Artificial Intelligence (F19)
Quiz 2 (QZ2)

Identikey: ________________________

First Name: ________________________

Last Name: ________________________

Overview
7.5 Point Quiz on Search (7.5% of final grade)
30 minute closed book quiz

Learning Objective
This assignment satisfies learning objective 1 (LO1) as specified in the syllabus. You will demonstrate conceptual understanding of the core AI topics.

Questions

1. Genetic Algorithms [Total points: 2.0]
   You decide to apply genetic algorithms to the problem of creating cheap, but tasty meals from four main ingredient types. The fitness function is based on the cost of each ingredient, **cheaper is better!**

   The first ingredient type is a starch. Ramen and pasta are available.
   The second ingredient type is a sauce. Soy sauce and tomato sauce are available.
   The third ingredient type is a vegetable. Carrots, peas, and onions are available.
   The fourth ingredient type is a protein. Only tofu is available.

   a. [Points: 0.25] *Using a bitstring representation*, create a meal with ramen, soy sauce, carrots, and tofu.

      Solution: [1 0   1 0   1 0 0   1]

   b. [Points: 0.25] *Using a bitstring representation*, create a meal with pasta, soy sauce, carrots, onions, and no protein.

      Solution: [0 1   1 0   1 0 1   0]

   c. [Points: 0.5] Show the children of the chromosomes from (b) and (c) using crossover (you may select any crossover point). Show all your work.

      Solution:
      Chromosome 1 [1 0 1 0   1 0 0 1]   Offspring 1 [1 0 1 0   1 0 1 0]
      →
      Chromosome 2 [0 1 1 0   1 0 1 0]   Offspring 2 [0 1 1 0   1 0 0 1]

   d. [Points: 0.25] Mutate the chromosome from (a) to include pasta.

      Solution: Chromosome [1 0   1 0   1 0 0   1] → Offspring [1 1   1 0   1 0 0   1]

      Genes in red were mutated.

   e. [Points: 0.75] Is a cross-over always guaranteed to yield offspring that are fitter than the parents? If yes, provide justification. If not provide a cross-over counterexample using the bitstring meal representation and below food prices. *Remember cheaper is better*:

Ramen	\$1	Pasta	\$2		
Soy sauce	\$2	Tomato sauce	\$1		
Carrots	\$3	Onions	\$2	Peas	\$1
Tofu	\$5				

Circle one: Yes No

Justification:

Solution: No. Cross over involves randomness and could produce offspring that are less fit than the parent. For example,

Chromosome 1 [1 0 1 0 1 0 0 1]
Fitness = 1 + 2 + 3 + 5 = \$10

→

Offspring 1 [1 0 1 0 1 0 1 0]
Fitness = 1 + 2 + 3 + 1 + 0 = \$7

Chromosome 2 [0 1 1 0 1 0 1 0]
Fitness = 2 + 2 + 3 + 1 + 0 = \$8

Offspring 2 [0 1 1 0 1 0 0 1]
Fitness = 2 + 2 + 3 + 5 = \$12 *Offspring 2 is less fit than either of the parents.*

2. Ant Colony Optimization [Total points: 2.5]
   a. [Points 0.75] We are using Ant Colony Optimization to solve a Traveling Salesperson Problem (TSP) involving three cities A, B, and C. The path costs are: **AB =** 4, **AC =** 5, **BC =** 2. An ant located at A is considering the next edge to add to its tour. If the pheromone levels are 0.5 on all paths, which path is the ant more likely to take?
      i. AB
      ii. BC
      iii. AC
      iv. All paths are equally likely
      v. The ant will not take any of the paths and will stay at A.

      Justification:

      Solution: AB because the cost is the lowest of the available paths and the pheromone levels are all equal so it will have no influence on the choice.

   b. [Total Points: 0.75] Consider the cost of the following 3 tours taken by 3 ants *on a different TSP*:

      Ant 1: P - Q - R - S - P ; Cost = 10
      Ant 2: P - R - S - Q - P ; Cost = 30
      Ant 3: S - Q - R - P - S ; Cost = 20

      What is the local pheromone update for the paths QR and PR (note paths are **not** symmetric so QR ≠ RQ; PR ≠ RP)? *Show your work to get full credit.*

      Solution: $\boldsymbol{\tau}_{QR} = 1/10 + 1/20$
      $\boldsymbol{\tau}_{PR} = 1/30$

c. [0.75 points] Consider a variant of the problem of creating a cheap meal from the four ingredient types from #1 above. Note that we need to **consider** all four ingredient types to obtain a complete meal. However, we **do not** know the cost of each ingredient, but instead know the total cost of a meal. How would you apply the ACO algorithm to obtain the cheapest meal? *Note, we are looking for a description of your solution (with your assumptions clearly specified) rather than a formal solution.*

   Solution: Each ant starts by randomly picking one ingredient from each ingredient type (e.g., ramen or pasta or none). It does this for all ingredient types until it has a complete meal. It then adjusts the pheromone values for each ingredient based on the total cost of the meal. These updated pheromone values are then used in the next decision in that ingredients which cost less will be more likely to be selected.

