

Question 1

- a) How would you define swarm intelligence?
- b) What is stigmergy?
- c) What do we mean by emergence in swarm intelligence?

Question 2

The Ant System (ACO-AS) algorithm is applied to the Traveling Salesman Problem (TSP) of 4 cities $\mathbf{v} = \{v_1, v_2, v_3, v_4\}$ of distances $\mathbf{d} = \{d_{12}, d_{23}, d_{34}, d_{14}, d_{13}, d_{24}\}$ where d_{ij} is distance between city i and j .

- a) What is the transition rule (the probability of going to city j) in AS? Explain the variables and parameters.
- b) What is the pheromone update rule in AS? Also here explain the variables and parameters.
- c) Calculate a tour of one of the ants in the TSP using ACO-AS assuming:

$$v_1 = (1,5)$$

$$v_2 = (6,4)$$

$$v_3 = (5,1)$$

$$v_4 = (1,3)$$

and $\alpha = 1, \beta = 5, \rho = 0.5, Q = 100, \tau_0 = 10^{-6}$ and simulate the required probabilities.

- d) Calculate the tours of the rest of the ants assuming $m = n$ where m is number of ants and n is number of cities.
- e) Apply the AS pheromone update rule to the system. What is the best tour now?

Optional:

- f) Simulate the next iterations in this ACO-TSP, either by own code or by some third-party code. What is the optimal tour after 10 iterations?
- g) Experiment with different parameters, city configurations and other ACO methods (MMAS or ACO).