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Exercises to
Swarm Intelligence
Summer 2022
Sheet 7

These problems are for the meetings on July 5th/12th and on July 8th/15th. Please start implementing your solutions at home before visiting the meetings. The room will always be *0.157-115 – CIP Pool EEI*, the times will be the regular exercise times.

Problem 18:
In order to test heuristics for solving difficult problems, there are often established so-called *benchmarks*, as we have already seen in the context of particle swarm optimization. These are inputs which have turned out to be particularly difficult or which have proved to be "typical" application problems. It is then possible to compare the quality of different heuristics.

For the *Traveling Salesperson Problem (TSP)* presented briefly in the lecture, the TSPLIB is such an established benchmark set. You can find it on the following webpage of the *Konrad-Zuse-Zentrum für Informationstechnik Berlin* (ZIB):
`http://elib.zib.de/pub/mp-testdata/tsp/tsplib/tsplib.html`
You get the input instances, when you follow the link "→TSP data", the manual, which describes the input format, can be found under "doc.ps".
`http://elib.zib.de/pub/mp-testdata/tsp/tsplib/doc.ps`.

An algorithmic description of ant algorithms can be found in the doctoral thesis *Convergence Analysis for Particle Swarm Optimization* by Manuel Schmitt on pages 45 to 48.
The webpage of this thesis in our library:
`https://nbn-resolving.org/urn:nbn:de:bvb:29-opus4-61621`
The pdf file of the thesis for direct download:
`https://opus4.kobv.de/opus4-fau/files/6162/Dissertation_BertholdImmanuelSchmitt.pdf`
The given text passage describes the *Ant Algorithm* with the so-called *Ant Cycle* strategy for the *Traveling Salesperson Problem (TSP)*.

(a) Implement the *Ant Algorithm* with *Ant Cycle* strategy for the TSP. Note that the pheromone concentration should **not** change during the construction of a single round trip, but only **after** all ants have determined a round trip. This is line 12 in Schmitt's „Algorithm 3: Ant Algorithm."

What results do you get for the problem instances `ulysses16` and `ulysses22` of the TSPLIB (files for the graphs **including the distances (very important!)**, can be downloaded from the StudOn page of this Sheet 7)?

(Settings for the implmentation are given here ➺)

Notes:

– Use the following (parameter) settings for your test runs: $\alpha = 1$, $\beta = 2$, $\varrho = 0.5$, and, for $Q_3 = 100$,

$$\Delta\tau_{i,j}^{(k)} = \begin{cases} Q_3/L^{(k)} & \text{if edge } \{i,j\} \text{ is traversed by ant } k, \\ 0 & \text{otherwise} \end{cases}$$

(i. e., use $Q_3/L^{(k)}$ instead of $1/L^{(k)}$ in Schmitt's thesis on p. 48 for $\Delta\tau_{i,j}^{(k)}$), $A =$ number of nodes of the TSP problem, initialize $\tau_{i,j} = A/200.0$, 100 iterations, $\eta_{i,j} = 1/d_{i,j}$, where $d_{i,j}$ is the distance between nodes i and j.

– Try to separate the Ant Algorithm and the TSP from each other so that you can easily apply your ant algorithm to other permutation problems.

(b) Optimum solutions for `ulysses16` and `ulysses22` can be found in the TSPLIB. Compare your results with

– the optimum solutions.

– (optional) the result of a random search. (technical term: *blind search*). Let $n =$ (number of iterations $\cdot A$) be the number of function evaluations that the ant algorithm needs. Implement the random search in such a way that n random solutions are generated and then the best solution found is output.