Load Dependent Electric Vehicle Routing Problem With Time Windows Considering Nonlinear Charging Function

Surendra Reddy Kancharla, Gitakrishnan Ramadurai
Department of Civil Engineering, Indian Institute of Technology Madras, India

Abstract

The transportation sector is one of the major contributors of greenhouse gases worldwide. There is a need to significantly increase efforts in this sector towards reducing emissions. Many countries have started paving ways towards the ban on sale of all fossil fuel based vehicles within a decade or two. Electric vehicles (EV) are one of the most viable alternatives to fossil fuel vehicles; however, they do have certain limitations, such as range anxiety and long recharge times, with current battery technology. Even though researchers are working on improving the range and reducing charging time, they are not as flexible and convenient as fossil fuel vehicles. The above limitations of EV pose new challenges in the routing of vehicles.

There is a significant increase in the number of research papers published on Electric Vehicle Routing Problem (EVRP) in the recent past. Most papers on EVRP assume: (a) linear recharge time, (b) that amount discharged is proportional to the distance covered, (c) there are no time windows, (d) vehicles are fully charged at recharge stations, and (e) a fixed number of visits to the charging stations. Few papers have considered one of the following: non-linear charging rate, load dependent discharge, time windows, and partial recharge at a charging station. However, none of the papers consider a combination of all or even a few of these factors. Existing formulations limit the number (β) of visits by any vehicle to a charging station. Fixing the value of β leads to suboptimal solutions.

The present paper proposes a new MILP formulation for EVRP with Time Windows (EVRPTW) that: i) considers a load dependent discharge, ii) uses a nonlinear charging function, and iii) allows partial recharge. Further, it overcomes the issue of limiting the charging station visits by proposing a three index formulation which allows any vehicle to visit a charging station as many times as required without significantly increasing the computational burden. Since the problem becomes intractable to solve for medium to large size instances, an Adaptive Large neighborhood Search (ALNS) heuristic is proposed. The proposed ALNS is based on ruin and recreate strategy and uses record-to-record acceptance criteria. This study proposes few unique strategies applicable to the problem structure. 120 new instances are solved that are modified versions of the instances in [1]. Major modifications being the addition of time windows, amending the location of charging stations to make the instances feasible given the new time windows, and adjusting the battery capacity to suit load dependent discharge.

References

[1] Montoya, A., Guéret, C., Mendoza, J.E., and Villegas, J.G.,(2017), The electric vehicle routing problem with nonlinear charging function, *Transportation Research Part B: Methodological*. doi: 10.1016/j.trb.2017.02.004