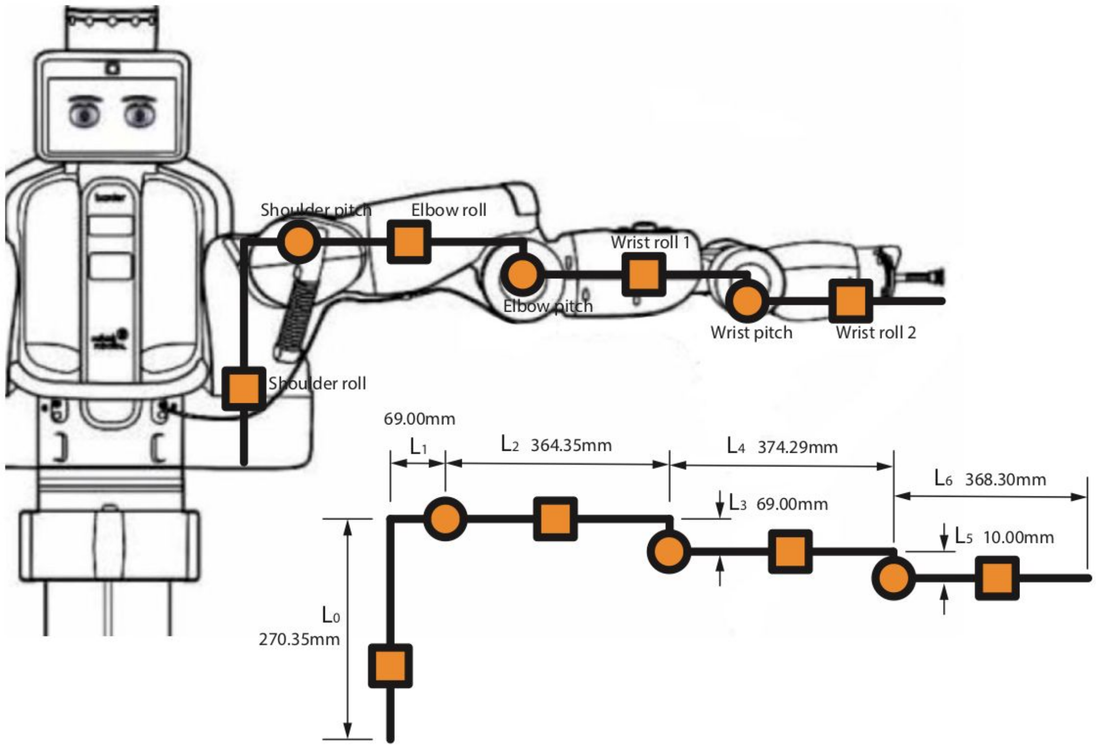

Fig. 2: The home configuration of the left arm.

1. ***Baxter Forward Kinematics*** Write a function that takes the seven joint variables of the Baxter left arm and visualize the resulting configuration of the arm (for example, as a stick figure).

2. ***Baxter Workspace*** Using your forward kinematics solution, write a function that visualizes the reachable workspace of the tip of the left arm (for example, as a point cloud). The joint angle limits of the arm are as follows:

Joint Name	min	max
Shoulder roll (θ_1)	-141°	$+51^\circ$
Shoulder pitch (θ_2)	-123°	$+60^\circ$
Elbow roll (θ_3)	-173°	$+173^\circ$
Elbow pitch (θ_4)	-3°	$+150^\circ$
Wrist roll 1 (θ_5)	-175°	$+175^\circ$
Wrist pitch (θ_6)	-90°	$+120^\circ$
Wrist roll 2 (θ_7)	-175°	$+175^\circ$

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3. *Baxter Inverse Kinematics* Write a function that takes a desired x-, y-, and z-position of the end-effector (that is, the tip of the arm), returns the inverse kinematics solutions, and visualizes the solutions.

4. *Application of Inverse Kinematics* Write a function that moves the end-effector around in space to write down the initials of your name (max. three characters) on the plane. Visualize the result, for example, as a trace of the points that the end-effector follows.

5. *(25% Extra credit)* How do you want to modify the design of the arm to simplify its inverse kinematics? Make slides to elaborate your idea.

Follow the instructions below:

1. Use a high-level programming language. You are recommended to use Matlab or Python.
2. Upload a single zip file containing the functions you have implemented, along with the slides for the extra credit (if any) and a “readme.txt” file briefly describing how to run your codes. Note that if your readme.txt is unclear, there will be a significant penalty.

Remark: You will have a chance to present your work to the teaching staff after the due date.