Design Engineering

ISSN: 0011-9342
Issue: 11 | Pages: 457 - 467

Method for Constructing the Model of Parking Demand Forecasting Based on Time Interval Statistical Analysis

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Abstract:

Urban parking lot planning and management are the main measures to solve the problem of parking and road traffic congestion, and accurate understanding of parking demand is a prerequisite for parking lot planning and design. In the existing research on forecasting methods of urban parking demand, there arefew researches on forecasting methods of dynamic changes of daily parking demand. Therefore, this paper proposes a parking demand forecasting method based on time interval statistical analysis. The basic idea of the method is as follows: First, according to the travel characteristics of urban residents, the parking demand within a day is divided into several stages. Secondly, within a predetermined period, the parking demand in different stages of a single piece of land is counted. Then, the statistical average value of each stage during the period is calculated and used as the initial parking demand forecasting data of a certain piece of land at a certain stage. Finally, according to the coefficient of trip attraction of a certain piece of land in a period of time, the initial parking demand forecasting data is revised, and the revised data can be used as the parking demand forecasting result of a certain stage of a certain piece of land. This method simplifies the complexity of the existing forecasting model, with simple calculation and clear thinking, which can be a reliable basis for the planning and management of urban parking lot.

Keywords:*Statistical analysis,Parking lot,Demand forecasting,Model construction.*

I. INTRODUCTION

Since the first automobile was invented and used in human history in 1885, there has been a demand for parking. This problem didn't appear in the early stage of automobile development. The real parking demand was after the Second World War, and it gradually became prominent with the development of cities, industrialization and the improvement of people's living

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standards. Parking has already become a prominent urban management problem. On the one hand, the parking problem causes mutual interference between dynamic and static traffic, and serious congestion of dynamic traffic on urban roads, resulting in a decline in road capacity; On the other hand, parking that frequently occupies roads and residential green spaces has seriously damaged the urban environment, greatly affected the road traffic safety, hindered the normal process of urban social and economic activities, and reduced the vitality of the city. At present, the parking problem is no longer a simple urban traffic problem, but it has become a prominent problem affecting the social and economic development of cities.

The main reasons for the prominent urban parking problem are as follows: First, the total amount of urban parking facilities is seriously insufficient. Due to the lack of parking planning awareness in urban development, many cities start to build parking facilities only after this problem become quite prominent. However, the shortage of parking supply in the past cannot be remedied due to various reasons such as shortage of land and funds, resulting in a serious lack of urban parking facilities. The second is the lack of scientific and reasonable parking planning and management. Due to the prominent contradiction between parking supply and demand, the planning department is forced to accelerate the building of parking facilities in the city, but some other problems arise accordingly: After some parking facilities are planned in some areas, not only do it not alleviate traffic congestion, but it causes more serious traffic congestion. In other areas, after new parking facilities are built, especially large parking lots, the utilization rate is extremely low, which is due to the lack of scientific planning and management of parking facilities.

Urban parking facilities are an important part of urban traffic planning,building parking facilities with high service level can promote the sustainable development of cities, reduce road traffic congestion, enhance the accessibility between different areas of the city and improve the safety of urban traffic. The planning and management of urban parking facilities are based on parking demand forecasts. Therefore, accurate parking demand forecasts are a prerequisite for planning parking facilities. Otherwise, parking demand forecasts that are far different from actual demand will cause parking chaos and traffic jams. Under this background, using scientific and reasonable methods to forecast parking demand in urban areas has become a research hotspot and an important topic to solve the problem of urban congestion, which is of great significance to improve the overall planning, and management level of urban parking facilities.

II. RELATED RESEARCH

The United States "Parking Generation Rate" has studied the relationship between parking demand and land use characteristics of 64 kinds of land in detail, and obtained the parking generation rate of each kind of land [1]. Wong S C et al. determined the scale of in-road parking berths and off-road parking berths through the relationship between berth turnover and land use, obtained the vehicle violation rate based on parking survey, and then determined the number of

