ESIGELEC – Project S8

The Overview of the thesis

An efficient Itinerary Management Scheme for Electric Vehicles using ACO

Project efficient itinerary – Team 1
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Protecting environment, reducing pollution and improving the transport infrastructures are some of the main topics of our modern society. Several studies were already conducted to solve these problems. The implementation of I.C.T infrastructure through the electric grid and the development of electric vehicles lead us to a new era of technology.

However, there are still some limitations which are mainly due to the level of technology. As a result, the battery capacity limits of electric vehicles and the charging time of the battery also bring about problems.

Therefore, we have studied the thesis "An efficient Itinerary Management Scheme for Electric Vehicles using ACO" written by Deepika Hooda and Neeraj Kumar from Thapar university, India, who tried to find out the most efficient method for route optimization which is influenced by three arguments: the distance, the cost and finally the time. The algorithm which they have chosen is ACO (Ant Colony Optimization).

We will summarize their approach, and finally we will try to figure out the advantages and drawbacks of this these.

Hypothesis and limits

- Hypothesis:
  - There is only one type of electric vehicle (no differences between the electric vehicles)
  - The nodes of the itinerary are the charging points
  - There are less than 100 charging stations between the starting point and the destination
- Limits:
  - The number of the charging stations between the starting point and the destination
  - The type of the road (free road or toll road)
  - The traveling time between the two charging stations
  - The cost of charging at a station
  - The type of the battery used in the electric vehicles

Used approach

This study adopted the ACO algorithm (Ant Colony Optimization). The ants always use the most optimized path to search for resources. Ants make several round trips between the anthill and the location of the resources. Then they leave a trail of pheromones on their path. This algorithm considers the mostly used path as the shortest and the one containing the higher quantity of pheromones. The longer paths will have the lowest pheromones quantities and be less used by the ant colony. The authors of the article have made a mathematical formula out of the ants' behaviour. Then, they modified this formula to use it with electric vehicles by replacing the quantity of pheromones, data impacting the path choice for the ants, with the cost of the travel (road toll + charging cost).

Results

Thanks to the ACO method, the researchers have created an algorithm that takes several arguments such as the number of charging stations, the road type (toll road or free road), the fare, the travel time for each road, the charging cost at each station and finally the battery type used in the vehicle. This algorithm allows to compute for each charging station the coefficient of going from one charging station to another. The station with the highest coefficient will be chosen and step by step the optimized route will be established.

Advantages, disadvantages and errors

- Advantages:
  - Developer-friendly, easy to understand:

The algorithm used in the article does not require a complex implementation. It just requires the application of probability formula deduced from the method.

  - Inspired by existing algorithm:

The method used is strongly inspired by the ACO, which facilitates the understanding and verification of the results obtained.

- Disadvantages:
  - Non-dynamic:

The method proposed in the article is optimal only if the input values of arguments are fixed. In fact, all the probabilities are calculated before the departure, but real journeys usually contain changes. As a result, the non-dynamic method may not provide a very reliable route since no modifications or improvements will be made during the journey.

  - Not very efficient:

ACO is a long process which requires a lot of time to find the most efficient path. In order to limit the processing time, the authors modified the algorithm. They finally decided to determine the most efficient way by looking for the optimal path from each node to next node rather than from the beginning to the destination. As a result, the path obtained is not guaranteed to be optimal.

  - Structure of the algorithm is unsuitable for dealing with large quantities of data:

The final algorithm consists of 2 loops (one nested in the other one) each browsing N values (N represents the number of charging stations). If N is very high (for example N> 1000), the execution time of this algorithm will be relatively long because the program will run N^2 calculations.

- In this thesis, some errors can cause problems:
  - In the equation [3] and [5], they didn't explain the difference between the variables L_m and D_{ij}, which can lead to comprehension problems.
  - The equation [4] is not correct. After our research, we found out that $w_{ij}(t+1) = (1-\rho).w_{ij}(t) + \sum_{k=1}^{m} \Delta w_{ij}^{k}(t)$ is the right one. (The equation in Wikipedia page ACO, view references)
  - Some typos in the text complicate the understanding of the results
  - The example of the pathway is unrealistic, which doesn't work in all actual circumstances.

Conclusion

The algorithm of ACO is one of the methods which can solve the problem of route optimization of electric vehicles. By using the ACO, the users will gain the competence to find the most efficient path between two stations. We cannot deny that developer-friendliness and simplicity of implementation are advantages of this method. Nonetheless, there still exists some disadvantages that we cannot ignore, such as the lack of dynamism, the limited amount of calculation and the issue of efficiency, which make this solution become unsuitable for our project.

References:

https://fr.wikipedia.org/wiki/Algorithme_de_colonies_de_fourmis