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Vehicle Routing Problem using ACO

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Vehicle Routing Problem: Problem Formulation

The vehicle routing problem is a combinatorial optimization problem that aims to find a set of optimal distinct paths for multiple vehicles travelling a set of given locations, such that each location is visited only ONCE by one vehicle. Each vehicle starts from a depot node, and returns back to the same node after visiting a set of locations once its capacity becomes equal to zero. It is an extension of the Travelling Salesman Problem which was about finding the minimum total distance for one vehicle to travel a set of given locations and return back.

Using ant colony optimization, n number of artificial ants will stochastically construct n number of solutions which will be then compared and the pheromone trails will be updated accordingly. This process will continue for k number of iterations. In the end, the minimum total distance of a set of paths will be printed. Each ant will stochastically select the next location to visit using a probability function, which is based on the distance between the current location and the next possible location, and the intensity of the pheromone level. Each ant will visit each location ONCE, and its solution will be a list of distinct paths and its total distance ([[list of paths], total distance]). This is continued for a period of time, based on the parameters specified, and the best smallest distance found so far would be the output.

The algorithm is implemented using a Python class. It is implemented in the following way:
For some number of iterations and ants:
a) Each ant will construct a solution, such that each location is visited EXACTLY once, using a probability function.
b) Once each ant constructs a solution, the pheromone trails will be updated accordingly. [**2**]
c) After all the ants have constructed solutions in the k^{th} iteration, the best ant solution (minimum distance) will be used to update the pheromone trails accordingly.

Chromosome Representation

In our population, a chromosome for this problem would represent the list of paths each ant would produce by visiting each location exactly once. Each location in our data collection sets has its set of x and y co-ordinates. To calculate the distance between the two locations, we apply the Euclidean distance formula.

Fitness Function

The fitness function determines the total distance between each destination in each chromosome in the population. The fitness value of the chromosome will be considered high, if the total distance of the chromosome is small. As the value of the total distance grows smaller, the fitness value of the chromosome increases. High fitness values lead to the increasing of pheromone levels according to the trails created in the good solutions so that the artificial ants can move to these regions and further find better sets of paths.

Parameters Used

The following parameters are implemented in our program with some constant values that ensure fair comparison between all iterations of our algorithm. They can be changed to observe the behavior of our algorithm:

- Number of ants: 10
- Number of iterations/generations: 100

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- α: 4
- β: 10
- ρ: 0.6
- Q: 1

Results: Worst vs. Final

We repeated the ACO process for the following instances respectively:

Filename	Number of Locations	Number of Vehicles	Capacity	Worst Distance	Best Distance
A-n32-k05	32	5	100	1686	870
A-n44-k06	44	6	100	2131	982
A-n60-k09	60	9	100	3644	1465
A-n80-k10	80	10	100	4389	1980

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References

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[2] J. E. Bell and P. R. McMullen, "Ant colony optimization techniques for the vehicle routing problem," Advanced Engineering Informatics, vol. 18, no. 1, pp. 41–48, 2004.

[3] W. A. Othman, A. A. Abd Wahab, S. S. N. Alhady, and H. N. Wong, "Solving vehicle routing problem using ant colony optimisation (ACO) algorithm," International Journal of Research and Engineering, vol. 5, no. 9, pp. 500–507, 2018.