Optimization of an EV Charging Station Network in a Region

ME308 Project

Group 23

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Problem Description

The Electric Vehicle (EV) industry in India has seen tremendous growth in recent times due to favourable government regulations and growth in demand among middle-aged urban consumers. This has led to an increased impetus on setting up infrastructure (which includes charging stations, production and maintenance units) that can cater to this increased demand of EVs. The goal of this project is to explore the various ways in which charging stations can be placed and operated in the given region so as to reduce the number of stations and the total costs involved in constructing and/or operating them. An optimal charging station network will maximize utilization, minimize capital cost and improve driver experience. We will specifically work on two problems to achieve this.

A. What is the minimum number of charging stations which we need to construct in the region, such that a car starting from any location can reach its destination without running out of charge? And what are the locations of these stations? This could be formulated as a **graph** problem, with the charging stations being the nodes and the roads being the edges.
B. For a particular station, with a limited number of power outlets, in what way should we choose cars to charge so as to reduce the waiting time for customers? This is an important problem to consider because unlike petrol/diesel, even the fastest chargers take several minutes to charge. This could be formulated as a variation of the **job shop scheduling** problem.

Challenges

- We will need to come up with a formulation for the problem which will make it the easiest to feed into solvers like AMPL. The mathematical formulation should not be too complex and be preferably linear.
- Since the field of EVs is very new, it might be difficult to find existing algorithms or standard ways of planning such networks. It could be helpful to look at how gas/petrol stations were built in the early days of IC engine vehicles.
- Job shop scheduling problems are usually heuristics based, and may not have a single (mathematically provable) optimal solution. We will need to try out different heuristics and then compare the results to understand which works best.
- We need to adhere to the region's government guidelines regarding the layout of the charging stations.
- We need to account for variations in battery specifications which may result in different driving ranges and/or charging times.

Deliverables

<u>Part A</u>

- Creating small-scale (maybe artificial) map data to be used as a parameter for our formulation.
- Researching various available algorithms and techniques, and modifying them if need be for our task.
- Implementing the techniques and testing them on our small-scale map and comparing the results.
- Running the best found algorithm/technique on a real-world map like that of a city (Mumbai, for example), and presenting the results.

<u>Part B</u>

- Explore how various EV charging technologies work, with a focus on their charging times.
- Acquiring real-world data about the expected demand at charging stations (variations with respect to time of the day, charging time requirements of various types of vehicles, etc). This should be similar to the current demand at petrol pumps.
- Studying job-scheduling algorithms with the various heuristics used, and applying them to the above found data. Comparing the results over various metrics like response time, turnaround time etc.

Timeline