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vehicles for illegal parking, accumulated the three, and worked out the total parking demand[2]. Rojas D et al. used neural network algorithm to analyze the impact of parking behavior on parking demand, and built a corresponding model[3]. Sun J et al. took into account the influence of geographical location, social characteristics, parking supply and demand, traffic status and public transportation system on parking demand, and modified the parking generation rate model[4]. Chen K et al. based on the traditional trip attraction model, considered the influence of traffic development coefficient, social development coefficient and economic development coefficient on parking demand, and established a parking demand forecasting model adapted to regional development[5]. Rowe D et al. analyzed the characteristics of parking demand in residential communities, took into account the impact of land use and development intensity, public transportation and the Distance between destination and parking lot on parking demand, conducted regression analysis on the data obtained after parking survey, and determined the functional relationship between the above influencing factors and parking demand[6]. Yu J F et al. used the collected vehicle OD data to analyze the influence of building location and vehicle attraction on parking demand and established the corresponding relationship, and verified by examples that the accuracy of the prediction results was acceptable[7]. Jiang Y et al. on the basis of parking generation rate model, considered the influence of shared parking behavior such as distance between destination and parking lot, berth search time, parking duration and parking cost on parking demand, and established the corresponding function[8]. Fabien et al. used the theoretical model of the in-road parking facilities to summarize the calculation formula of the capacity and occupancy of the in-road parking in important locations[9]. H.llen et al. studied the influence of employment and parking supply in the central business district on parking generation rate, and elaborated the correlation between employment, parking demand and parking generation rate[10]. W. Bowman et al. conducted a survey on parking demand in some cities and towns of Los Angeles, analyzed whether the growth of parking demand would significantly affect the demand for parking lots, and proposed parking control standards for different types of land and parking lots in different areas[11]. An Shi et al. established a parking demand forecasting model based on G-Logit according to parking trip and attraction[12]. Chen Jun et al. proposed a static traffic incidence model, that is, the amount of parking attraction generated by the capacity of a certain piece of land. The basic idea is to use the collection of district data within the scope of the survey to replace the category survey statistics in the process of data collection. In the process of data analysis, the model algorithm is used to determine the static traffic incidence of different types of land[13]. Bai Yu et al. proposed a parking demand prediction method based on road network capacity with regional road network capacity and road network service level as constraints[14]. On the basis of the parking generation rate model, Guan Hongzhi proposed the "parking demand-supply model" by considering the impact of price and service level on parking demand[15]. Wang Fengyuan studied the relationship between properties of land utilization and parking generation rate, and established a parking demand forecasting model[16]. Yi Wu et al.

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proposed a parking demand prediction model based on Box-Cox Dogit, which is a parking demand prediction model based on G-Logit based on random utility theory, believing that parking demand is caused by traffic volume[17]. Wu Jiayou et al. analyzed the characteristics of traffic flow and parking demand in large trading markets through a large number of actual survey data, and established a parking demand forecasting model based on location analysis and induced flow[18].

III. THE MODEL CONSTRUCTION OF PARKING DEMAND FORECASTING

3.1 Model Building Process

Through statistical analysis of big data, the characteristics and laws related to urban residents' daily driving trips can be obtained. Because of this, the parking demand of each piece of land in the city changes dynamically in different stages within one day. Therefore, mastering the dynamic change law of parking demand in urban areas is conducive to promoting the rational planning and management of parking lot, actively guiding drivers to rationalize parking behavior and reduce the phenomenon of random parking, alleviating urban road traffic congestion and improving the efficiency of social and economic life.

Ina certain stage of a day in a city, whether a residential car is in a driving or parking state is determined by people's travel needs. If it is in a parking state, it may be parked in a residential area, on the side of the road, or a parking lot in the workplace. However, when driving, the corresponding vehicles do not occupy the resources of urban parking lot, which in a sense reduces the dynamic demand of urban parking. Therefore, in order to accurately obtain the dynamic changing demand for parking in different stages in an urban area within a day, on the basis of the related research on the forecasting model of land use parking demand, the model buildingprocess of urban parking demand forecastingis shown in Fig 1.

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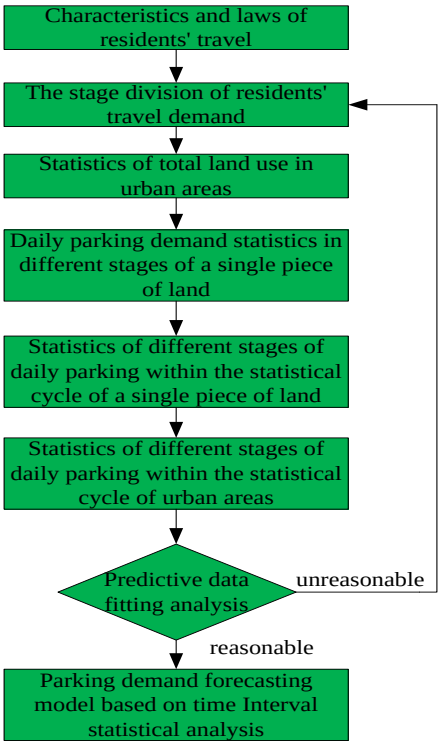

Fig 1: Building process of forecasting model

The first step of model building is to obtain the characteristics and laws related to urban residents' travel by driving through big data analysis.

The second step of the model building is to divide the daily parking demand into several stages with different time intervals according to the characteristics and rules of urban residents' travel by driving.

