The Electric Capacitated Arc Routing Problem with Time-Dependent and nonlinear Energy Consumption

Rafael Martinelli

Department Industrial Engineering, Pontifical Catholic University of Rio de Janeiro, Brazil

Email: martinelli@puc-rio.br

Jahir Llagas

Department Industrial Engineering, Pontifical Catholic University of Rio de Janeiro, Brazil

With energy and environmental issues rising, electric vehicles (EVs) will become an essential mode of transportation in logistics distribution. A vital scenario to consider is the dependence of traffic congestion on vehicle travel times, as it is common in urban areas today. This feature means that the speed of an EV on each route may be distinct during different periods. Because EVs have a limited driving range, various works in the literature have proposed energy consumption models as a function of speed and aerodynamic factors. However, current vehicle routing algorithms often reformulate the road network into a complete graph where each arc represents the shortest path between two locations, which can lead to results that differ from reality, particularly for Arc Routing Problems (ARP) involving services on the edges of a road network [1]. For this reason, we define the electric time-dependent capacitated arc routing problem (E-TDCARP), with travel and service speed functions given directly at the network level, i.e., over a planning horizon, each arc is associated with a piecewise constant speed function, and a vehicle's speed can change while traveling on a given edge based on this function. The objective is to serve a set of edges that require services through a fleet of electric vehicles with limited load and battery capacity, minimizing the total travel time. Furthermore, the energy consumption rate per unit of time traveled is considered a non-linear function based on speed. We then propose an Iterate Local Search (ILS) metaheuristic for E-TDCARP to realistically model the implementation of EVs in congested traffic conditions and compare their impact on the design of routes between these alternative vehicles and conventional ones.

References

[1] T. Vidal, R. Martinelli, T. A. Pham and M. H. Hà, “Arc routing with time-dependent travel times and paths”, *Transportation Science* 55(3), 706-724, 2021.