Case-Based Retrieval of Combined Weighted Nearest Neighbor Algorithm Method for the Electric Vehicle Charging Navigation

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Abstract: In recent years, the excessive use of fossil energy has become a global concern. The development of electric vehicles will help improve the energy structure and build a resource conserving and environment- friendly society. Compared with traditional fuel vehicles, electric vehicles have the problems of longer charging time and shorter endurance mileage. Therefore, the research of charging navigation scheme is of great significance to promote the development of electric vehicle. In this paper,a case retrieval method of electric vehicle charging navigation is described.In order to overcome the shortcomings of single subjective method or objective method, a combined weighting method based on AHP and entropy method is proposed, and the combined weighted nearest neighbor algorithm method method based on combined weighting is tested. The results show that the method has better identification.

1. Introduction

The construction of charging stations is the foundation of the development of electric vehicles. At present, compared with the rapid development of electric vehicles, the construction of charging infrastructure is relatively backward, with problems such as small scale of charging stations and unreasonable location of charging stations. Electric vehicles disorderly randomly choosing paths and terminal has two disadvantages, which are leading to the electric car users charge cost high and easy to causing the charging station loading imbalance.

At present, the electric vehicle navigation system put into use in the market is basically a static path planning method, which cannot effectively solve the problems of traffic congestion and charging waiting in line. Therefore, the research on real-time navigation of EV charging is of great significance.

In this paper, electric vehicle charging navigation situation is lucubrated, and a new method of electric vehicle charging navigation case retrieval is explored, and the application of case-based reasoning in the electric vehicle charging navigation intelligent recommended is further studied, eventually the effectiveness of the improved Euclidean distance method is verified. The research aims to enable users to obtain optimized route planning, and reduce charging time and charge cost, and conveniently and quickly replenish power, to promote the popularity of electric vehicles and reduce environmental pollution.

At present, case database and case retrieval have been studied extensively and deeply, but few studies have applied case database technology to automobile navigation decision-making, which is an exploration of case database retrieval technology in new fields. At present, research on EV charging navigation. The first category USES path planning to consider the charging problem of a single user [1]. The second category analyzes the influence of charging station operation strategy on users' charging choice [2]. The third category discusses the influence of charging order on power grid balance [3, 4]. The model assumed in the above study has many limitations, and does not consider the influence of road traffic, the situation of users' cars and the situation of charging stations on charging navigation. This paper deeply understands the situation of EV charging navigation and studies the application of case-based reasoning in EV charging navigation. The new retrieval strategy is applied to the case base of EV charging navigation to solve the optimal charging solution under the current situation, to meet the needs of users for charging navigation.

2. Case presentation of EV charging navigation

2.1 Case base structure of EV charging navigation

The Case model is expressed as A triple form: Case {A, W, R}. {A = (a1, a2, a3, an} represents the n-dimensional attribute information of the case that is the description of the problem. W represents the solution of the case that is the description of the solution. R is the comprehensive result of the case, namely the target output after the execution of the case.

Table 1. Table structure of EV charging navigation case base.

Case Number	Attribute	Scheme		Target Value
1	(Attribute 11, Attribute 12,...,Attribute1n)	Scheme 1	Cost 1	Time 1
2	(Attribute 21, Attribute 12,...,Attribute1n)	Scheme 2	Cost 2	Time 2
3	(Attribute 11, Attribute 22,...,Attribute 2n)	Scheme 3	Cost 3	Time 3
...	...	...	...	...
m	(Attribute m1, Attribute m2,...,Attribute mn)	Scheme m	Cost m	Time m

As shown in TABLE 1, by analyzing the characteristics of EV charging navigation events, the EV user charging navigation case in this paper includes case number, case attribute, case solution (charging navigation route), case target value (charging cost and total time).

2.2 Attribute representation of EV charging navigation cases

Case representation is the basis of case-based reasoning. The case of EV charging navigation can be divided into three parts: "vehicle and user attributes", "environmental attributes" and "navigation scheme and result".

Attributes of vehicles and users mainly include the two aspects:

(1) Automobile condition of users

The status of the user's vehicle is a description of the current power status of the electric vehicle. The main attributes are battery capacity (cap), residual power (SOC) and residual Mileage [5].

(2) Itinerary information

The influence of time on charging navigation mainly comes from the change of traffic and electricity price in different time periods. According to the peak and valley information of traffic and electricity price, this paper divides the time of a day into four types of time periods, which are represented by Numbers 1, 2, 3 and 4. The trip information describes where the electric car user is expected to travel from. The main attributes are the initial position and the target position at the current time. The initial position is the current position of the EV, and the target position is the position that the user will arrive after charging. Generally, location information is represented by longitude (LNG) and dimension (lat). According to the above research on road network, road nodes represent vehicle location according to previous studies on road network in this paper.

