Bus Scheduling During Peak and Peak Transition

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Abstract: Considering the waiting time cost of passengers and the income of bus companies, this paper mainly studies the optimal scheduling strategy of buses during the transition period of "peak" and "flat peak", so as to achieve a more reasonable allocation of the number and frequency of buses in different periods on the premise of better meeting the travel demand of citizens, thus saving the cost. We use the second-order fitting of MATLAB and the peak hour coefficient to define and analyze the "peak" and "flat peak" data of a bus line. Then, through the establishment of optimization model, the genetic algorithm is used to calculate, and the scheduling scheme of "transition period" is given, which indicates under what circumstances the bus scheduling scheme is optimal, and on this basis, discusses the influence of the proposed scheduling scheme on the parameters. Finally, the grey prediction model is used to give the prediction methods of "peak" and "flat peak". Finally, the results are tested to ensure their accuracy.

1. Introduction

With the rapid development of China's economy and society, the popularity of private cars is increasing, and people travel is more free. However, the problem of urban traffic congestion is also increasing. Among them, vigorously developing urban public transport represented by buses is an important method to solve the problem of urban traffic congestion and improve public travel satisfaction.

The vehicle scheduling problem is an important factor affecting the bus operation cost, operation efficiency, service effect and so on. However, people travel is not "uniform", and the starting and ending points are not the same when there are many passengers and when there are not too many passengers. Therefore, according to the requirements of the problem, the interests of both passengers and bus companies should be taken into account. On the one hand, in order to reduce the waiting time of passengers and improve the satisfaction of passengers, on the other hand, in order to reduce the waste of resources, reduce the cost of the bus company as much as possible. Therefore, we need to establish, optimize and calculate the relevant model to solve the problem, so as to make the transition scheduling between "peak" and "flat peak" more smoothly.

2. "Peak" and "flat peak"

In order to facilitate the case study, we use the statistical data of passenger flow monitoring of a bus line at different time periods in a certain day in relevant academic articles, and then carry out the definition and in-depth study of the "peak" and "flat peak" of the bus line .We will divide the data of each period from 6:30 to 22:10 with every 20 minutes as the interval, and make the table of passenger flow data of different periods into the following scatter chart.

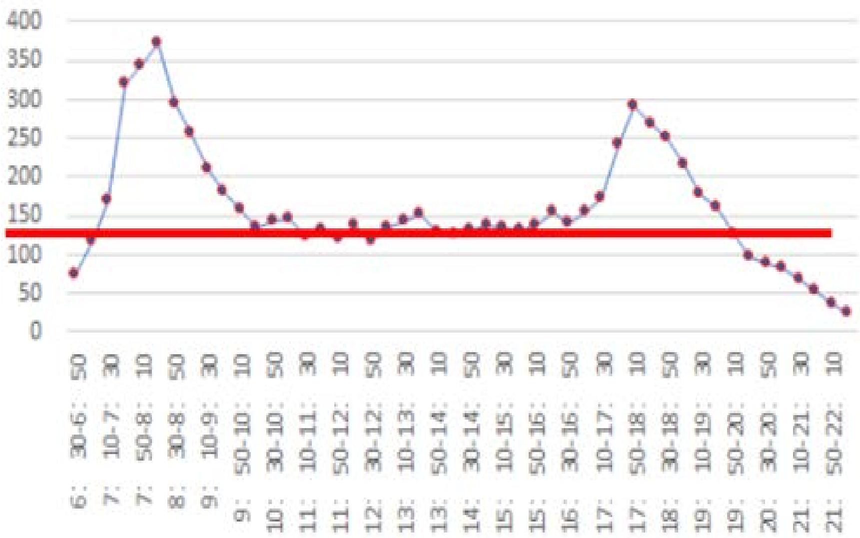

Figure 1 Total passenger flow in different time periods (interval: 20min)

Through this chart, it is not difficult to find that the total passenger flow of 7:30-9:30 and 17:30-19:30 is significantly higher than other periods, which are "peak" period. Therefore, the morning peak is mainly concentrated in 7:30-19:30, the evening peak is mainly concentrated in 17:30-19:30, and other periods are "flat peak".

In order to define "peak" and "flat peak", we introduce the concept of peak hour coefficient (PHF) to help explain the division of "peak" and "flat peak" of this bus line.

Peak hour refers to an hour in which the number of trips caused by commuting and commuting in urban areas is significantly higher than that in other times. It is generally divided into morning and evening peak hours. The level of peak hour flow is generally determined by the peak hour coefficient, that is, the ratio of peak hour flow to 4 * 15 minutes flow. Here, for the convenience of calculation and observation, we divide the time interval into 20 minutes. From the definition, it is not difficult to find that when the peak hour coefficient is too low or too high, the travel volume of the city is low and the travel situation is good. Therefore, combined with the relevant case data, we define the "peak" and "flat peak" of the bus line as follows:

Generally speaking, when the peak hour coefficient value is less than 1.2, we define this period as "peak". When the peak hour coefficient is in the range of more than 1.2, we define this period as "flat peak".

