COMP0246 Modelling and Motion Planning
Lab 3 for submission: Jacobian, Inverse Kinematics and Path Planning

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To get full credit for an answer, you are *required* to provide a .pdf report. There are no coding examples this week. When ready, *upload* your pdf on Moodle.

Jacobian and Inverse Kinematics

1. How many inverse kinematic solutions exist for a 2D 4R-planar manipulator, if an achievable pose of the end-effector x_e is given? Give a full explanation to support your answer. [report - 10 pts]

2. Suppose that the robot is moving in a free space (i.e. there are no obstacles) and that more than one inverse kinematic solution exist for a desired pose of the end-effector x_e, what criteria should you consider when choosing an optimal solution? [report - 10 pts]

3. When is the output of the function atan2(y, x) different from atan$(\frac{y}{x})$? [report - 5 pts]

4. The following questions refer to the YouBot configuration from the previous lab

   a. Explain how you would compute the Jacobian matrix for the YouBot manipulator. [report 5 pts]

   b. Derive the closed-form inverse kinematics solutions for the YouBot manipulator. You can represent any non-zero length parameters as variables. [report - 15 pts]

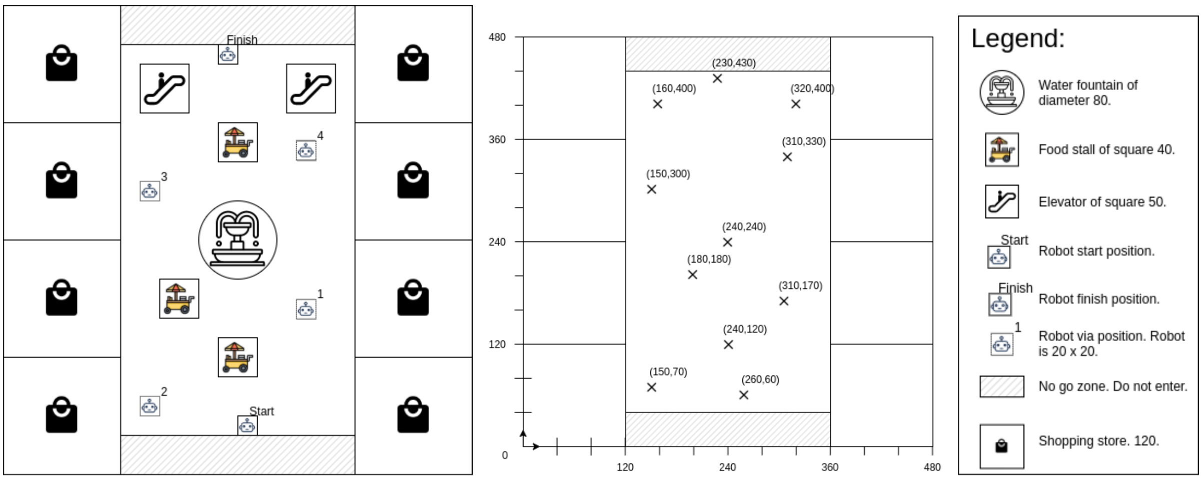
c. Describe what method you would employ to detect a singularity for a given input pose. [report - 5 pts]

[50 pts]

TURN OVER

Path and Trajectory Planning

5. Assume the following scenario: A shopping mall is testing autonomous cleaning robots to clean floors of a section of the mall. They have given you the following floor map defining no go zones, cleaning via points and obstacles. Cleaning will occur at night, so no dynamic obstacles will be present. Consider only passing through via points not total floor coverage. They also allow external cameras and tracking, so perfect odometry can be assumed. Present a robotic solution by choosing a drive system to complete the task, addressing path planning and trajectory planning. You can assume the position and orientation of your chosen robot is given as $q = (x, y, \theta)$ where x and y describe the position and θ describes the orientation of the robot. You have a perfect controller that can control you wheel velocities to attain the given position and orientation. When choosing the drive system, consider that the vacuum is located at the back of the robot so during turns and rotations, the vacuum may miss water pickup. Your solution should address the following specifically. (Recommended answer is up to 50 words per sub-question and the word count for the entire question should not exceed 300 words.)



(a) Map (b) Coordinates (c) Legend

Figure 1: Map, coordinates and legend of shopping mall cleaning area.

a. What kind of drive system configuration would you choose? Explain your reasoning. Investigate holonomic or non-holonomic wheeled solutions? What is the configuration space? [report - 10 pts]

b. Describe how you would find a path that goes from the starting point to the final point while passing through all the via points in order. How would planning change if the ordering did not matter? [report - 10 pts]

c. Describe a time scaling function you would use when constructing a trajectory. Consider initial and final accelerations as well as at the via points. [report - 10 pts]

d. The robot is designed with a water vacuum at the back of the robot, meaning during turns and rotations, the vacuum may miss water pick-up. What ways can you design your path or trajectory to prevent left-over water? [report - 10 pts]

e. Describe a path planning approach for full floor coverage while avoiding obstacles. [report - 10 pts]

[50 pts]

END OF COURSEWORK