Department of Computer Science
University of Kerala
M Sc Computer Science & M Sc Computer Science (Sp: Artificial Intelligence)
CSA-DSE-436(v): Nature Inspired Computing
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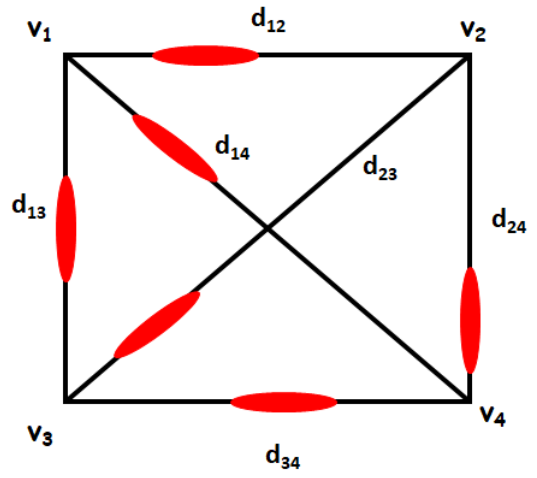
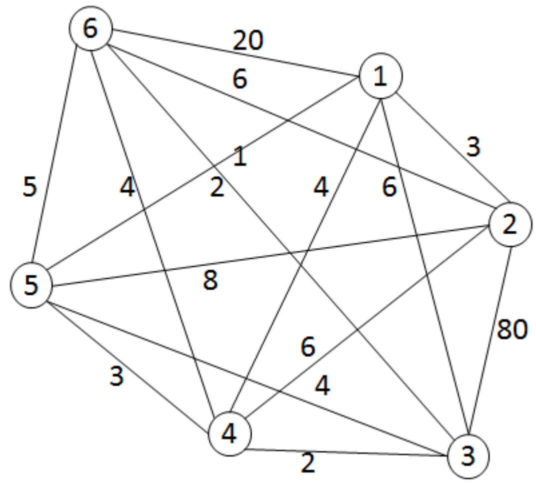
1. In the travelling salesperson problem, we could represent the problem as a sequence of cities, 1..n. We could get infeasible solutions using a genetic algorithm with 1- point crossover. Assuming we could not change the crossover operator, how could we overcome this problem? If we could use a different crossover operator, which one would you suggest? Give an example.
2. Consider a population of simple creatures with a single chromosome of length n= 1000. Each entry in the chromosome can take four values (A, G, C, T). Assume M is the population size.
   a. How many possible chromosomes are there?
   b. Assuming that the chromosome length and the population size remain constant, what is the upper limit of the number of different chromosomes evaluated in the course of G generations?
   c. If the population size is constant and equal to 1022, how large is a fraction of the total number of chromosomes evaluated during 109 generations, assuming all evaluated chromosomes are different?
3. Consider the problem of finding the shortest route through several cities, such that each city is visited only once and returns to the starting city (the travelling salesperson problem). Suppose that to solve this problem, we use a genetic algorithm in which genes represent links between pairs of cities. For example, a link between London and Paris is represented by a single gene,' LP'. Let's also assume that the direction we travel is not important, so LP = PL.
   a. How many genes will be used in a chromosome of each individual if the number of cities is 10?
   b. How many genes will be in the alphabet of the algorithm?
4. Write an evolutionary algorithm that searches for the shortest route between N cities. Use an encoding method such that the chromosomes consist of lists of integers determining the indices of cities. Examples of five-city paths starting in city 4 are examples (4, 3, 1, 2, 5), (4, 1, 5, 2, 3), (4, 5, 1, 2, 3) etc. The first chromosome thus encodes the path 4→3→1→2→5→4. The fitness should be taken as the inverse of the route length (calculated using the ordinary Cartesian distance measure, not the Manhattan measure). The program should always generate syntactically correct routes, that is, routes in which each city is visited once and only once until, in the final step, the tour ends with a return to the starting city. Specialized operators for crossover and mutation are needed in order to ensure that the paths are syntactically correct.
   a. Define a mutation operator for the travelling salesperson problem that maps valid chromosomes (that is, paths) onto other valid chromosomes.
   b. Define a crossover operator for the travelling salesperson problem that maps valid chromosomes onto other valid chromosomes.
   c. Using the specialized crossover and mutation operators, write an evolutionary algorithm that solves the Travelling Salesman Problem
5. The ACO algorithm is applied to the Travelling Salesman Problem (TSP) of 4 cities is given in Figure 1
   a. What is the transition rule (the probability of going to city j) in the ant system? Explain the variables and parameters
   b. What is the pheromone update rule in the ant system? Also, here explain the variables and parameters.
   c. Calculate a tour of one of the ants in the TSP using ACO, assuming:
   d. $v1 = (1, 5)$, $v2 = (6, 4)$, $v3 = (5, 1)$, $v4 = (1, 3)$ and $\alpha = 1$, $\beta = 5$, $\rho = 0.5$, $Q = 100$, $\tau0 = 10-6$ and simulate the required probabilities.

e. Calculate the tours of the rest of the ants, assuming m = n where m is the number of ants and n is the number of cities.
f. Apply the ant system pheromone update rule to the system. What is the best tour now?
g. Simulate the next iterations in this ACO-TSP, either by own code or by some third-party code. What is the optimal tour after ten iterations?

h. 

i. Figure 1

j. 

