Artificial Intelligence : Final Lab Exam

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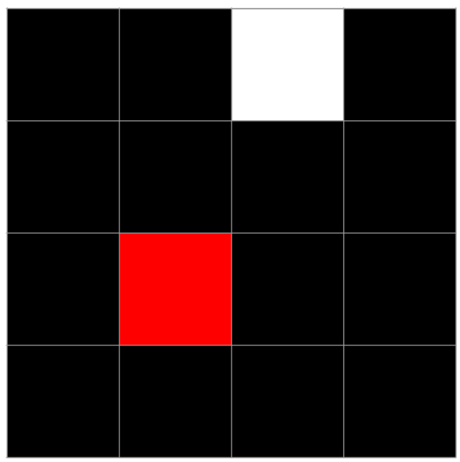
1 Question 1: 20 marks , $30 - 45$ minutes

Consider a $n \times n$ grid, with blocks represented by black color, and empty spaces represented by white color. The goal is to move the block in red color to the top right corner (see). Use A^* to find the shortest number of moves to attain the goal.



2 Question 2: 20 marks , $30 - 45$ minutes

Consider the following multi-objective optimization problem, where $F = (f_1, f_2, f_3)$ forms the objective function. $x \in \mathcal{X} \subset \mathcal{R}^5$. Each dimension of $\mathcal{X}$ is -2.04 to 2.04.

$$
\begin{aligned}
f_1(x_i) &= \sum_{i=1}^{5} x_i^2 \\
f_2(x_i) &= \sum_{i=1}^{5} integer(x_i) = floor(x_i) = \lfloor x_i \rfloor \\
f_3(x_i) &= \left(\sum_{i=1}^{5} i x_i^4 \right) + N(0,1)
\end{aligned} \tag{1}
$$

Develop a multi-objective genetic algorithm to solve the above problem.

- Real values are allowed. Explain with brief justification how you modified the phenotype to genotype encoding to handle real values. Take precision to be 2 decimal places.
- Vary population size N as $\{50, 100, 200\}$

- Vary cross-over probability as $\{0.2, 0.3\}$
- Vary mutation probability $\{0.01, 0.05\}$
- Iterate for $\{10, 20, 50, 100, 200, 500\}$ epochs
- Compare among following methods
  - Random search
  - Basic genetic algorithm (what is basic is defined in the class)
  - GA with elitism (you can choose your parameter and technique)
  - GA with diversity (you can choose your parameter and technique)
- You can extend the code you developed during lab session.
- Show plots that best explain your experiment. In each plot you can use the value of the objective function in y-axis, and x-axis appropriately.

3 Question 3: 20 marks, $1:30-2$ hrs

(Sutton and Barto [1]) Jack manages three locations for a nationwide car rental company. Each day, some number of customers arrive at each location to rent cars. If Jack has a car available, he rents it out and is credited 10 by the national company. If he is out of cars at that location, then the business is lost. Cars become available for renting the day after they are returned. To help ensure that cars are available where they are needed, Jack can move them between the locations overnight, at a cost of 2 per car moved, and no cost of moving between second and third location . We assume that the number of cars requested and returned at each location are Poisson random variables, meaning that the probability that the number is n is $\frac{\lambda^n}{n!}e^{-\lambda}$, where λ is the expected number. Suppose λ is 3, 2 and 2 for rental requests at the first, second and third locations and 3, 1 and 1 for returns.

To simplify the problem slightly, we assume that there can be no more than 19 cars at first location and 9 cars each in the second and the third locations (any additional cars are returned to the nationwide company, and thus disappear from the problem) and a maximum of five cars can be moved from one location to the other in one night. Take the discount rate to be 0.9 and formulate this as a infinite horizon discounted cost MDP, where the time steps are days, the state is the number of cars at each location at the end of the day, and the actions are the net numbers of cars moved between the two locations overnight.

Code the value iteration algorithm in Python using a threshold of 0.1 (for convergence) . Have your code print the converged value functions and the associated policy in a $20 \times 10 \times 10$ array (this can be done by printing say 10×10 entries one after the other in the form of a 200×10 array).