BITS F327 AI for Robotics

BITS-Pilani, Hyderabad, 2022-23-I

Mid-sem Exam [make-up]

Duration: 90 mins. [***Close Book/Note Exam***] Total Marks: 45

Answer all Questions

1. How to perform *Rank Based Selection* in a Genetic Algorithm? Explain with example. [2+2]

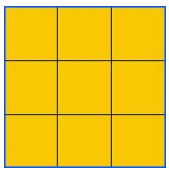
2. For a differential drive mobile robot – Assume that its left wheel speed is V_l, its right wheel speed is V_r, the robot speed is V_o, and the track (distance between the wheels) is W.

   a. Derive its kinematic equations for position and orientation. [2+2]

   b. If the Robot is moving with wheel velocities $\omega_r = 10$ and $\omega_l = 5\sin(2t)$. Find out the equation of motion in the Global coordinate frame. Where W = 2 and wheel diameter is 1.5 unit. [6]

3.

   a. For the following environment use D* algorithm? Start and Goal blocks are two diagonally opposite blocks. [3]



   b. If in the beginngin the middle block is found to be the obstacle. How it will be avoided using the algorithm. Show steps. [4]

4. Show the DoFs of a Castor wheel with proper diagram. [2]

5. Explain two limitations of the Grid representation of a map. [2+2]

6. What is Pareto Optimality? [2]

7. The state evolution and measurement are governed by

$$x_{k+1} = \frac{x_k}{2} + 25\frac{x_k}{1+x_k^2} + 8\cos(1.2(k+1)) + v_k$$

$$y_k = \frac{x_k^2}{20} + e_k$$

with independent Gaussian noise $v_k \sim N(0, 10)$, $e_k \sim N(0, 1)$.

Show the estimate of the state after the implementation of Kalman filter for two steps. [4+4]

8. Sensor noise is characterized by the conditional probabilities, given as the probability of correct measurement as $P(Z_t) = 0.xy$ [xy = last two digits of your roll number] for detecting open/closed doors correctly.

   Also, when the robot uses its manipulator to push the door open, it has an 85% chance that the door will be open afterwards.

   a. In the case of the initially unknown state of the door, predict the state of the door after the robot takes a control action of 'pushing the door'. [4]

   b. Find out the state of the door after the measurement update. [4]

9. GA:

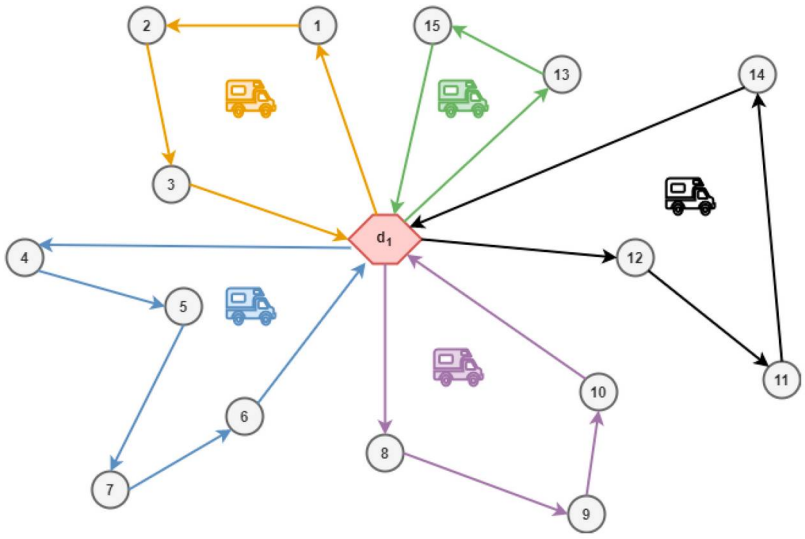
   https://www.phase-trans.msm.cam.ac.uk/2006/ga_html_files/ga_html_files/ga_questions.html

   https://www.mlstack.cafe/blog/genetic-algorithms-interview-questions

   https://www.mlstack.cafe/interview-questions/genetic-algorithms

   https://testbook.com/objective-questions/mcq-on-genetic-algorithms--5eea6a0e39140f30f369e524

10. https://arxiv.org/pdf/1308.4675.pdf
11. Vehicle routing problem - https://www.mlstack.cafe/blog/genetic-algorithms-interview-questions



a.

12. How would you encode the structure of a *Neural Network* into a *genome*?

13. What is *NEAT (Neuroevolution of Augmenting Topologies)* algorithm?

14. What is *Time Complexity* of a basic *Genetic Algorithm*?

15. https://www.phase-trans.msm.cam.ac.uk/2006/ga_html_files/ga_html_files/ga_questions.html

    a. A Bayesian neural network has been trained for the yield stress σ_y of stainless steel. The inputs to the neural network are listed in Table 3.

2. Write down a suitable chromosome for the optimisation of this model.
3. Assume a target yield stress $\sigma_{y,\text{target}}$ is desired, with low uncertainty. Write down a suitable fitness function F_i.
4. Draw up a flowchart showing the steps a genetic algorithm optimisation would take for this network model.

Remember to include some way of preventing non-physical values, and a suitable termination

condition.

a. **Table 3:** Inputs to the neural network for question 2.

Input	Definition
Cr	Chromium (wt %)
Ni	Nickel (wt %)
Mo	Molybdenum (wt %)
Mn	Manganese (wt %)
Si	Silicon (wt %)
Nb	Niobium (wt %)
Ti	Titanium (wt %)
V	Vanadium (wt %)
Cu	Copper (wt %)
N	Nitrogen (wt %)
C	Carbon (wt %)
Ratio	Ti and Nb stabilisation ratio $\frac{(Ti/4)+(Nb/8)}{C+N}$
T_{heat}	Heat treatment temperature (K)
t_{heat}	Heat treatment time (hr)
$\ln(t_{heat})$	Natural log of t_{heat}
T_{test}	Tensile test temperature (K)

b. Ans. https://www.phase-trans.msm.cam.ac.uk/2006/ga_html_files/ga_html_files/ga_answers.html

2.