Rational analysis:

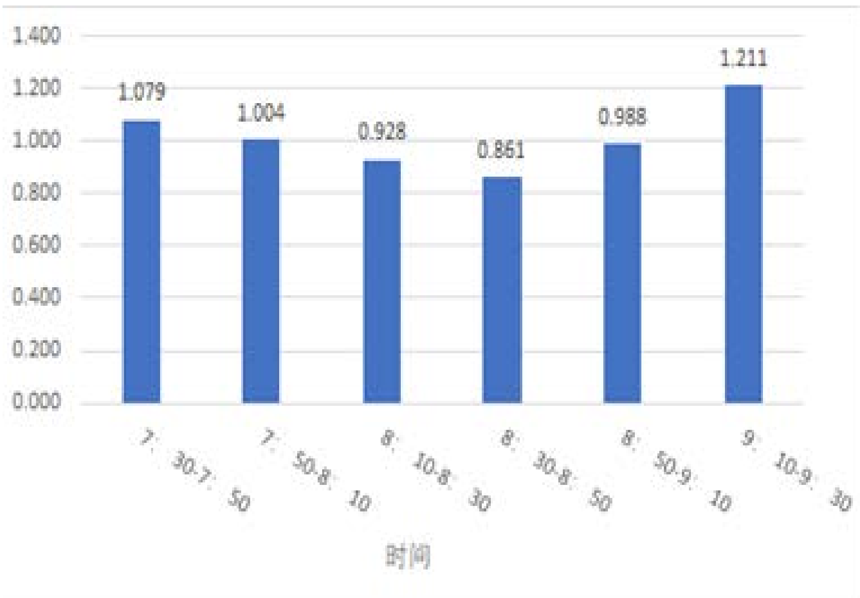

Figure 2 Peak hour coefficient (PHF) at 7:30-9:30

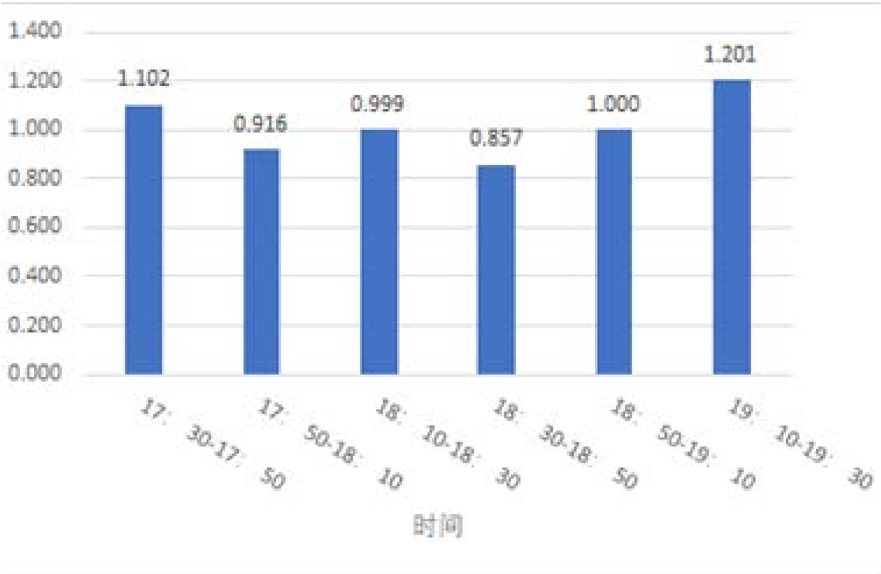

Figure 3 Peak hour coefficient (PHF) during 17:30-19:30

Through the analysis and calculation of passenger flow time distribution and total passenger flow, we draw the peak hour coefficient diagram of morning and evening peak periods (Fig. 2 and Fig. 3). In the morning and evening peak periods, the peak hour coefficient is within the range of less than 1.2 (some deviation is allowed).According to the definition of peak hour coefficient, we can know that in these two periods, the smaller the peak hour coefficient is, the larger the passenger flow of buses is compared with other periods, and it is in the "peak".

Combined with the above intuitive perceptual analysis and data validation analysis, we verify that the previous definition of "peak" and "flat peak" of the bus line is more accurate. This also provides a feasible condition for the subsequent model establishment and verification.

3. How to get the optimal solution

The public transportation scheduling problem is a complex nonlinear optimization problem, and involves many parameters. The general optimization algorithm is difficult to converge, so it can be solved by genetic algorithm. Genetic algorithm represents the solution of the problem as the survival of the fittest process of chromosome group. Through the continuous evolution of chromosome group from generation to generation, the genetic algorithm converges to the "most suitable individual" to obtain the optimal solution of the problem.

