Assignment 3.2

Application of Ant Colony Optimization (ACO) to search for the shortest route among locations. All locations have to be visited once and the starting and ending point must be the location number 1.

1. Explain the important operations of the Employed algorithm. (0.25)

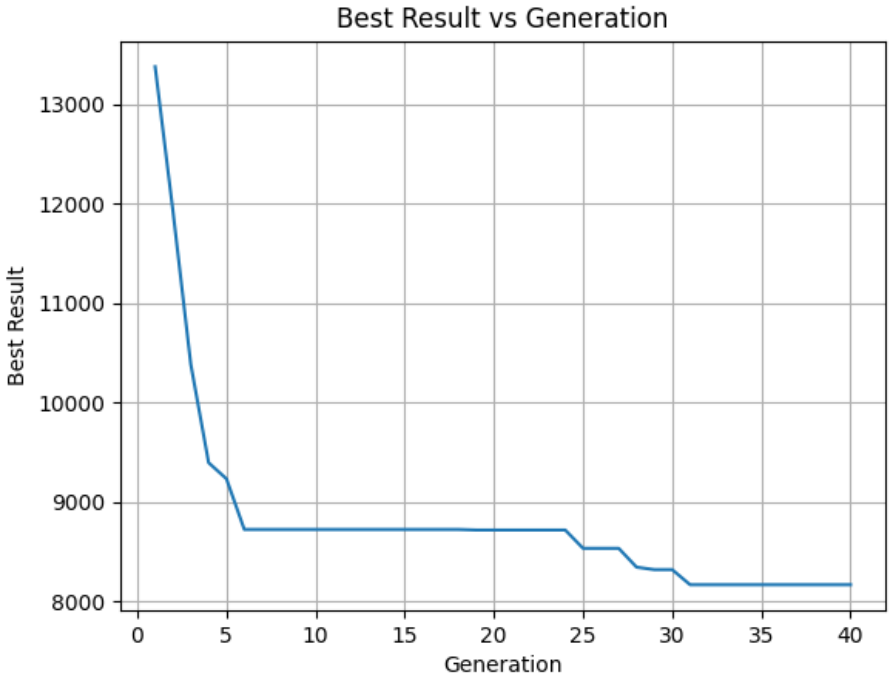
The Ant Colony Optimization (ACO) is an algorithm that draws inspiration from biology, precisely from the way ants choose and mark paths. It works through depositing of pheromones on the trails which are chosen by some of the ants, and the other ants can then sense the pheromone levels and follow the path to their goal location. In the TSP problem, the pheromone represents the distance value of a path (its preferability), and the ants represent the optimization process.

In every step, ants make a probabilistic decision based on the pheromone levels and the heuristic information. Once all the ants have constructed a solution, the weights on the paths between locations are updated based on the overall distance of the route and proportion of ants that chose this specific path, as the pheromone eventually evaporates.

The main operations of the Ant Colony Optimization (ACO) in my interpretation are as follows:

1. **Initialization**: In the `Berlin` class constructor, the pheromone matrix is initialized to 1.0 for all edges. The heuristic information (distances between cities) is also calculated and stored in the `heuristics` matrix.
2. In the `get_random_path_from` method, each ant (100 total) constructs a solution (path). The ant starts from a city and moves to another city based on a probability which is calculated in the `get_edge_probability` method. The probability depends on the pheromone level and the heuristic information (inverse of the distance) of the edge.
3. **Pheromone Update**: In the `run_aco_ants` method, after all ants have constructed their paths, the pheromone on all edges is evaporated by multiplying it with 0.981. Then, new pheromone is deposited on the edges based on the path length. The shorter the path, the more pheromone is deposited.

2. Illustrate how the performance of the population evolves with generations (with a figure.)



The figure above demonstrates the change in current best distance route found by each generation of ants. A rapid decrease is experienced in the first 5 generations, then for a few generations it converges to a value below 9000 and towards 40th generation most optimal route is found.

3. Compare the results found by this algorithm with the results found with GA. Analyse the differences between the algorithms and the difference in the performance between both.

The ACO algorithm produced better solutions in significantly shorter runtime compared to the Genetic Algorithm. It could be explained by the fact that GA moves very randomly on its search of local minima and often gets stuck at certain points since there is not enough change introduced with each generation and it is not guaranteed that those changes went in a positive way. On the other hand, the ACO utilized heuristics and sort of a historical knowledge from previous attempts(generations of ants), which in turn leads to achievement of more global minimum as opposed to the GA algorithm, as the ACO searched for a generally good solution not based on the initial configuration of the population so much as the experience of the population. Additionally, in the GA algorithm the set of parameters chosen, like mutation rate and population size, significantly impact the performance and can be best determined only through intensive experimentation, whereas ACO is less dependent on specific parameter values while still valuable.