The attributes of charging stations include the rest rest amount, unit charge fee and reservation quantity of the 16 charging stations in He Xi District, Tianjin. The number of dowries remaining describes the current residual charging amount for each station. Unit charging fee refers to the sum of unit electricity price and unit service fee of each station in the current period. Reservation quantity refers to the current number of reserved vehicles in each station.

Road traffic attributes are divided into two aspects: road network and road information. Road network can be represented by topology structure.Road section and road connection point can be abstracted as edges and nodes in the topology structure [6]. Current road information refers to road congestion information that affects vehicle charging navigation. The congestion index of the road is expressed by the average current traffic flow speed of the road, and the unit is km/s.

The scheme and result of navigation refer to the final route scheme, time and cost of each charging navigation which include the navigation route, distance length, total time, total charging cost and the number of charging station.

3. Combined weighted nearest neighbor algorithm method

3.1 Determination of case attribute weight

Considering the disadvantages of the single weight determination method, the weight determination method combining the analytic hierarchy process and the entropy method was adopted. WAHP represents the weight value obtained by the analytic hierarchy process, and Ws represents the weight value obtained by the entropy method. α is subjective-objective preference coefficient that flexibly represents the proportion of the two methods. Then the comprehensive weight is:

$$W = \alpha W_{AHP} + (1-\alpha) W_S \tag{1}$$

Yaahp software was used to calculate and allocate the attribute weight of EV charging navigation case. According to the two goals of least cost and shortest time, the weights are calculated and allocated twice. According to the calculation results, the weight value of each road in the fewest cost model is 0.0075; The weight of each road in the shortest time model is 0.00169. Similarly, in the fee-minimum model, the residual amount, unit charge price, and reservation quantity weights for each charging station are 0.0042, 0.0065, and 0.0031, respectively. In the shortest time model, the residual amount, unit charge price and reservation quantity weights of each charging station are 0.0032, 0.0014 and 0.0027 respectively.

Both the initial position and the target position contain longitude and latitude. Therefore, the weight of the four attributes including the initial position longitude and latitude, the target position longitude and latitude are 0.1243 in the least cost model and 0.1240 in the shortest time model.

The initial position and the destination position are the most important factors for the two different goals. For the model with the least cost as the target, the unit charge price has a great influence. For the model with the shortest time as the goal, the weight of road traffic, residual charge amount and reservation condition is increased significantly. We disperse the composite attribute into a single attribute, so that the weighted value of each attribute with the lowest cost as the target can be W_{AHP1} and the weighted value of each attribute with the shortest time as W_{AHP2}.

3.2 Similarity calculation

The formula for calculating the distance similarity between the case base and the target case is as follows:

$$Sim(m,n) = 1 - \sqrt{\sum_{n=1}^{i} W_n * \left(X'_{mn} - M'_n\right)^2} \tag{2}$$

The X'_{mn} represents the property value of the case after standardized processing where m and n represents the orders of the case and the attribute respectively. Also, M'_n refers to the value of the target case standardized where n is the ordering of attributes. W_n represents the comprehensive weight value assigned to the attribute with ordinal number. After standardized processing, the value range of the distance value obtained by the formula is [0,1]. The closer the value is to 1, the higher the similarity of the two objects calculated will be, and the closer to 0, the lower the similarity will be.

Combined with the combined weighting method of case attributes where W_n is denoted by W in formula (1)

$$Sim(m,n)=1-\sqrt{\sum_{n=1}^{i}(\alpha W_{AHP}+(1-\alpha)\vec{W_S})*(X'_{mn}-M'_n)^2} \quad (3)$$

A charging navigation case attribute value matrix was constructed and normalized by the min-max function method. The matrix size was 122× 200 that represents 200 cases and 122 attribute values of each case.

The similarity threshold is set to 0.7, and we calculate the similarity of 200 randomly selected cases according to formula (3). The precision rate was defined as the ratio of "the number of cases retrieved with similarity greater than or equal to 0.7" to "the total number of cases retrieved". The three weight calculation methods can be used to retrieve the cases with the highest similarity from the case database. The attribute weight calculation method in this paper not only retrieves the cases with high similarity, but also has a high precision. Table 2 shows the retrieval results under several weight determination methods.

Table 2. Comparison of maximum similarity results.

Retrieval Methods	**The number of cases for similarity>0.7**	**Total number of cases retrieved**	**Maximum Similarity**	**Precision Ratio**
Nearest neighbor	3	7	0.7643	0.43
Minimum cost	2	4	0.7856	0.5
Time minimum	3	5	0.8102	0.6

4. Conclusion

A design of EV charging navigation system based on case-based reasoning was proposed in this paper. The key problem to be solved is to put forward a combined weighted nearest neighbor algorithm retrieval method. Compared with subjective expert and user experience method. This method makes the navigation decision-making of EV charging more reasonable and effective. In the future, factors affecting the navigation of charging cars in emergencies will be included into the research scope.

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