PRACTICE QUESTIONS

Multiple Choice Questions

Introduction to CI and Responsible CI

1. (1 point) What is the main point of the Chinese room thought experiment, as proposed by the philosopher John Searle in 1980?
    A. A machine's "intelligence" is proportional to the number of operations that it can do autonomously.
    B. Machines might be able to demonstrate "intelligent behavior" while not being conscious or having understanding in a human sense.
    C. Machines that demonstrate "intelligent behavior" must posses some sort of consciousness, even if that consciousness is different from what humans have.
    D. In order for a machine to be considered "intelligent", it needs to be able to translate messages between two native speakers of different languages without being identified as a technical artifact.

2. (1 point) What statement best captures the relation of transfer and fitness function?
    A. After specifying the fitness function, the transfer function is no longer needed.
    B. The fitness function specifies the objective for the behavior modeled by the transfer function.
    C. The transfer function specifies how to behave by investigating the fitness function.
    D. They are two words for the same thing.

3. (1 point) The main difference between regression and classification is:
    A. Targets of a classification problem are discrete, while regression targets are continuous.
    B. Regression cannot be done with neural networks.
    C. Regression is unsupervised while classification is supervised learning.
    D. Regression is supervised while classification is unsupervised learning.

4. (1 point) A conundrum known as the frame problem within artificial intelligence concerns the application of knowledge about the past to draw inferences about the future. More specifically, it deals with defining what is relevant for a given system. Why is the frame problem so difficult to solve?
    A. We don't know everything contextually required to solve a particular problem, so we cannot convey all the relevant data to an AI agent.
    B. We need tremendous amounts of computational capacity to compute it.
    C. AI agent always make generalizations that may end up harming people even when we do not expect it.
    D. Because there is always the possibility the AI agents hacks his way into optimizing its utility function rather than solving the problem.

Artificial Neural Networks

5. (1 point) Which of the following statements about convolutional neural networks (CNNs) is **FALSE**:
    A. Filters at the first layers detect more low-level features than filters at last layers.
    B. Multiple convolution filters are applied in parallel in every CNN layer.
    C. Convolution filter can only be applied on 2D feature maps.
    D. CNNs are more sparsely connected than MLPs.

6. (1 point) What type of activation function is best to use for the output layer of a multilayer perceptron if you want to train the model on predicting a person's weight given her height?
   A. None.
   B. ReLU.
   C. Tanh.
   D. Softmax.

7. (1 point) Which of the following statements about the standard backpropagation algorithm is **FALSE**:
   A. Backpropagation computes the gradient of the loss (objective) function with respect to the weights of the neural network.
   B. Backpropagation reduces the number of operations by reusing the results of previous gradient computations.
   C. The gradient of the loss (objective) function indicates the direction of steepest descent.
   D. Backpropagation always leads to the global optimum.

Genetic Algorithms

8. (1 point) Consider that you are designing a tablet computer for children. You want to optimize the dimensions ($width$, $height$, and $length$) of the tablet. The evaluation criterion is the $comfort$ with which the children can hold the tablet in their hands. If you want to solve this problem via the Genetic Algorithm, how would you encode the problem?
   A. The chromosome represents the sum of the three dimension of the tablet.
   B. The chromosome is a concatenation of 3 elements, representing each dimension of the tablet.
   C. The chromosome has one element, representing the evaluation criterion.
   D. The chromosome is a concatenation of 4 elements, representing each dimension of the tablet and the evaluation criterion.

9. (1 point) The *performance graph* of a Genetic Algorithm plots ...
   A. the computational time and memory used by the GA over generations.
   B. the convergence time of the GA over different sizes of initial population.
   C. the average fitness of the last generation (of a fixed number of generations) over different chromosome sizes.
   D. the average fitness of the population and the fitness of the fittest individual per population over generations.

10. (1 point) Consider that a genetic algorithm uses chromosomes of the form $X = abcd$ with a fixed length of four genes. Each gene can be any integer value between 0 (inclusive) and 9 (inclusive).

    Let the fitness of an individual be calculated as: $F(X) = 18 + (a - b + c - d)$.

