

The Departure Interval and Minimum Vehicle Arrangement Predicated by Real-time “Three-dimensional” Data based on Urban Bus

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Abstract: Along with the rapid development of Chinese urbanization, people's travel demand of motor vehicle dramatically increases, resulting in serious traffic congestion and limiting people's living quality. According to practical management experience and studies, to improve the ratio of transit of urban bus can effectively solve the traffic congestion. However, the supporting facilities of bus in China is not perfect and the management is poor, so the transit in various cities is not ideal. The formulation of reasonable departure interval and vehicle arrangement is one of most direct and effective methods to enhance the quality of urban transit services [1]. This paper focuses on collecting the real-time “three-dimensional” data of each urban bus in operating through intellectualized Internet of Vehicles, including the number of passengers in bus, travel speed and time headway, draws data image and constructs model, to predicate the departure interval of urban bus to meet the requirement of passenger flow volume, and the traffic conditions that bus will face, so as to optimize the control of urban bus company to departure interval. Besides, the number of vehicles operating at the same time in different situations is monitored to obtain the number of minimum vehicle arrangement of each bus route and save public traffic resources.

1. Introduction

The traditional control of departure interval is to predicate the time and morning peak and evening peak according to the experience of people scheduling urban bus, meet the requirement of passenger flow volume in peak period and formulate the departure time-table. Drivers can start vehicles to begin the operation business of this shift according to the departure time-table. With the development of times, motor vehicles on urban road increase gradually, whereas, the service quality of road fails to be improved, which causes the greater frequency of various uncertain traffic conditions. These traffic conditions cannot be predicated by people scheduling bus, so traditional method cannot satisfy the requirement of bus vehicle in ideal situation, and the negative impact of decreasing the satisfaction of passengers will occur, which has a negative influence on the development of urban bus. The poor satisfaction of passengers caused by the high rate of loading in peak hours has become a serious problem in bus scheduling. In the operation of buses, the high density of passengers in bus or the longer time for waiting the bus will lead to passengers' anxiety, utility loss and the impact on passengers' choice of travel mode. Thus, to take the quantized passenger subjective perception into account in bus scheduling, including the perception in bus and the perception of waiting for the bus is an important measure to improve the quality of public transportation services. The traditional method cannot accurately predicate the departure interval and decrease the transportation efficiency of urban bus.

In contrast, the control method of departure interval with the intellectualized Internet of Vehicles will collect the information such as the number of passengers in bus, the operational speed and traffic conditions, and analyze these information with algorithm and finally provide the reasonable departure interval at different time in that day. It is advantageous in providing realistic data for the control of departure interval as the support and avoiding the subjective awareness of human, so as to improve the accuracy of departure time and enhance the transportation efficiency of bus company.

The control of departure interval of urban bus is the basis for the operation of the entire bus system. The reasonable departure interval can reduce passengers' waiting time and promote the

economic and social benefits of bus company. From the perspective of passengers, the shorter the departure interval, the less time they need to wait; in terms of bus company, when the number of passengers is certain, the longer departure interval, the lower operation costs, which results the contradiction between the demand of transportation from passengers and the benefits of company. As a result, in the entire operation, it is necessary to control the departure time of bus in departure station [2].

The traditional plan for fitted out bus is similar with traditional scheduling plan, also the gradual adjustment of vehicles according to the experience of personnel in bus company. However, manual judgment is blind and ones-sided, there is always the problem of excessive vehicles in some lines and insufficient vehicles in some lines, causing the unbalanced allocation of vehicle and further the waste of vehicle resources. This problems can be solved by judging the required number of vehicles in each line and scientifically allocating corresponding vehicle resources.

