

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

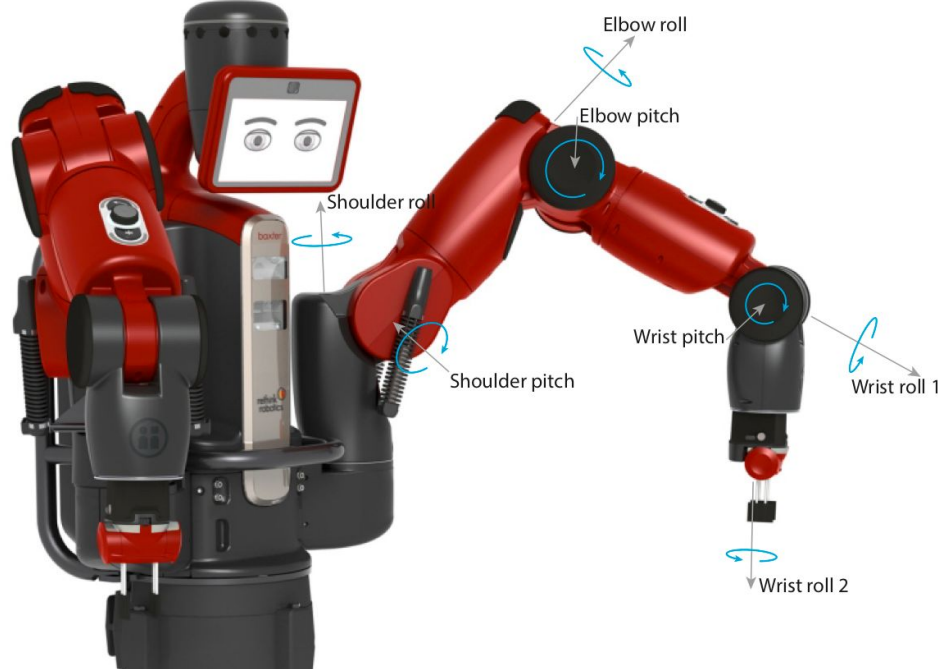


Fig. 1: The Baxter robot system. Each arm is composed of seven 1-DOF revolute joints. The names of the joints and the positive directions of the joint axes of the left arm are shown.

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.

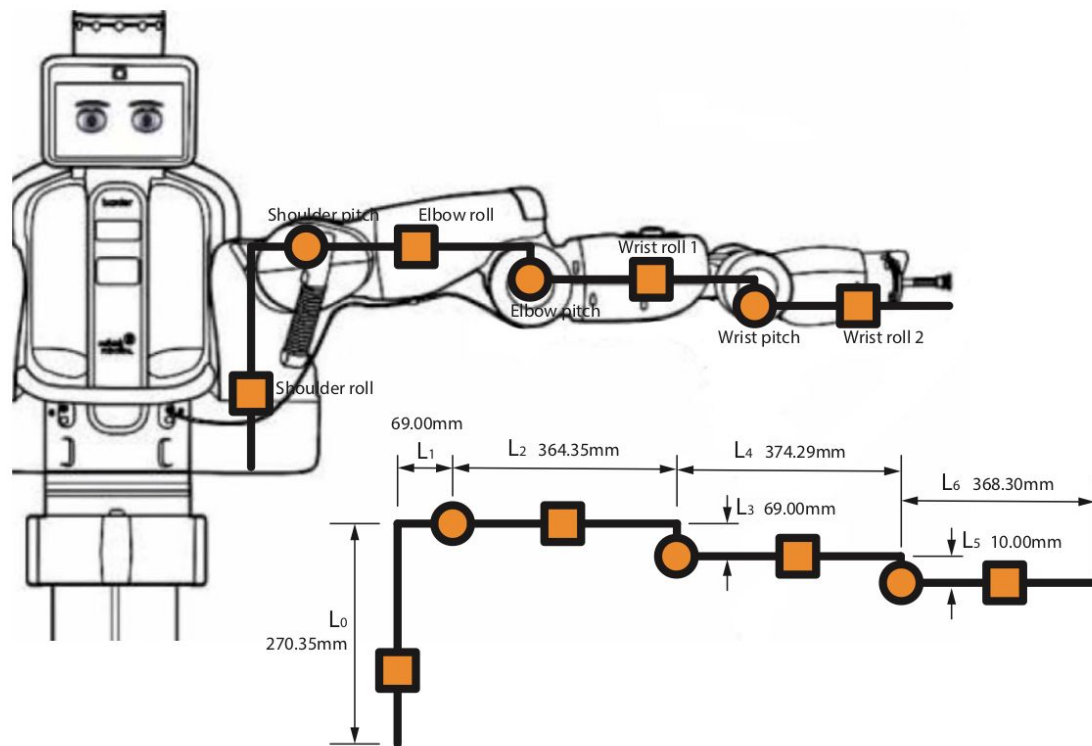


Fig. 2: The home configuration of the left arm.

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°	$+175^\circ$

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

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.
3. The use of built-in functions for forward/inverse kinematics is NOT allowed. Your task is to develop such functions yourself.

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