    Which of the following four chromosomes has the highest likelihood of getting selected for modification according to roulette wheel selection strategy?
    A. $X_1 = 5412$
    B. $X_2 = 1987$
    C. $X_3 = 3693$
    D. $X_4 = 0450$

Swarm Intelligence

11. (1 point) A key difference between Particle Swarm Optimization (PSO) and Genetic Algorithms (GA) is:
    A. A GA uses stochastic search, PSO does not.
    B. A GA uses a population of individuals, PSO does not.
    C. A GA uses a fitness function, PSO does not.
    D. A GA has generations of individuals, PSO does not.

12. (1 point) In Particle Swarm Optimization (PSO), each particle i moves through the solution space depending on its velocity v, which for each solution space dimension j, is expressed as:

$$v_{ij}(t+1) = v_{ij}(t) + c_1 r_{1j}(t)[y_{ij}(t) - x_{ij}(t)] + c_2 r_{2j}(t)[\hat{y}_{ij}(t) - x_{ij}(t)]$$

If you want the whole swarm to be strongly biased towards the collectively found best solution, then you need to set:

A. $c_2 \gg c_1$.

B. $c_2 \ll c_1$.

C. $\hat{y}_{ij}(t) \gg y_{ij}(t)$.

D. $\hat{y}_{ij}(t) \ll y_{ij}(t)$.

13. (1 point) What is a valid reason for the evaporation of pheromone in an Ant Colony Optimization algorithm?

A. The evaporation of pheromone indicates a clear route so that, ant after ant, shorter and shorter routes can be found.

B. The evaporation of pheromone avoids that a single ant can reach the shortest route before the other ants.

C. The evaporation of pheromone avoids that ants visit the same node more than once.

D. The evaporation of pheromone can be seen as an exploration mechanism that avoids quick convergence of all the ants toward a suboptimal path.

Reinforcement Learning

14. (1 point) Reinforcement Learning (RL) is *NOT* needed to (pick one):

A. solve a repeated action selection problem with delayed rewards.

B. optimize expected cumulative return over a series of state-action-state transitions.

C. solve *supervised classification* problems.

D. solve temporal credit assignment problems.

15. (1 point) In Reinforcement Learning (RL), which reward formulation might be used:

A. $R(s')$

B. $R(s, a, s')$

C. $\Pr(r|s, a, s')$

D. All of the above.

Open-ended Questions

Artificial Neural Networks

16. A multilayer perceptron (MLP) is designed to perform binary classification (i.e. two classes) given a 3-dimensional input. The network has one hidden layer with 4 hidden neurons.

(a) (1 point) Write down the equations in matrix form for forward-passing one sample. Please, define any new notation you introduce that is different from the one we used in class.

(b) (1 point) What type of activation function did you use? Why?

(c) (1 point) Specify the size of all vectors and matrices you indicated in part **a**.

(d) (1 point) How would you forward-pass 10 samples at the same time? What would be the new dimensions of all vectors and matrices?

Genetic Algorithms

17. (4 points) Assume that we are employing the Non-dominated Sorting Genetic Algorithm, NSGA-II, for finding vendors of COVID-19 test kits. We are interested in finding vendors who supply test kits having low *cost* and high *reliability*.

    At an intermediate stage in the search process, we have eight candidate vendors (A–H) whose test kits have the cost and reliability as shown in Table 1. All the values have been normalized from 0 to 10.