k. Figure 2

6. Consider the TSP in Figure 2. Edges are marked with pheromones (the numbers next to the edges) that have been deposited during previous tours of one ant, which is now sitting at the black vertex.
    a. What will be the route the ant most likely takes (assume heuristic information not to be available/constant)? Your solution should be a sequence of integers.
    b. Ignore now the pheromone values (Figure 2), and let the ant decide solely based on heuristic information. What will be the route that is most likely taken by the ant in this case? Keep in mind that the heuristic information associated with an edge is anti-proportional to the Euclidean distance in the Figure. Your solution should be a sequence of integers.
    c. Revisit Figure 2 and imagine an ant constructing a solution for the TSP using an elitist ant system given the current pheromone table. What happens when (a) an entry in the pheromone table reaches zero, and (b) an entry in the pheromone table gets much higher than others?
7. Consider an illustrative example of a particle swarm optimisation system composed of three particles and Vmax = 10. To facilitate calculation, we will ignore that r1 and r2 are random numbers and fix them to 0.5 for this exercise. The space of solutions is the two-dimensional real-valued space R2, and the current state of the swarm is as follows:

    Position of particles: x1 = (5,5); x2 = (8,3); x3 = (6,7);
    Individual best positions: x1= (5,5); x2= (7,3);x3= (5,6);
    Social best position: x= (5,5);

Velocities: v1= (2,2);v2 = (3,3); v3 = (4, 4).

   a. What would be the next position of each particle after one iteration of the PSO algorithm using inertia w= 1? (0.5%) and using w= 0.1? (0.5%)
   b. Explain why the parameter w is called inertia. (0.5%)
   c. Give an advantage and a disadvantage of a high inertia value. (0.5%)

8. Consider Figure 3. The PSO algorithm calculates the shortest path from Source A to destination E. What results when three sources and multiple destinations are assigned (say A, B are sources and E, F are destinations)?

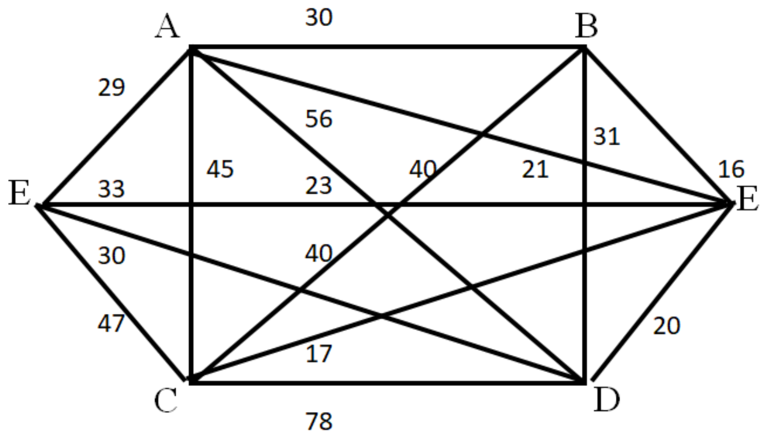


Figure 3

9. Consider Figure 4. Implement a multi-objective optimisation ABC algorithm to stove the problem for multiple source destination problems. Calculate the results for the following.
   a. Source node is 1, and the destination nodes are 14, 17 and 20.
   b. Source nodes are 1 and 5. The destination node is 20.
   c. Source nodes are 2 and 3. Destination nodes are 18 and 19.
10. Consider Figure 4, all nodes are cities. Is it possible to implement TSP using ABC algorithm for a start node 1?

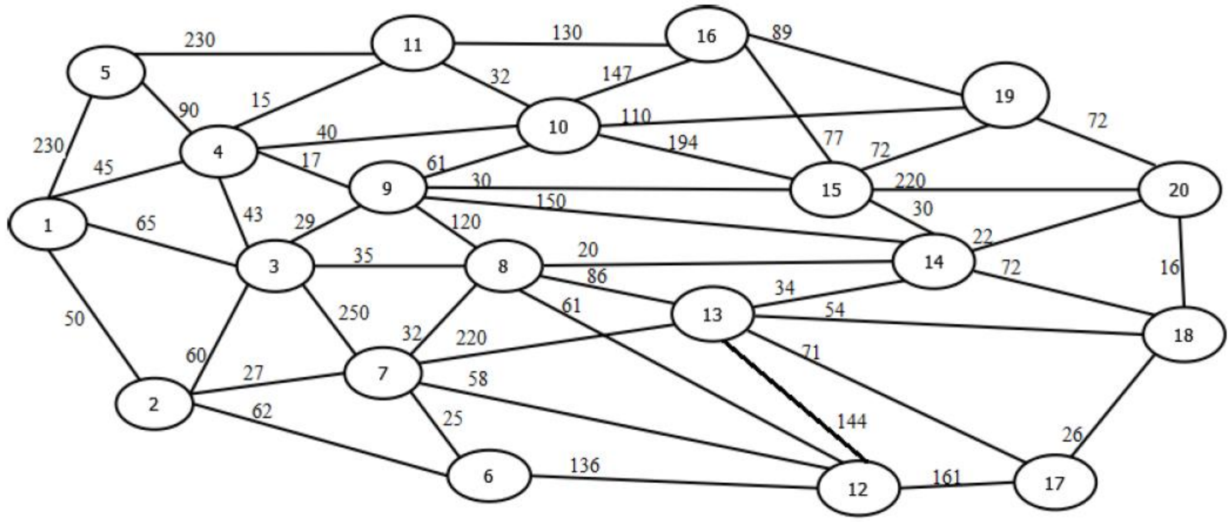


Figure 4