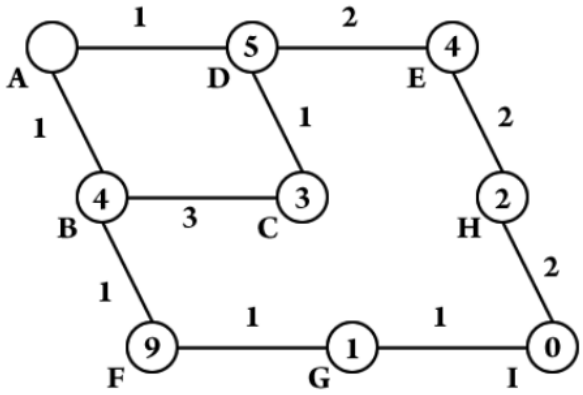
BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI
COMPREHENSIVE EXAM, CLOSED BOOK,
FIRST SEMESTER, 2023-2024
AUTONOMOUS MOBILE ROBOTICS (BITS F451)

DATE: 13th Dec 2023 **MAX MARKS: 35** **WEIGHTAGE: 35%** **TIME: 180 Min**

Q.1. (a) For the graph below, **run the A-Star algorithm and report the nodes visited in order**, and the best path that A-Star returns. Start at node A and the goal is node I. The heuristic values are the numbers inside the nodes, and the numbers on the edges are their cost.



(b) Did A-Star return the correct shortest path? Why or why not? If it did not, what number would you change to guarantee that the path A-Star returns is the shortest?

(c) The A∗ algorithm employs a heuristic to perform the search with higher efficiency than the Dijkstra algorithm. What properties of the heuristic are required to ensure that A∗ is optimal?

(d) What type of graph search is A-Star? Why? **[02+01+01+01 = 06 M]**

Q.2. Given the masks:

$$A = \begin{pmatrix} \frac{1}{9} & \frac{1}{9} & \frac{1}{9} \\ \frac{1}{9} & \frac{1}{9} & \frac{1}{9} \\ \frac{1}{9} & \frac{1}{9} & \frac{1}{9} \end{pmatrix} \quad B = \begin{pmatrix} 1 & 0 & -1 \\ 1 & 0 & -1 \\ 1 & 0 & -1 \end{pmatrix}$$

(a) What do the two masks do? Please justify your answers.

(b) If you applied mask A to an image several hundred times, and then applied mask B to the result, what would expect the output values to be? Please justify your answer.

(c) Design a 3x3 mask that to detect edges that are at a 45-degree angle to the horizontal.

(d) What is the convolution output if filter F is applied to the following A matrix assuming zero padding?

$$F = \begin{bmatrix} 0 & 0 & -1 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \end{bmatrix} \qquad A = \begin{bmatrix} 1 & 2 & 3 & 4 \\ 5 & 6 & 7 & 8 \\ 8 & 7 & 6 & 5 \\ 4 & 3 & 2 & 1 \end{bmatrix}$$

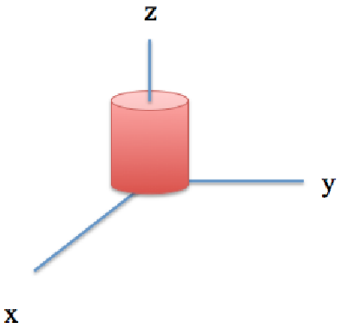
[01*4 = 04 M]

Q.3. (a) Why is the term "encoder error" misleading? Answer in not more than two sentences.

(b) You run a basic differentially driven robot with two motors and no control system 20 feet and record the ending location. You repeat this process 100 times. Draw what the distribution of endpoints might look like.

(c) What quantity does the velocity and odometry motion models compute? **[01*3 = 03 M]**

Q.4. Homogeneous Transformations and Forward Kinematics



Starting cylinder configuration. Bottom face resting on XY plane. Centre of circle on origin.

(a) Draw the outcome of the above cylinder that experiences the following RELATIVE transformation: Translation 3 units in the x direction. Rotation 90 degrees on the z axis. Make sure you keep the world frame in your drawing, also.

(b) Draw the outcome of the above cylinder that experiences the following RELATIVE transformation starting from the initial pictured configuration: Rotation 90 degrees on the y axis, translation 2 units in the y direction, translation 1 unit in the negative x direction. Make sure you keep the world frame in your drawing, also.

(c) Write the homogeneous matrices representing the previous relative rotation 90 degrees on the y axis, 2 units in the y direction, then 1 unit in the negative x direction. **[01*3 = 03 M]**

Q.5. In some multiple-choice examination each question has exactly two possible answers. A student knows the correct answers to a proportion K of all the questions and makes a random guess for the remaining questions. The evaluator observes that question two is correctly answered (Z_2 = correct) by the student. What is the probability that the student was guessing based on this observation? Derive the formula for the conditional probability and calculate the actual percentage for K = 0.5. **[04 M]**

Q.6. List the main 3-5 steps of the Canny edge detector. **[05 M]**

Q.7. List the main 3-5 steps of the Harris corner detector. **[05 M]**

Q.8. How do you make an image patch descriptor rotationally invariant? **[05 M]**

***** **BEST OF LUCK** *****