The Electric Vehicle Routing Problem: Literature Review

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Keywords: *Electric Vehicle Routing Problem (EVRP), Classification, Literature Review.*

Abstract:

In this paper, we present a state-of-the-art survey with electric vehicle routing problem (EVRP). Our review has considered some papers published since the year 2011, in which several variants of the model are studied: time windows, heterogeneous fleet, homogenous fleet and recharging station. We present here a summary of every article and propose research leads relative to the type of problem. The review is classified them into three criteria. First of all, the approaches according to the multiple or single objectives that are optimized. Second, the solution methods, both exact and approached (heuristics and metaheuristics). Finally, the classification depends on the type of vehicle and the type of recharging the battery.

1. INTRODUCTION

The development of an eco-sustainable transportation solution represents one of the most significant steps towards the design of smarter cities; in which the attention is devoted to citizens' quality of life. Nowadays, to get an efficient urban transport we use an innovative technological solution, like, electro-mobility, in which it plays a significant importance in reducing the harmful emissions. In order to lower the bad effect on the environment, it is crucial to consider the importance of a "green" sustainable and energy-efficient freight transport system. In fact, freight transport activities are responsible for the consumption of a large percentage of oil reserves worldwide over the last decades, which are expected to rise in the future. And that's why in the logistics field, electric commercial vehicles (ECVs) are now taken into account. Many big companies have previously used them in urban areas, although requiring finding effective route-planning techniques considering their specifics.

In this context, we note several works that deal with the problem where the Electric Vehicles (EVs) were used in various sectors and with different methods. (P. H. V. Penna, M. M. Afsar, C. Prins, C. Prodhon, 2016) predict that of among the first attempts to study the specific characteristics of VE was achieved by (Gonçalves et al. 2011), where solve the pickup and delivery problem using a mixed fleet that consists of EVs and vehicles using internal-combustion engines. The main objective is to minimize total costs, taking into account the following constraints, the time and capacity restriction and assume a time for recharging the EVs. (R. G. Conrad and M. A. Figliozzi 2011) introduces the Recharging Vehicle Routing Problem (RVRP), where these vehicles with a limited range and can be recharged in customer locations. Two objectives treated, first, minimize the number of routes or vehicles and second minimize the total costs. (Sweda and Klabjan 2012) study a possibility of the vehicle must recharge along the way and they solve this problem as a dynamic programming to minimizing the cost path of EVs.

The Electric Vehicle Routing Problem with Time Windows (EVRPTW) was introduced in (M. Schneider et al. 2014). It includes first recharging times, second vehicle capacity, and finally customer time windows. The aim of this study is to find tours in order to satisfy charge constraints and time window constraints while minimizing the total travelled distance. The problem is solved by a Variable Neighbourhood Search (VNS) approach using the Tabu Search (TS). The proposed approach was tested on a new benchmark set based on the traditional Solomon instances for the VRPTW, which have been extended with recharging stations, which incorporates the possibility of recharging at any of the available stations, which commonly reloads at full.

(S.Shao et al. 2017) treated the E-VRP with the same type of vehicle and recharge, such as (M. Schneider et al. 2014), where the vehicles are homogeneous and with full recharge, using tow algorithms; Genetic Algorithm (GA) to obtain the routes and Dynamic Dijkstra Algorithm is applied to find the shortest path. The aim objective is to minimize total costs. Therefore, to evaluate the methodology and the performance of the proposed method, they apply in a realistic case study with a road network in the Beijing urban area.

J. Lin et al. (2016) studied the E-VRP whose prime target is to determine the optimal routing strategy with minimal travel time cost and energy cost as well as the number of EVs dispatched, such as the vehicles are heterogeneous. This is the first EVRP model to consider the vehicle load effect on battery consumption, in which the type of recharge is full. They used a mathematical model to solve this problem and they are applying the same methodology in a case study in Austin TX.

(G. Hiermann et al. 2016) examined the electric vehicle routing problem with the same type of vehicle and recharge of the battery using different methods to solve other objectives. To solve the electric vehicle routing problem they used Branch-and-Price Algorithm and a hybrid method combined the Adative Large Neighbourhood Search (ALNS) and the Embedded Local Search, first, to minimize the sum of the costs of all vehicles used and subsequently the total cost of moving EVs.

2. ARTICLES CLASSIFICATION

After presenting some different works dealing with electric vehicles and in this section we would try to classify these various works according to the following criteria put in Table 1.

Table 1.The classifications' criteria of the treated papers

Papers	Fleet of vehicle		Type of refill		Method				Objective	
	Homogeneous	Heterogeneous	Full	Partial	Exact	Heuristic	Metheuristic	Other	Multiple	Single
S. Shao et al. (2017)	×		×				×		×	
M. Braglieri et al. (2017)	×			×			×		×	
G. Hiermann et al. (2016)		×	×	×	×					×
J. Lin et al. (2016)		×	×					×	×	
M. Schneider et al. (2014)	×		×			×				×

3. CONCLUSIONS

In this paper, we presented selected works interested in electric vehicle routing problem (EVRP). The aim objective is to offer a reference paper for the recent works treating the EVRP since the year 2011. According to the presented paper, we note that: the interest of many researchers is focused on the type of recharge of battery, which is a limited driving range. There are obviously many extensions of the proposed EVRP. We also noticed that many researchers are interested in this problem as it has many advantages environmental, social or economical. As a future work, we might propose a new formulation of the routing model in order to add another extension. The new resolution methods could be inspired by nature such as "Genetic Algorithms, Differential Evolution, Cuckoo Search... which provide good results in a reasonable time

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