Goal-Oriented Graphics Animation:

Drawing an Articulated Object

Contents

1 Overview

In this assignment, you will write a program that draws a 2-D robot arm (i.e., its movement will happen on the xy-plane only). The robot arm should have at least 4 parts. An example of a 4-part robot arm is shown in Figure 1.The base of this arm is fixed (i.e., $\phi_1 = 0$ and the part does not rotate). All other joints are *elbow* rotate. The y-axis of the local coordinate frame of the part is aligned with the corresponding arm part that attaches to the joint.

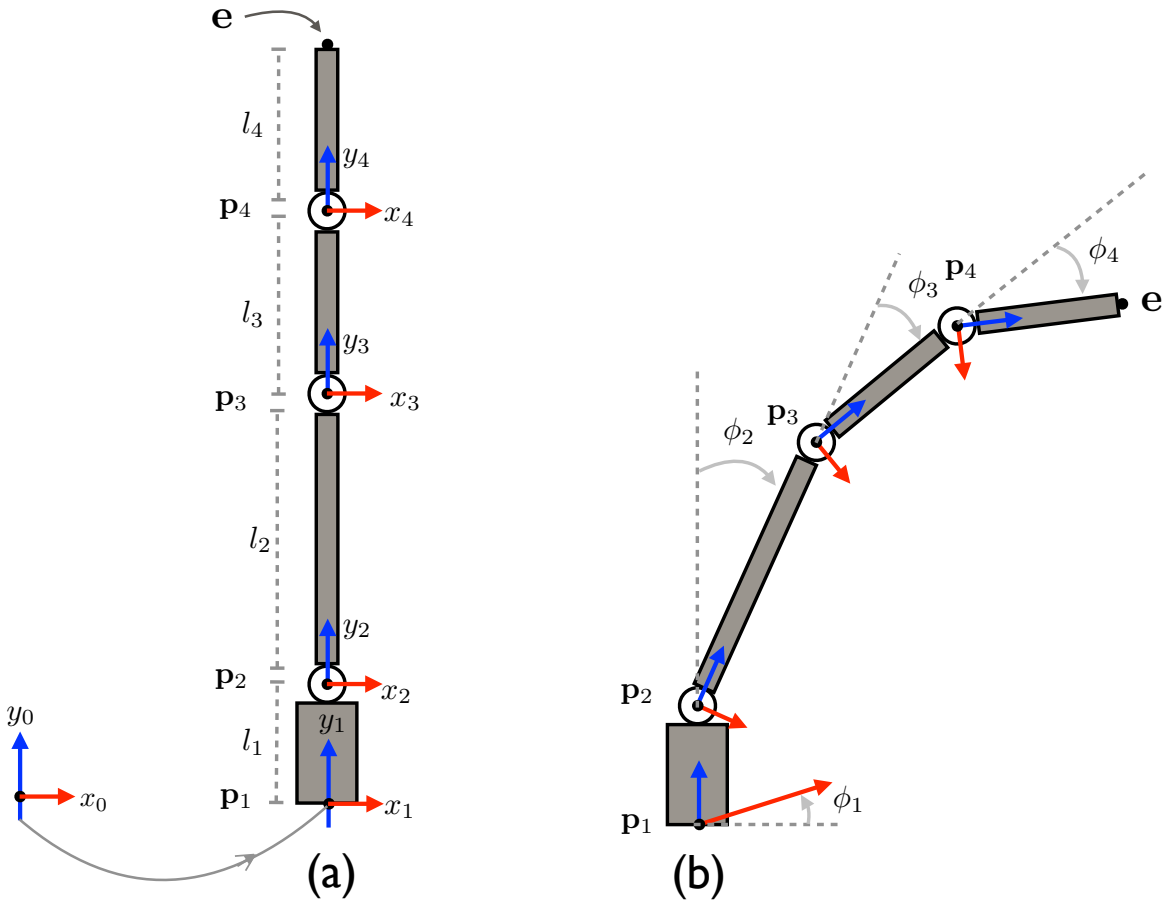

Figure 1: A 4-part robot arm. (a) Robot arm in its home (i.e., zero) configuration, i.e., all joint angles are zero. The arm part that connects to the joint is aligned with that part's y-axis. (b) Part l_1 is fixed, i.e., $\phi_1 = 0$ and the part does not rotate. All other parts have joints that rotate. The joint center $\mathbf{p}_5$ is the end-effector position $\mathbf{e}$.

2 Drawing and moving the robot

To draw the robot, you will follow the descriptions in the lecture notes and lecture slides.

3 Forward-kinematics function

The change in position of the arm's end effector is governed by the following forward-kinematics function:

$$\mathbf{e} = f(\mathbf{\Phi}). \tag{1}$$

This function receives a set of joint angles (i.e., joint-angle configuration) as input and outputs the end-effector position. To implement this function, you need to calculate the matrix of last frame in the kinematic chain, which is given by:

$$T_{0,5} = T_{0,1}T_{1,2}T_{2,3}T_{3,4}T_{4,5} = \begin{bmatrix} R_{0,5} & \mathbf{p}_5 \\ \mathbf{0} & 1 \end{bmatrix}. \tag{2}$$

In these notes, we assume that the end-effector is located at $\mathbf{p}_5$, i.e., $\mathbf{e} = \mathbf{p}_5 = (e_x, e_y)^\mathsf{T}$. Thus, this is the location is the translation component of the last transformation written with respect to the global coordinate frame.

Algorithm 1 Forward-Kinematics Function (end-effector)

1: **function** $\mathbf{e}$=f($\mathbf{\Phi}$)

Require: $l_1, \ldots, l_4$ ▷ Lengths of each part of the arm

Require: $T_{i-1,i}$, for $i = 1, \ldots, 5$. ▷ Local frame transformations

2:

3: $T_{0,5} \leftarrow T_{0,1}T_{1,2}T_{2,3}T_{3,4}T_{4,5}$.

return $\mathbf{p}_5$ ▷ Translation component of $T_{0,5}$

4: **end function**