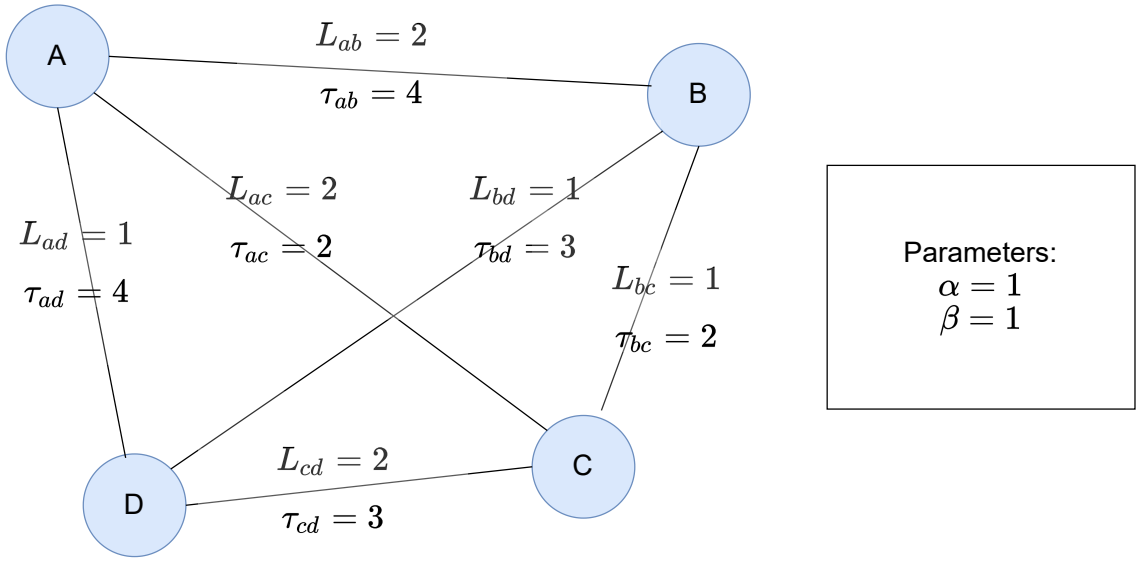
    Now, if we want the NSGA-II algorithm to select only **four** candidates to pass onto the next step, which four candidates would the algorithm choose? For each candidate you identify, provide a justification as to why NSGA-II would choose that candidate.

Table 1: Candidate COVID-19 test kit vendors

Vendor	Cost	Reliability
A	0	4
B	6	2
C	2	7
D	8	3
E	7	9
F	2	2
G	4	4
H	8	6

Swarm Intelligence

18. Consider the Traveling Salesman Problem presented in the figure below. The length of the links (L) and the amount of pheromone (τ) deposited in each link after a given number of iterations are indicated in the figure. Answer the following questions using Ant Colony Optimization (ACO, Ant-Cycle algorithm), considering the parameters indicated in the box.



(a) (2 points) Suppose a given ant starts at node A. What is the probability that this ant will move from node A to node B?

(b) (2 points) Consider that the same ant that started on node A has now moved to node B. What is the probability that the next move of this ant will be from node B to node C?

Reinforcement Learning

19. You ran out of coffee, and are busy, so you send your robot to the store on your behalf. The store consists of 4 locations: entrance, aisle 1, aisle 2, and checkout that can be navigated in the stated order by the action "move on" and in the reverse order by action "move back". There is a small probability (10%) of not moving. The coffee is located in aisle 2, and can be grabbed with the "pick coffee action" (80% success rate, if not successful the state does not change). When the robot has the coffee, it should of course "pay" at the checkout (100% success rate), after which the problem terminates and the robot is rewarded with $R(s = *, a = *, s' = terminated) = +10$. Otherwise, the reward is -1. There are no other action effects: e.g., performing the "pick coffee" in aisle 1 means that the state will not change. The problem begins after robot enters the store at the entrance, without coffee.

    (a) (2 points) Draw a description of the transitions of the MDP: nodes represent states, while arrows annotated with actions and probabilities should represent the transitions. Actions that lead deterministically to no change in state can be omitted to avoid clutter. Put names in the states that you can use below.

    (b) (3 points) Iterative policy evaluation, applies the Bellman equation in iterations indexed by k. For a deterministic policy π, that takes action $\pi(s) = a$ in state s, the update rule is given by:

$$v_{k+1}(s) := \sum_{s'} P(s'|s, \pi(s)) \left[R(s, \pi(s), s') + \gamma v_k(s')\right]$$

    In this question, you need to use this formula to determine the $k = 4$-steps-to-go value function, $v_4(s)$, for a policy that we will now describe:

    - When coffee is picked up: move towards the checkout and then pay. When not picked up: perform the "pickup" action.
    - First write down the explicit (tabular) representation of the policy
    - Use a discount factor of 0.9.

    (c) (1 point) What is $v_\pi(s_0)$ the value for the policy π starting in the initial state s_0. Clearly explain your calculations.

End of exam.
Please make sure you answerred all 19 questions.