3.1 Model solution

By substituting the specified parameters into the genetic algorithm, the optimal departure interval and the optimal departure schedule can be obtained.

Table 1

Best departure schedule			
type	time slot	Departure interval (min)	Number of departures
Early low peak T1	6: 30-7: 10	10	4
Morning peak T2	7: 10-9: 10	8	15
Zaopingfeng T3	9: 10-10: 50	20	5
Wupingfeng T4	10: 50-16: 50	12	30
Evening peak T5	16: 50-18: 50	6	20
Late Pingfeng T6	18: 50-20: 50	12	10
Late low peak T7	20: 50-22: 30	10	10

It can be seen from the results in the table that the departure interval

3.2 Model stability analysis

A good model can not be caused by a small fluctuation of a certain parameter, which will lead to great changes in the results of the model solution. In this paper, we compare the stability of the model solution when the weight values of the two objectives of passenger waiting cost and company income are different.

Table 2

weight	$\alpha = 0.6, \ \beta = 0.4$	$\alpha = 0.4, \ \beta = 0.6$	$\alpha = 0.5, \ \beta = 0.5$
Departure interval	10,8,20,12,6,12,10	5,10,20,18,12,10,10	8,12,5,30,10,10,10
Departure times	80	77	81
objective function	2178.5	2247.4	2298.4

The value of different weights in the objective function can well reflect the interest trend of passengers and public transport enterprises. From the results of departure times and departure intervals in the table, different weight values have little impact on the final results. Therefore, it can be considered that the bus dispatching optimization model established by us is stable. Public transport does not aim at profit, but it is not free. Under the given financial allocation constraints, public transport should take into account the two major objectives of "reducing the use of private cars as much as possible to alleviate urban traffic congestion" and "making the public as satisfied as possible". Therefore, we can focus on the interests of travelers in the peak stage of crowd travel, and focus on the interests of public transport enterprises in the low peak stage of crowd travel.

3.3 Forecast of passenger flow distribution

Through the passenger flow of the first three weeks, the passenger flow of the fourth week is predicted, and the results are as follows.

Table 3

time	Passenger flow (true value)	Passenger flow (predicted value)	relative error
5May 25	246	255	0.0366
5May 26	259	263	0.0154
5June 27	247	249	0.0081
5June 28	279	287	0.0287
5May 29	281	271	-0.0356
5May 30	252	243	-0.0357
5December 31	250	254	0.0160

The relative error between the predicted passenger flow in the coming week and the actual passenger flow is less than 5% by using the grey prediction model, and the prediction effect is good. It can accurately predict the passenger flow of bus stops in the future, which provides a good auxiliary guidance for the optimization model of bus dispatching.

4. Conclusion

Based on the characteristics of the reference data and the actual situation, this model divides the bus travel time into a time period every 20 minutes, and further considers that the departure time interval in each time period is equal, so as to simplify the problem.

First of all, because the division of "peak period" and "normal peak period" is not absolute, the division standard has strong subjectivity. Therefore, we use the statistical data of public transport passenger flow in the appendix of relevant journals as the support, draw the data into a scatter diagram, and then use the second-order fitting of MATLAB to get a smooth curve through all points to compare the bus passenger flow horizontally, and then define the "peak" and "flat peak" of the bus line. Through the accumulation of real life experience and the observation of charts, the rationality of the definition is analyzed, and the peak hour coefficient is introduced to calculate the PHF value of "peak" and "flat peak", which can help explain the rationality of the definition of "peak" and "flat peak" theoretically.

Then, because the model is a nonlinear programming and involves many parameters, the general algorithm is difficult to converge. So we decided to use genetic algorithm. Its main characteristics are that it can operate on the structural object without the limitation of derivative and function continuity; it has inherent implicit parallelism and better global optimization ability; it uses probabilistic optimization method, and can automatically obtain and guide the optimization search space and adjust the search direction adaptively without certain rules

By removing the unnecessary data and retaining the needed data, after testing, it is decided that the genetic algorithm can converge under the action of the main parameters, and then find the optimal solution. Next, we test the stability and sensitivity of the model, change the vehicle load rate and weight, output the final optimal solution, departure interval and number of vehicles.

Finally, we use the grey model method to predict the "peak" and "flat peak". First of all, correlation analysis is carried out, that is, the degree of difference of development trend among system factors. And the collected data are generated and processed to find the law of system changes, generate a strong regularity of data series, and then establish the corresponding differential equation model to predict the future development trend of things. Because the grey model method itself can weaken the randomness of time series method, it does not consider the randomness factors including labor day in the process of prediction. Moreover, the correlation between passenger riding volume and date is small, but it is closely related to the number of vehicles, departure interval and other factors. Finally, by comparing the measured data with the corresponding calculation data, it is found that the difference is not big, so the model selection is accurate.

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