Edinburgh Napier UNIVERSITY

Physics-Based Animation (SET09119)

Tutorial 02 - Kinematics & Inverse Kinematics

1 Question

Alignment: An object is at position p with a unit length heading of h. We want to rotate it so that the heading is facing some target t. Find a unit axis (a) a and an angle θ to rotate around.

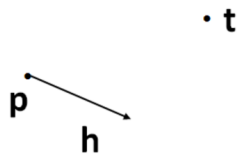

Figure 1: Question: Alignment.

Given $p =< 1, 2, 0 >$, $h =< 1, 0, 0 >$, and target of $t =< 3, 3, 0 >$ what is the unit axis (a) and angle (θ)?

2 Question

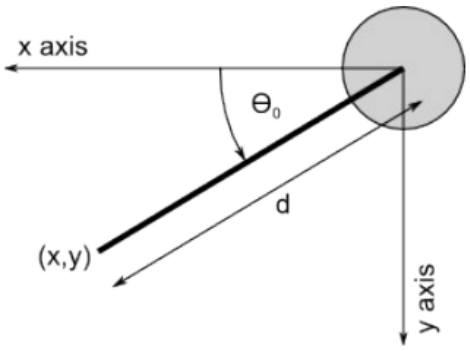

Figure 2: Planar manipulator with a single joint and extendible limb.

Part A

Forward Kinematics. Given the joint angle and length for the articulated geometry in Figure 2, find the orientation of the end-effector relative to the base frame (i.e., x and y in terms of θ_0 and d)

Given $d = 2$ metres and $\theta_0 = 0.2$ radians, what is (x, y)?

Part B

Inverse Kinematics. Given the position and orientation of the end-effector relative to the base frame (see Figure 2), compute the joint angle and arm length for the articulated link geometry, which could be used to attain the given position and orientation of the end-effector (i.e., θ_0 and d in terms of x and y)

Given $(x, y) =< 5, 10 >$ what is θ_0 and d?

3 Question

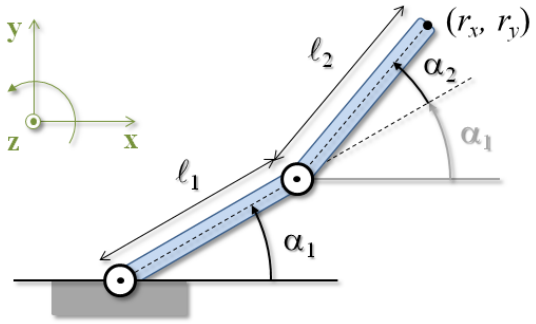

Figure 3: Two-link planar kinematic chain with revolute joints

Part A

Forward Kinematics. Given the joint angles and the linked geometry, compute the orientation of the end-effector relative to the base frame for Figure 3

Given $l_1 = 2$ and $l_2 = 3$ metres with $\alpha_1 = 0.4$ radians and $\alpha_2 = 0.2$ radians, what is the end-effector position (r_x, r_y)?

Part B

Inverse Kinematics. Given the position and orientation of the end-effector relative to the base frame, compute all possible sets of joint angles and link geometries which could be used to attain the given position and orientation of the end-effector (see Figure 3)

Given $(r_x, r_y) =< 2, 3 >$, $l_1 = 2$ and $l_2 = 2$ metres, calculate α_1 and α_2?