Metaheuristics Exam – M1

March 2024

Calculator authorized. Documents not authorized.

Fill annexed tables to answer questions from the different parts. Do not forget to fill your full name.

Part1 – Course questions. Check these statements if they are true or false. (9)

1. Metaheuristic algorithms give the guaranty to find the absolute best solution to optimization problems in reasonable time.

2. In Metaheuristics, encoding a solution has the same meaning as representing a solution.

3. The search space of a problem corresponds to the set of all possible solutions of the problem.

4. In Simulated annealing algorithm, low temperatures increase the probability of degrading current solution.

5. In Tabu search algorithm, diversification permits to focus the search around the best solution.

6. In Ant Colony Optimization, the evaporation process allows the pheromone matrix to fade over time to concentrate only on the elite solutions.

7. In genetic algorithms, crossover operation is equivalent to mutation in terms of solution representation.

8. The neighborhood of a solution in a metaheuristic corresponds to the set of all possible solutions in the search space.

9. In simulated annealing, the temperature parameter is increased during the search to escape local optima.

Part2 – Single solution based metaheuristics (5.5)

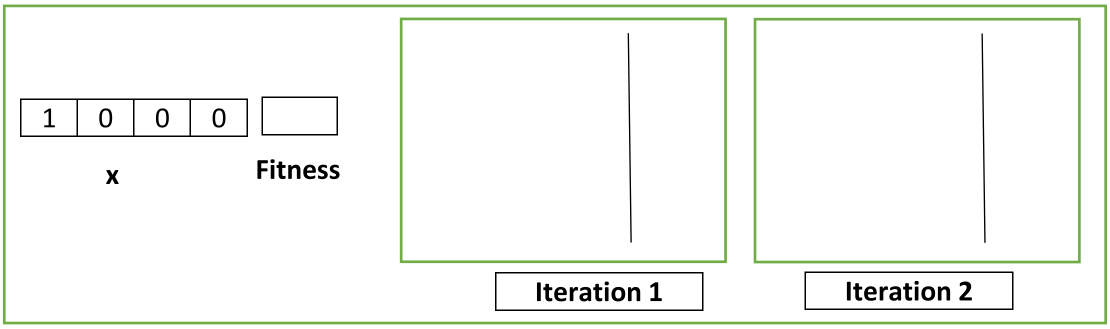
1. In order to find the integer $x \in [0, 63]$ that minimizes $f(x) = -6x^2 + 4x + 9$, we want to use binary presentation for x to solve this optimization problem. (1.5)

   a. What is the length of x solution (number of binary variables)?
   b. What is the size of the search space for this problem?
   c. What is size of the neighborhood for a given solution?
   d. Generate randomly a solution then calculate the fitness value of this solution using the objective function.

2. In order to find the value of the integer x that maximizes f(x), we decide to exploit a **local search** algorithm and we randomly generated the following solution x = [1, 0, 0, 0]: (1)

   a) What is the range of the solution x?
   b) What is the size of the search space for this problem?
   c) What is size of the neighborhood for a given solution?

3. Now, we go through the first two iterations of the local search algorithm. Complete Figure 1 by using the following local search strategies: (3)
    a. Best improvement.
    b. First improvement.
    c. Random improvement (here it is supposed that the last improvement which will be selected).



Part3 – Population solution based metaheuristics (6.5)

Considering the TSP problem with the following data and based on a genetic algorithm:

	1	2	3	4	5	6
1	0	12	5	4	6	3
2		0	8	11	20	9
3			0	7	10	14
4				0	11	12
5					0	6
6						0

SYMMETRIC COST MATRIX

1	1	2	3	4	5	6
2	3	4	6	1	5	2
3	4	3	6	5	2	1
4	6	1	3	2	4	5
5	4	6	5	1	2	3

POPULATION OF 5 SOLUTIONS

1. Calculate the objective function for each solution of the population. (1.25)
2. Using Rank based selection strategy indicate which solution will have the highest probability of selection when the selection pressure *s* is (0.5)
    a. Equal To 1
    b. Equal to 2
3. Give the result of a crossover operation at position 3 between solutions (1)
    a. (1, 4)
    b. (2, 5).
4. Based on the produced children give the new population following a steady state replacement strategy. (1)

5. Now we will use Ant Colony algorithm to solve this TSP problem, and we have two ants in our population, which corresponds to the first two solutions of the genetic algorithm seen in the previous questions.
   a. Initialize the pheromone matrix. (0.5)
   b. Use the two ants to update the pheromone matrix, supposing that the reinforcement is applied ant by ant and the Evaporation is applied once after passing all the ants population with $\rho = 0.1$. . (1.5)
   c. By using the pheromone matrix and the symmetric cost matric, construct the path of the two new ants. In this example, we suppose that the highest probability is always selected to define the next city, also, we suppose that the pheromone matrix is updated after constructing each ant path ($\alpha = \beta = 1$). (0.75)