The third step of model building is to make statistics on the total land use of the whole city or a certain area.

The fourth step of model building is to make statistics on parking demands in different stages of daily parking for a single piece of land.

The fifth step of model building is to calculate the average value of daily parking in different stages in the statistical cycle of a single piece of land.

The sixth step of model building is to make statistics on the parking demand of the entire city or a certain urban area in different stages of daily parking to obtain the corresponding statistical average value.

The seventh step of model building is to make a fitting analysis on the obtained urban data, propose a solution method for the corresponding coefficient of trip attraction of a certain land, build a corresponding forecasting model of parking demand, and make reasonable analysis. If reasonable, it can be used as parking demand forecasting model, otherwise the data must be re analyzed to rebuild an accurate parking demand forecasting model.

3.2 Division of Time Interval of Daily Parking Demand

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The division of time interval of urban residents' daily parking demand depends on the characteristics and laws of urban residents' travel. Therefore, it is necessary to make big data statistical analysis on urban residents' travel. Through investigation and statistical analysis, urban residents' travel mainly has the following characteristics: The parking demand caused by going to work in the morning is mainly caused by the change of parking demand from residence to workplace. The parking demand reduces in the residence, while the parking demand increases in the workplace. Parking demand caused after work in the morning or afternoon is mainly caused by the change of parking demand caused by eating out, shopping and leisure. In this process, parking demand in entertainment, leisure, catering and other places will increase greatly, while parking demand at workplace will decrease. The parking demand caused by the end of a day's work is mainly the change in the parking demand caused by urban residents returning to their residence,the parking demand of the workplace has drastically reduced, while the parking demand of the residence increases rapidly. Based on the above analysis of residents' travel characteristics, the time interval of daily parking demand within a day is divided into five stages as shown in TABLE I.

TABLE I. Division of time interval of daily parking demand

SERIAL NUMBER	TIME INTERVAL	PARKING CHARACTERISTICS
1	20:00—8:00	The change in parking demand ofthis stage is caused by the end of a day's work, entertainment, and leisure.
2	8:00—12:00	The change in parking demand ofthis stage is mainly caused by the change from residence to workplace.
3	12:00—14:00	The change in parking demand ofthis stage is caused by lunch, leisure and entertainment after work in the morning.
4	14:00—18:00	The change in parking demand ofthis stage is caused by returning to the workplace after the lunch break.
5	18:00—20:00	The change in parking demand ofthis stage is caused by eating out, entertainment, and leisure after a day's work.

3.3 Building of Forecasting Model

The model of parking demand forecasting based on time interval statistical analysis proposed in the paper is constructed on the basis of the statistical analysis of urban area division, land use and trip attraction. As the parking demand of a single piece of land fluctuates in one day, the parking demand in a certain area of the city also changes dynamically,so the whole day is divided into several stages. Through the statistical analysis of several stages in a day, we can accurately grasp the characteristics and changing rules of parking demand data in each stage. By fitting the statistical data, a high-precision forecasting model of urban dynamic

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parking demand is built. The specific form of its model construction is shown in the following formula.

$$P_i = \frac{\sum_{i=1}^{5} \lambda_k D_{ijk}}{n} (j = 1,2 \cdots, n;\ k = 1,2 \cdots, m) \quad (1)$$

In the above formula:

P_i refers to the forecastingdata of total parking demand in a certain period of time in an area of the city.

λ_k refers to the coefficient of a certain piece of land in a city in travel attraction. The higher the activity level, the greater the value of coefficient, and vice versa, the smaller.

i refers to the historical statistical data of parking demand in a certain stage. According to the statistical accuracy requirements, the daily parking demand can be divided into i stages.

j refers to the historical statistical data of parking demand on a certain day within thestatistical cycle, and the value of the statistical cycle depend on the accuracy of the statistical data.

k refers to the historical statistical data of parking demand for a certain piece of land,according to the actual situation, a certain area of the city can be divided into m pieces of land.

By using the historical statistics and accurately selecting the coefficient of travel heat of a single piece of land, the forecastingdata of parking demand in urban area can be correct in theory.

IV. FORECASTING MODEL CACULATION

4.1 Calculation Process

The model built in the paper is used to forecast the parking demand in a certain area of the city, the calculation process is shown in Fig 2.

