Robotics Exam II: Mobile Robots Exam Name: Jeremy Winterberg

**#1 (20 points) Explain the concept Monte Carlo Localization.**

Monte Carlo Localization is an algorithm to determine the location of a robot within an area. By using particle filters, you can calculate this quite accurately. It recursively searches, narrowing down the most likely positions till it has a lock on the robot.

**#2 (20 points) Explain what SLAM is in terms of mobile robots.**

Simultaneous Localization and Mapping is a set of methods used in building a map of a robot’s surroundings while simultaneously navigating around the environment. This allows a mobile robot to continuously update its surroundings to best avoid obstacles. The basic steps of accomplishing this include landmark extraction, data association, state estimation, state update and landmark update. However, since these are general goals, there are multiple ways to accomplish their intended outcomes.

**#3 (20 points): In kinematics one needs to be able to describe the relationship between the different coordinate system frames. For this question, assume we are only dealing with rotations (i.e. all coordinate system frames have the same origin). Given the following 3 coordinate system frames, describe in a 3x3 matrix, the relationship between frame 2 and frame 0 (i.e. the transformation that will translate points from frame 2 to 0).**

I wanted to give a written answer in case my matrix translations aren’t precise. First, you must rotate along the z axis 90 degrees, then rotate along the y axis 90 degrees. This will achieve the translation depicted in your pictures.

Z-Rotation

|  |  |  |
| --- | --- | --- |
| cos θ (90) | -sin θ (90) | 0 |
| sin θ (90) | cos θ (90) | 0 |
| 0 | 0 | 1 |

Y-Rotation

|  |  |  |
| --- | --- | --- |
| cos θ (90) | 0 | sin θ (90) |
| 0 | 1 | 0 |
| -sin θ (90) | 0 | cos θ (90) |

**#4 (20 points): Explain what Denavit-Hartenberg (DH) parameters are and how they are used in Forward Kinematics.**

They are the four parameters used to determine forward kinematics transformations in relation to the previous state.

Alpha rotates along the new x axis to bring the z axis in line with its new orientation

d is the depth of joint axes, from previous origin to z axis along the next joint.

Theta is the angle from the previous z to the x of the new origin

r is the length of the common normal, and is the radius of rotation for that joint.

**#5 (20 points): Explain the concept of Inverse Kinematics and what is difficult about it.**

As its name suggests, it’s the opposite of forward kinematics. In simple terms, forward kinematics takes a set of joint angles, and determines the arrangement of the kinematic chain. Inverse kinematics takes the arrangement and determines the required joint angles to accomplish that pose. In our kinematics simulation assignment, we used inverse kinematics to reverse engineer the angles required to have our robotic arm’s tip at a desired location. In something such as animation, you have a desired look you need to accomplish, and would use inverse kinematics to accomplish that look with your 3D models.

The challenge behind this is being precise. Real applications of this outside of animation would be something like a robotic welder. It knows the path it needs to weld along, but needs to determine the rotations for each joint required to move along that line.