   For example:

   Ant 1: ramen, soy, carrot, tofu = 11
   Ant 2: ramen, soy, pea, no tofu = 4

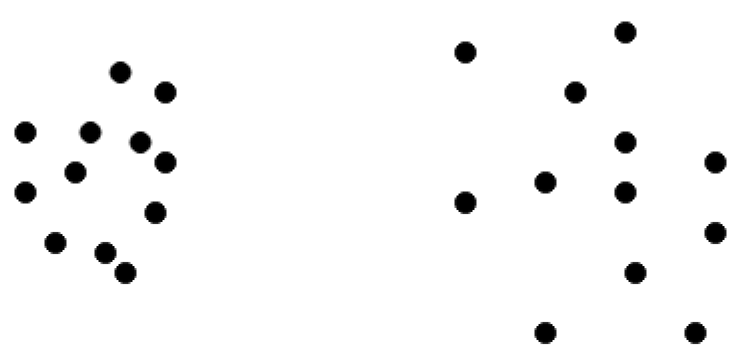
   So ramen = 1/11 + 1/4
   Pea = 1/4

   and so on.

d. [0.25 points] What is the role of the rho parameter in the ACO algorithm?
   i. There is no such parameter
   ii. It increases the pheromone value
   iii. It decreases the pheromone value
   iv. It has no influence

   Solution: Option iii) It decreases the pheromone value via "evaporation".

3. Particle Swarm Optimization [Total Points: 1.5]
   a. [Points: 0.5] The images below show two runs of a PSO simulation at iteration 50. Both simulations had the same starting conditions (number of particles, initial positions, initial velocity),, the same social and individual influence, and the same randomization values at each iteration. Which simulation has the higher inertia value? Justify your choice.



(A) **(B)**

i. Simulation (A) has the higher inertia value
ii. Simulation (B) has the higher inertia value
iii. They have the same inertia value

Justification:

Solution: (B) has the higher inertia value. Since other parameters are kept constant, inertia explains why the particles in (B) are slower to converge.

b. [Points: 0.5] Consider iteration 100 of two runs of PSO shown below. Both have the same starting conditions (number of particles, initial positions, initial velocity), the same inertia weights, and the same randomization values at each iteration. How do you explain the differences in behavior?

(X) **(Y)**

Solution: The differences in behavior can be attributed to (Y) having a higher individual to social influence ratio than (X). Due to that, Y's particles are more likely to follow their local optima than to converge to a single solution.

c. [Points: 0.25] Which of simulations (X) and (Y) from (b) above are more likely to find the global optimum.

i. They are both equally likely
ii. Simulation (X) is more likely
iii. Simulation (Y) is more likely

Solution: (X) is more likely. Since (Y) has a higher individual to social influence ratio, its particles may get stuck in local optima.

d. [Points: 0.25] Which natural behavior does PSO most closely model? Circle one answer. Provide justification.

i) Flocking
ii) Foraging
iii) Learning
iv) Socializing

Solution: Flocking. Particles follow and match each other, generally trending towards a converged solution over time.

4. Behavior Based AI[Total Points: 1.5]

How do **behavior networks** implement the following core concepts of multiagent systems?

a. [Points: 0.5] "society of mind"

Solution: The power of intelligence stems from our vast diversity, not from any single, perfect principle. In behavior nets, each behavior is a simple mind, each performing a single task under the appropriate circumstances. However, when connected in a network, the sum total of their behaviors can be very intelligent.

b. [Points: 0.5] "emergence"

Solution: Intelligence emerges from the interaction of simple modules E.g. obstacle avoidance, goal finding, wall following modules. Individual components are simple, but resulting combined behavior appears intelligent, such as a robot safely performing a task in the real world.

c. [Points: 0.5] "decentralized control"

Solution: In a behavior network, there is no central controller scheduling the order in which the behaviors should execute. Rather it is the dynamics of the network itself with health cooperation and competition among behaviors that determines the dynamics.