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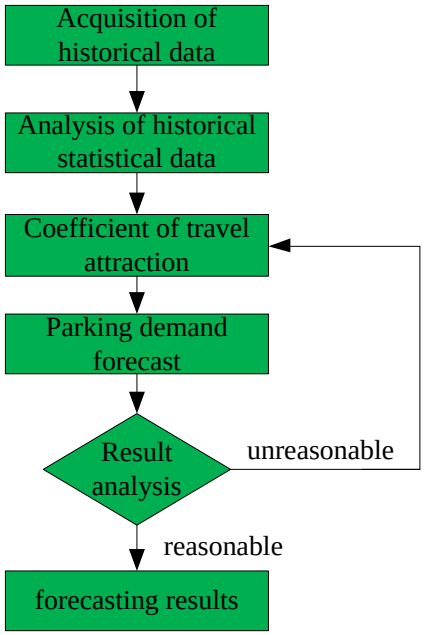

Fig2:Steps of forecasting parking demand by model

The first step is to obtain historical statistics of parking demand in the urban area to be predicted.

The second step is to analyze, organize and summarize the acquired historical statistics of a certain piece of land, and draw the corresponding change trend chart of parking demand.

The third step is to systematically analyze the data based on factors such as economic development, improvement of living standards, and activity levels in a certain period of time, and calculate the coefficient of travel attraction of a certain piece of land.

The fourth step is to calculate the forecasting model according to the corresponding coefficient of travel attraction t and historical statistical analysis data.

The fifth step is to make an overall analysis of the calculation results of the forecasting model. If reasonable, it can be used as the urban parking demand forecasting data; otherwise, it will return to the third step in the model solving process and modify the model parameters again until the obtained data is reasonable.

4.2 Model Parameter

Parameter i of stage division of daily parking demand. In the paper, it is divided into five stages according to the travel characteristics of residents in a certain city. The value of this parameter can be determined according to the specific travel conditions and characteristics of residents in different cities.

Travel attraction coefficient λ_k of a certain piece of land. The determination of this parameter needs to be based on the average of historical statistical data, combined with the economic, social and living standards of the city where it is located, as well as the active degree of a certain piece of land in a certain period of time, etc., to obtain the corresponding travel attraction coefficient of a certain land by appropriate weighting. When the active degree of a

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certain land is enhanced, the corresponding travel attraction coefficient will increase, and its value will be greater than 1; otherwise, it will decrease, and its value will be less than 1.

Parameter k of urban land use.The larger the divided area, the greater the corresponding statistical workload, otherwise, the smaller the divided area, the smaller the statistical workload, which can be determined according to the specific situation of urban parking demand.

Parameter j of statistical period.The longer the forecasting period is, the more the statistical data tends to the average value. Of course, the workload of data calculation also increases greatly, and the reference of corresponding parking demand forecasting is better. The shorter the forecasting period is, the less accurate the statistical data will be, and the workload of model calculation will also be reduced, but the overall reference for parking demand forecasting will be poor.

4.3 Forecasting Accuracy Analysis

The accuracy of the model's forecasting of urban parking demand depends on whether the stage division of daily parking demand is reasonable, the length of the statistical period, and the accuracy of the coefficient of travel attraction for a certain piece of land. The finer the stage division of daily parking demand, the higher the accuracy, but the corresponding number of parking stages will increase, and the statistical workload will increase. The longer the statistical period is, the more representative the statistical data will be, and the calculation accuracy of the model will be improved, which will also lead to an increase in workload. The determination of the travel attraction coefficient requires a reasonable combination of the city’s economic living standards and the activity levels of the corresponding urban areas. These data directly affects the forecasting accuracy of the urban parking demand. Therefore, special attention should be paid in the analysis and selection. The higher the accuracy of model parameters is, the higher the theoretical forecasting accuracy is, and the more reliable and referential the results are.

V. CONCLUSION

The shortage of urban parking spaces, unreasonable planning, inadequate utilization efficiency and other factors are the direct causes of urban parking difficulties and traffic congestion, and the forecasting of urban parking demand is the prerequisite to solve these problems. The research on urban parking demand forecasting is currently mainly focused on the forecasting method of parking demand throughout the day, while the research on the dynamic changes of parking demand in different stages within a day in various parts of the city is relatively rare. In order to accurately grasp the law and characteristics of dynamic change of parking demand in urban areas in different stages within a day, this paper puts forward a parking demand forecasting model based on time interval statistical analysis. This method takes into account the dynamic change characteristics of parking demand in different stages within a day of each single piece of land in the urban area. Firstly, the daily parking stages are reasonably divided, and then the parking demand of each stage of a single piece of land is statistically analyzed in the statistical period, and the parking demand data of each stage of a

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single piece of land in the statistical period are obtained. By fitting and analyzing the data, the corresponding parking demand forecasting model is constructed. On the basis of historical reference data, the model constructed in this paper can be used to predict the dynamic characteristics and laws of parking demand in different stages of urban areas, thus providing a basis for the building and planning of urban parking lot, which has important practical significance in improving the dynamic management level of urban parking lot, enhancing the utilization efficiency of social resources and the convenience of social and economic activities.

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