Chapter 94
Optimized Path Planning for Electric Vehicle Routing and Charging Station Navigation Systems

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ABSTRACT

With the increase in the number of electric vehicles (EV) on the street in the last years, the drivers of EVs are suffering from the problem of guiding themselves toward the nearest charging stations for recharging their batteries or finding the shortest routes toward their destinations. Although, the electric vehicle planning problem (EPP) is designed to achieve several transactions such as battery energy restrictions and the challenge of finding the nearest charging stations to the position of the electric vehicle. In this work, a new distributed system for electric vehicle routing is based on a novel driving strategy using a distributed Ant system algorithm (AS). The distributed architecture minimizes the total travelling path for the EV to attain the destination by proposing a set of the nearest charging stations that can be visited for recharging during his travels. Simulation result proved that our prototype is able to prepare optimal solutions within a reasonable time and forwarding EVs toward the nearest charging stations during their trips.

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INTRODUCTION

Electric vehicles (Zhang et al., 2016) are different from traditional vehicles in various ways. First, the battery capacity (Wu et al., 2017) remains weak and make the maximum travelling distance very limited, it may be needed for recharging the battery of the vehicle at certain times during the trip (Tan et al., 2017; Abdullah Al-karakchi et al., 2015). Secondly, Electric Vehicles are more efficient in terms of energy consumption than fuel vehicles. We measure the energy consumption of EVs according to the average stopping and acceleration during the travelling mode. In EVs system, the electric energy used is generated from natural resources, so the EVs will not release any dangerous gases. On the other hand, the cost of EVs compared with regular vehicles is very optimized. Also, we have several techniques for recharging batteries according to your needs, we can find (Wu et al., 2017) fast charging, normal-charging and slow charging method. At each station, the driver can swap his battery and the charging price is depending on the charging mode used and the time consumed for recharging the battery.

Studies on vehicle routing system for the EVs were handled by some scientific researchers. In those studies, the traveling plans and charging stations choice procedures are taken into consideration the total length of the trip and the traveling time consumed, the battery capacity and the amount of energy offered by each charging station. But these strategies treated only the re-routing objective of the EV and ignoring the rest of constraints such as the variation of traffic road and the batteries limit, etc.

Based on such arguments, we develop an efficient path planning using a distributed ACO (Kromer et al., 2015; Schyns, 2015; Kaplar et al., 2017; Elgarej et al., 2017) algorithm that finds the optimal route from a specific source location and helps the driver to reach his destination in the minimal distance and travelling time. The current coordinate of the EV is retrieved from a GPS (Global Position System) device, the position of charging stations is located and referenced by a point of interest (POIs) and showed on the map, this map will be used to calculate the optimal path planning followed by the driver.

Each station will be characterized by several attributes such as the current level of electric energy and the charging mode (slow, normal, high). The algorithm presented in this paper will take into consideration several parameters such as the position of each charging station and the location of the EV, the proposed path planning should across the nearest charging stations in the case if the battery of the EV cannot support the distance of the proposed route. The main objective of this solution is to minimize the travel time, energy consumed by the EVs. The proposed model considered the limited battery capacity and the needed time for recharging the battery at the station.

In this work, we introduce a new distributed vehicle routing system based on a multi-agent architecture. The system is based on a collective group of agents, and they cooperate to generate the best routes to the driver of the vehicle. They work in parallel to solve complex problems using optimal solutions. The system is based on two main components: (i) the road topology, for preparing the infrastructure of the road network (which uses several entities that guarantee the best exchange of information between vehicles and road controller agents), and (ii) The Ant colony optimization (ACO) techniques, which is used to compute the shortest path.

The rest of this paper is organized as follows: section II looks at previous research which is related to our work, Section III describes the ACO technique. Section IV formalizes the problem of the electric vehicle routing. Section V focuses on the modeling of a decentralized and a distributed solution based on the ACO technique to optimize the electric vehicle routing problem, section VI looks at on our implementation with its results based on a multi-agent environment for the EVR, the paper is ended with a conclusion and offers some research direction for the future.