CS485 AUTONOMOUS ROBOTICS

Homework 1 Kinematics

Due: September 21 before class

Name:

G Number:

Email:

1 Transformations

1.1 Which two components does a rigid body transformation entail? How do we represent such a transformation? (10 points)

1.2 List all five types of transformations in a plane, how their transformation matrices look like, and how many degrees of freedom they have. (15 points)

1.3 Why do we need pose, instead of position, to represent a robot configuration? (5 points)

1.4 List (at least) two ways to represent rotations. (10 points)

1.5 Frame Transformation for Navigation (20 points)

During the BARN Challenge, the Jackal starts at (x, y, yaw)=(0, 0, 0°) and navigates to a goal at (x, y)=(5, 6), both expressed in the world frame. Now the Jackal reaches (1, 1, 45°). What is the coordinates of the goal expressed in the current robot frame of the Jackal?

Please provide detailed derivation and schematics if necessary to illustrate your derivation.

2 Kinematics

2.1 Forward Kinematics (20 points)

You have a three-link manipulator robot. The 1st link is attached to the ground with a 0.3m length and a 30°angle with respect to the horizontal axis (towards right); The 2nd link is 0.2m and attached to the end of the 1st link with a 45°angle with respect to the 1st link; The 3rd link is 0.3m and attached to the end of the 2nd link with a 30°angle with respect to the 2nd link. Please draw a diagram of this manipulator and derive the position of the end-effector.

2.2 Inverse Kinematics (20 points)

For the same manipulator robot above, the end-effector is at $(0.2, 0.6)$. How many degrees do all three joints need to rotate from (0°, 0°, 0°) so that the effector can reach this position? Please at least provide one solution (you will get extra 10 points if you provide a 2nd solution).