Capacitated Electric Vehicle Routing Problem: Granting green deliveries

Bosse Bandowski
Universidad Eafit
Colombia
bbandowsk@eafit.edu.co

Manuela Zapata
Universidad Eafit
Colombia
mzapatag1@eafit.edu.co

Luis Bernardo Zuluaga
Universidad Eafit
Colombia
lbzuluagag@eafit.edu.co

Mauricio Toro
Universidad Eafit
Colombia
mtorobe@eafit.edu.co

ABSTRACT

Given a set of vertices, we must find a way to visit each vertex once, and only once, in the most efficient way; a Hamiltonian Cycle. This assures us that the suggested solution is the best that there is, given certain interests. There are many similar problems with several solutions, such as: the traveling salesman problem, the ant colony optimization, among others.

1. INTRODUCTION

The origin of this problem can be tracked back to the 1800s, when Irish mathematician W.R. Hamilton and British mathematician Thomas Kirkman first formulated the Travelling Salesman Problem (TSP). However, it wasn't properly studied by mathematicians until the 1930s, when a group of scholars in Vienna and a professor from Harvard began to actually look for the different possible algorithms to solve said problem. The first solution, suggested by Karl Menger, was the obvious brute force algorithm, but he then observed the low optimality of the closest neighbor heuristics. As the years passed, the TSP's popularity increased, along with the possible solutions given by several mathematicians. Ever since then, the TSP has been widely discussed and researched.

2. PROBLEM

Saving up and cutting expenses has become a necessity to survive in the industry of selling goods. Technology has replaced many traditional walk-in stores with e-commerce, and deliveries have become the way companies get to their customers' doorstep, which has made optimizing delivery services extremely important. Retail companies, whether they're an e-commerce company or not, that offer delivery services often face the TSP issue; how can the delivery man pan out his route in a way that is more efficient time-wise and fuel-wise, ensuring that he visits every customer. The better the solution, the greater the saving – which results on the better chance the company has to survive in the industry.

3. RELATED WORK

3.1 Ant Colony Optimization Algorithm

In the natural world, ants wander randomly, and upon finding food they return to their colony while laying down a pheromone trail. When the other ants find such path they are likely to travel through that path, however, if the path is to long, the pheromone trails start to evaporate. The longer the path, the more likely it is to be forgotten. On the other hand, a short path gets used more often, and thus the pheromone density becomes higher and the longer paths are forgotten. One solution to this problem is the ant colony system, which consists of traveling through the graph and leaving "pheromones" on each node, the amount of "pheromones" in each node is inversely proportional to the length of the route, at the end, the route with the most pheromones is the shortest.

3.2 Traveling Salesman Problem

Given a list of cities and the distance between each pair of cities, what is the shortest possible route that visits each city and returns to the origin?

There is no exact solution to this problem because the problem grows depending on the given graph, its importance lies in the fact that many problems can be crafted like this one and if one efficient solution is found it can be applied to many problems, one solution to this problem is Simulated annealing the simulated annealing heuristic considers some neighboring state $s*$ of the current states, and probabilistically decides between moving the system to state $s*$ or staying in-state s. These probabilities ultimately lead the system to move to states of lower energy. Typically, this step is repeated until the system reaches a state that is good enough for the application, or until a given computation budget has been exhausted.

3.3 Branch and Bound Algorithm

The branch and bound algorithm consists on a systematic enumeration of candidate solutions, or a rooted tree, which expands as the algorithm runs through every possible path given by the graph's structure. Instead of generating all the possibilities (or branches) like in brute force, it checks if the current path has a heavier (more expensive) route than the "best" path so far. If yes, it stops expanding the branch and carries on to the following path. If not, the "best" path becomes the current path and it carries on to consider the remaining paths.

REFERENCES

1. Retrieved from Wikipedia, Travelling Salesman Problem history.
https://en.wikipedia.org/wiki/Travelling_salesman_problem#History .

2. Retrieved from Wikipedia, Ant colony optimization. https://en.wikipedia.org/wiki/Ant_colony_optimization_algorithms

3. Retrieved from Stanford, Branch and Bound Methods. https://web.stanford.edu/class/ee364b/lectures/bb_slides.pdf

4. Retrieved from Coursera. https://www.coursera.org/lecture/delivery-problem/branch-and-bound-UyBJC