# Assignment 3.2: ACO on TSP problem

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**1. Important operations**

Main idea behind Ant Colony Optimization algorithm is to every worker (ant) behind him leave some marks ie. pheromones, how much pheromones will leave depends of length of path, how much that pheromones will be valid in relation to the old one depends on evaporation rate, in order to calculate that in solution is applied Pheromone Update rule ie *Evaporation*. Another part of algorithm, before calculating Evaporation, is focused on the way how an ant will choose which path to use. That depends of pheromone and heuristic for each path and about what information we care more ($\alpha$ and $\beta$), and for choosing path is provided *Probabilistic Transition rule.*

Probabilistic transition rule:
Calculating probability that ant k will move from city r to the city s. In the equation: $\tau_{ru}$ is pheromone of the edge, $\eta_{rs}$ is heuristic, $J_k(r)$ are not visited cities, $\alpha$ how important is pheromone, $\beta$ how important is heuristic. In my solution $\alpha = 4$ and $\beta = 3$, in the case if $\beta$ is higher than $\alpha$ then algorithm will be more greedy in the way that it will not take care so much about history, more important will be what is in that moment best option looked throw the heuristic.

$$P_k(r,s) = \begin{cases} \frac{[\tau_{rs}]^\alpha \cdot [\eta_{rs}]^\beta}{\sum_{u \in J_k(r)} [\tau_{ru}]^\alpha * [\eta_{ru}]^\beta} & \text{if } s \in J_k(r) \\ 0, & \text{in other case} \end{cases}$$

Pheromone update rule:
Show us how we will update paths. First part of equation will how us how important is pheromone from before and that depends of $p$ ie Evaporation rate, in my case it is 0.25. The second part will calculate new pheromone.
$m$ - number of ants.

$$\tau_{rs}(t) = (1-p) * \tau_{rs}(t-1) + \sum_{k=1}^{m} \Delta\tau_{rs}^k$$

$$\Delta\tau_{rs}^k = \begin{cases} \frac{1}{c(s_k)}, & \text{if the ant } k \text{ visited the edge } e_{rs} \\ 0, & \text{in other case} \end{cases}$$

**2. Performance throw generations**

In figure1 we can see that updating pheromone has effect, but doesn't mean that the best path will be choosen by every ant, we can see that in the end where the global best is better than generation best. Reason for that can be that there is not a lot of ants which choose this path, so this path has a less pheromone. When the distance was around 9500 we can see that we had twice generation best near that value, and other ants started choosing this path after when second generation best was around that value.

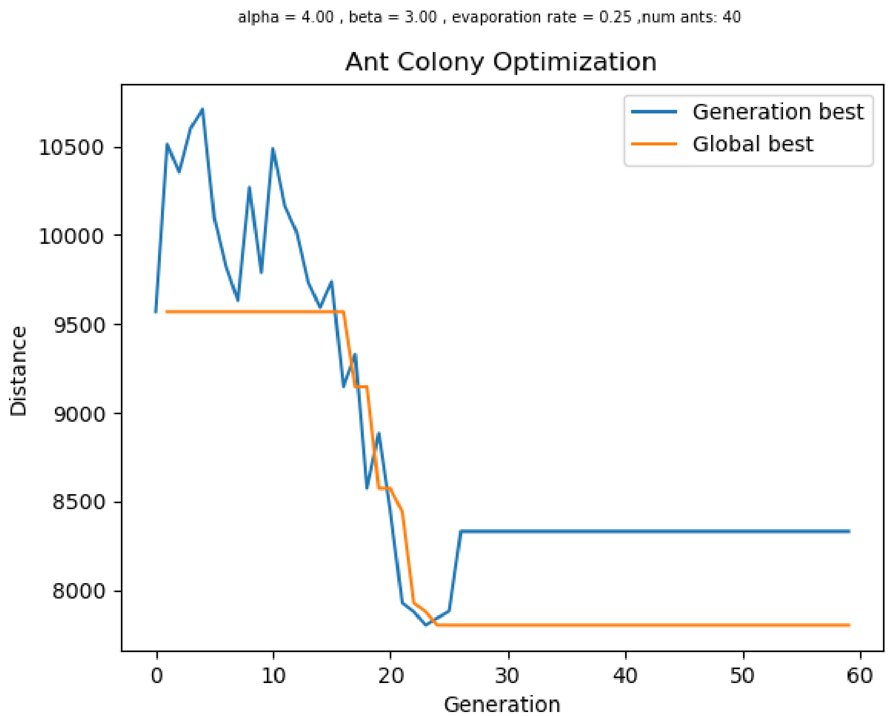


Figure 1: Performance of the population evolves with generations

### 3. Comparison of the results

In figure1 and figure 2, we can see that in ACO algorithm we have 40 ants, and in Genetic algorithm we have also population size 40, that mean that in every generation we have same amount of new possible solution, with that I tried not to favoritaze any of algorithm. From graphs we can see that in order to achieve distance value near 8000 in ACO algorithm we need 20-30 generation, while another algorithm need more than 500 generation. Using ACO is faster achieved optimal solution, but it seems that it will not be improved soon.
In Genetic algorithm can happen that best path start to dominate and then it will be stuck on local minimum. Positive side of GA is that using mutation solutions can be improved while ACO will probably continue to go on the route which one is already defined as the best. In ACO every new ant contribute to finding solution, while in GA contribution of solution will happen on next generation, because we need to analyze new population. Common for both algorithms is that both of them are population based, and we cannot guarantee that they will find global minimum but they will find optimal solution, also choosing parameters and playing with them is important in both of them. Using population we are trying to parallelize finding solution.
Its seems that GA depends more on our implementation of crossover and mutation, while ACO is more dependent of math calculation of probabilistic and updating pheromone.
My solutions shows that on TSP problem ACO will achieve faster and better solution.

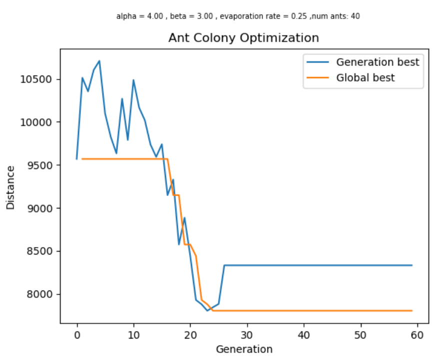


Figure 2: ANT Colony optimization.

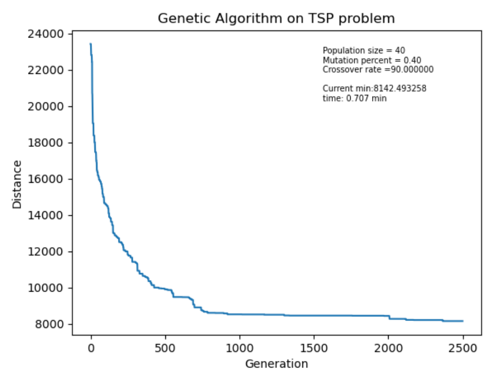


Figure 3: Genetic algorithm.