Neural and Evolutionary Computation (NEC)

A4: Optimization with Genetic Algorithms

Objective

Implementation of a genetic algorithm (GA) to find the solution to the Traveling Salesman Problem.

The Traveling Salesman Problem (TSP)

The TSP tries to answer the following question: "Given a list of cities and the distances between each pair of cities, what is the shortest possible route that visits each city exactly once and returns to the origin city?"

The input of the problema is a list of cities and their connections, usually in a graph format, and the expected output is a list that contains the cities ordered accoring to their visit order, which is supposed to minimize the total traveling time between them.

To learn more about all the details of the problem check:
https://en.wikipedia.org/wiki/Travelling_salesman_problem

Genetic algorithm

Given the network of cities *G*, any vector *S* may be seen as the chromosome corresponding to the route that travels across all the nodes of G. The objective is the implementation of a genetic algorithm to obtain the vector that minimizes the total time.

Data and libraries

To simplify the computation of distances and management of the graphs we are going to use the TSPLIB python library. You can find all the details of the library in the following page:

https://tsplib95.readthedocs.io/en/stable/pages/readme.html

The TSPlib works with a specific file format that describes different TSP problems. Some examples of datasets for the analysis can be found in this webpage, but there are other pages where you can find other datasets to analyze:

https://people.sc.fsu.edu/~jburkardt/datasets/tsp/tsp.html

Delivery of the activity

This assignment can be done alone or in pairs (groups of two)

For this activity you must deliver **one PDF document** that includes:

- A link to the Github repository where the code of all the activity is accessible. More details on the code in the following sections. Remember that we require a history of all the commits, not only the last one with the final code.
- The name of the file should be **A3-Name1Surname1-Name2Surname2.pdf**

Also, in the document you must include the following two sections:

1. **Description of the chromosome, and adaptations done to the algorithm:** Explain with detail how you translate the problem into the chromosome, and the different techniques that you have implemented for selection, mutation and crossover. You must AT LEAST implement two different techniques for each of those. You can also use elitism in the code if you think.

   You must also explain how you choose the size of the population and how you identify that the system reaches a stationary state.

2. **The results of executing the code for 5 problems of different sizes**: We recommend running at least one problem with less than 10 cities, one with 10-30 and one with more than 30 cities. Optionally you can try with even larger problems, since we will take into account the complexity of the selected datasets.

   For each of the executions you should include in the document:

   a. The description of the dataset (URL where the data was collected, explanation of the data).
   b. The results obtained with at least 6 different combinations of parameters described in the previous section.
   c. For the best solution, present a figure with the evolution of the minimum total traveling distance in each of the algorithm steps.