Klausur Braindump*

Swarm Intelligence

Various contributors

SUMMER SEMESTER '21

Note: This semester was the first time *Swarm Intelligence* — as compared to *Organic Computing* — was held, yet there was no time to discuss the last two chapters (P2P, CAN). Therefore this Braindump might not be representative.

1 Introduction — 11 Points

a) (3 Points) Recite three reasons given in the lecture as to why systems are becoming more complex.

b) (3 Points) Give three self-$*$-properties.

c) (3 Points) Define "emergence".

There might have been more here

d) (2 Points) Which research question and algorithm were related to emergence.
Hint: Swarm of webpages

2 Particle Swarm Optimisation — 13 Points

a) (1 Point) What properties does the objective function have?

b) (2 Points) Give and explain two similarly but opposing goals.

c) (2 Points) List all the attributes of a particle and a swarm.

Alternatively the question is what new attributes arise from a particle being part of a swarm

d) (4 Points) Draw a particle with its components, and how it changes in the next time step.

e) (4 Points) Give the exact formula for operating on a particle. Explain each parameter and type (random, dimensions, ...).

3 Convergence of PSO — 9 Points

a) (2 Points) When does PSO converge?
Hint: You only need reference two variables

b) Let the Matrix A be

$$A = \begin{pmatrix} 1-b & a \\ -b & a \end{pmatrix},$$

where the variables a and b may have any value.

i) (4 Points) Compute the eigenvalues of the matrix A.

ii) (2 Points) For which values of λ_1 and λ_2 ($\lambda_1 \geq \lambda_2$) does the swarm converge.

iii) (1 Point) Assuming λ_1 is real-valued and λ_2 is a non-real complex number, and the condition from ii) is given, sketch a diagram of how the simulation would converge.

This problem was probably broken, as this combination of Eigenvalues can only occur with a complex-valued matrix.

4 HITS **13 Points**

a) (1.5 Points) Give three kinds of search queries.

b) (1.5 Points) What does “HITS” stand for?

c) (2 Points) What do the variables $x^{(p)}$ and $y^{(p)}$ designate?

d) (6 Points) Give the formula for

The points were shared among d) and e).

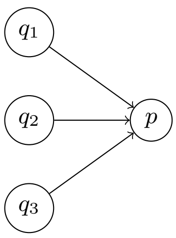
$$x^{(p)} =$$

and

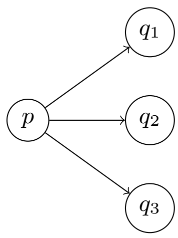
$$y^{(p)} =$$

Hint: Use $a \to b$ to represent edges

e) Mark the right variables being computed:



- ☐ $x^{(p)}$
- ☐ $y^{(p)}$



- ☐ $x^{(p)}$
- ☐ $y^{(p)}$

f) (2 Points) HITS uses the matrices $AA^\top$ and $A^\top A$. Give two important mathematical properties these matrices must have.

5 Evolutionary Algorithms **16 Points**

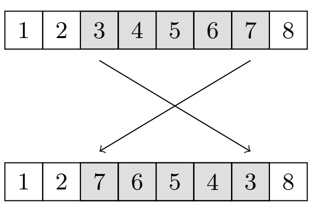
a) (6 Points) Draw the evolutionary cycle for an (μ, λ)-EA algorithm, with the objective function F.

b) (2 Points) Let $\pi = (7, 5, 3, 1, 2, 8, 4, 6)$ be an unsorted sequence. Compute INV(π) and HAM(π).

π might have alternatively ended in $\ldots, 8, 2, 4, 6)$ or $\ldots, 2, 8, 4, 6)$.

c) (2 Points) Assume π has been sorted. Give the values of INV(π) and HAM(π) that must hold in that case.

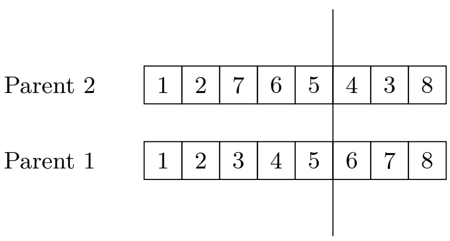
d) (3 Points) Given the following genotypes for the **Travelling Salesperson Problem**,



draw the phenotypes before and after applying the inversion operator.

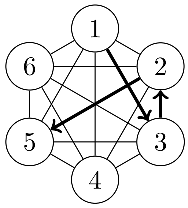
e) (3 Points) Apply the one-point crossover at the indicated line:

Parent 1 has a different value.



6 Ant Colony Optimisation **11 Points**

ACO is being used to solve TSP on the Graph



where the partial route of the ant a is $s_a = (1, 3, 2, 5)$.

It is assumed that the distance between every node is 1. The evaporation rate is $\rho = 0.5$. For every pheromone value $\tau_{ij} = \tau_{ji}$ holds.

a) (1 Point) Give the set of vertices ant a visiting the node 5 is allowed to consider next

$$\mathcal{N}(s_a) = \{$$

b) (6 Points) Compute the probabilities that ant a visiting the node 5 will choose these vertexes. Assume the pheromone values are $\tau_{45} = \tau_{25} = 3$ and $\tau_{56} = \tau_{15} = \tau_{35} = 2$.

- $p(\{1, 5\} \mid s_a)$ probability that is the ant a will move from node 5 to 1.
- $p(\{5, 6\} \mid s_a)$ probability that is the ant a will move from node 5 to 6.
- $p(\{4, 5\} \mid s_a)$ probability that is the ant a will move from node 5 to 4.

c) (2 Points) Compute the difference g_{56} that choosing the edge $5 \to 6$ would make, using "Ant Quantity" function and taking Q to be 2.

d) (2 Points) Compute the updated pheromone values for τ_{56} and τ_{45}, assuming there is only one ant a that chose the edge $5 \to 6$ in this turn.