# Homework 1

Geometric Simulation - Forward Kinematics - Homogenous Transformations

Deadline: Friday, October 6, 7:59pm.
Perfect score: 100.

**Assignment Instructions:**

**Submission Rules:** Submit a compressed file that contains your code through Sakai (`sakai.rutgers.edu`).

**Late Submissions:** No late submission is allowed. 0 points for late assignments.

**Collusion, Plagiarism, etc.:** Each team must prepare its solutions independently from other teams, i.e., without using common notes, code or worksheets with other students or trying to solve problems in collaboration with other teams. You must indicate any external sources you have used in the preparation of your solution. Do not plagiarize online sources and in general make sure you do not violate any of the academic standards of the course, the department or the university.

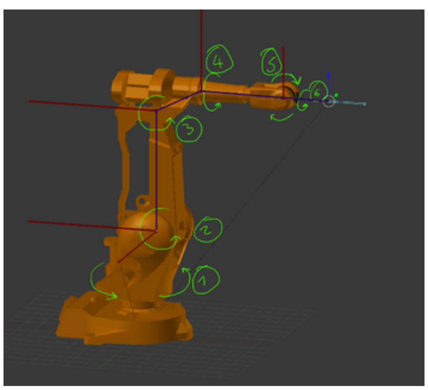
**Task:** rotation axis is always defined in terms of the previous frame

1. Define a 6-dof manipulator with rotation axises $\{r_1, r_2, r_3, r_4, r_5, r_6, \cancel{r_7}\}$ and link lengths $\{l_1, l_2, l_3, l_4, l_5, l_6, \cancel{l_7}\}$. Limit the range of each joint to an interval of your choice, i.e. $q_i \in [q_{imin}, q_{imax}]$ where $q_{imin}, q_{imax} \in [0, 2\pi]$ (by default, you can just assume that $q_{imin} = 0$ and $q_{imax} = 2\pi$). Different joints generally have different ranges. The link lengths $l_i$ are global variables that you can change whenever you want to modify your design. The choice of the rotation axis for each joint is completely up to you, try to choose rotation axises that would allow a maximum reachability in the workspace.

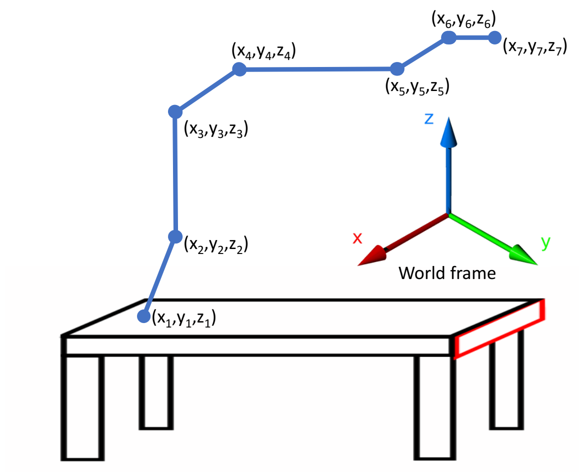
2. Write a forward kinematic function $f$ that takes as inputs a sequence of joint angles $q_{1:i} = (q_1, \ldots q_i)$ and returns $f(q_{1:i}) = (x_{i+1}, y_{i+1}, z_{i+1})$ where $i \in \{1, \ldots, 6\}$ and $(x_{i+1}, y_{i+1}, z_{i+1})$ are the coordinates of the $i + 1^{\text{th}}$ joint, and $(x_7, y_7, z_7)$ are the coordinates of the end-effector. Use what you have learned in the class about rotations and translation matrices to implement this function.

3. Using function $f$, you can get the coordinates of each joint in the world frame given any joint angles. Write a function that takes as inputs the coordinates of the joints and visualizes the links of the robotic arm in the corresponding configuration. You can do that by choosing a view angle that you think would give the best view, finding the rotation matrix corresponding to this view angle, rotating each point using this matrix, and finally dropping one coordinate (x, y or z) to project the image on the screen.

4. For fun, create a time sequence of angles for each of the six joints and show the animated robotic arm moving from an initial joint configuration to a final one.




(a) Example of a 6-dof robotic manipulator with the corresponding six rotation axises




(b) Schematic representation of the links

Figure 1: Example of a 6-dof manipulator design and schematic representation