2. The Intellectualized Data Collection System

2.1 The device collecting the number of passengers in bus

In this study, the photoelectric sensors are set separately in the front door and back door of bus to acquire the number of passengers. In the body outside surfaces of front door and back door, two pairs of external photoelectric sensors are installed separately; in the body inside surfaces of front door and back door, two pairs of internal photoelectric sensors are installed separately. When passengers get on bus, they block out the light of external photoelectric sensor, then the sensor transmits a pulse electric signal to single-chip, which means that one passenger gets on bus possibly. When the passenger goes inside the bus, the light of internal photoelectric sensor is blocked, in the same way, the pulse electric signal is transmitted to single-chip, which determines that one passenger already got on bus. The single-chip will compare the information transmitted from two sensors. If the frequencies of two pulses are same, the same value can be considered as the number of passengers getting on bus; if the frequencies are different, the smaller value is the number of passengers getting on bus. In the same way, when someone gets off the bus, the light of internal photoelectric sensor is blocked, and the pulse electric signal is transmitted to single-chip, which means that someone gets off the bus possibly. When the passenger gets out of the door, the light of external photoelectric sensor is blocked, and the pulse signal is transmitted to single-chip, which determines that one passenger gets off. The single-chip compares the information from two sensors. If the frequencies of pulses are same, the same value is taken as the number of passengers getting off from bus; if the frequencies are different, the smaller value is taken as the number of passengers getting off from bus. Then, the data monitored in front door and back door is real-time transmitted to the data processing system of bus company in a way of wireless transmission. The data processing system compares the accumulated number of passengers getting on bus and getting off from bus and obtain the real-time number of passengers in bus.

2.2 The device collecting the speed of vehicles

The speedometer on instrument panel can show the real-time speed of vehicle, but cannot record the real-time changes of speed in the whole journey. This study monitors the real-time speed with vehicle computer, sends it to data processing system, records the real-time speed of each bus and draws the changing curve of speed.

2.3 The device collecting time headway

The position information of each bus is acquired by the vehicle positioning system already set in each bus, and sent to data processing system. The system can calculate the real-time distance of two adjacent buses, and adopt the relevant formulas of time headway in the discipline of traffic engineering to calculate the time headway and perform the real-time collection. From the second shift of bus in every day, the real-time time headway is recorded.

2.4 The device collecting the real-time number of running vehicles

The principle of acquiring the real-time number of running vehicles is similar to that of time headway. The operation of vehicles is judged with the positioning system already in vehicles to obtain the number of running vehicles. At the same time, considering special situations such as gas refilling, charging and maintenance, the number of vehicles required of this line can be obtained, and the number of vehicle allocation can be scientifically obtained through the accumulation of data.

The data collection system is low-cost, just requiring the installation of photoelectric sensor in front door and back door, and the speed and position monitoring can be obtained from data in vehicle computer, so it is just necessary to send these data to data processing system of bus company. The system will process the data and obtain the optimal departure interval at different times and the minimum number of allocated vehicles of each bus route.

3. The Construction of Model

The number of passengers in bus, speed and time headway obtained already are taken as Z-axis respectively, the departure time in every day as X-axis, and the distance between stations and stops of bus as Y-axis, so the three space rectangular coordinate systems are established.

Taking the second shift of bus every day as an example, when it departs at a certain moment, the number of passengers in bus will change at every stop; the speed changes between the two adjacent stops; the time headway changes in the entire journey; these are shown as three different curves in coordinate system as Figure 1.

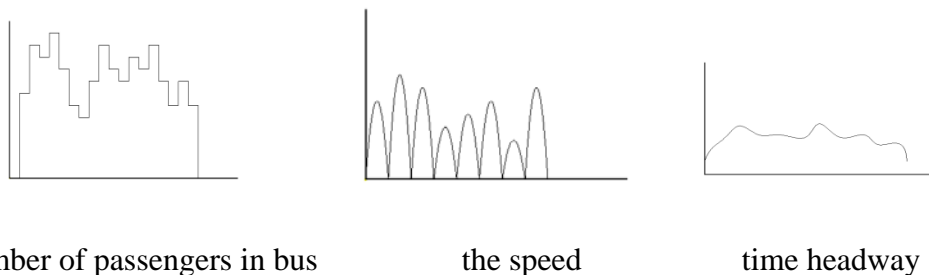


Figure 1 The number of passengers in bus, speed and time headway

In same way, assuming that there are n shifts on the same bus every day, there will be n different departure times, and there will be n curves drawn by each coordinate system. In other words, every bus departs, we will get three curves. Taking time headway as an example, it is shown in Figure 2.

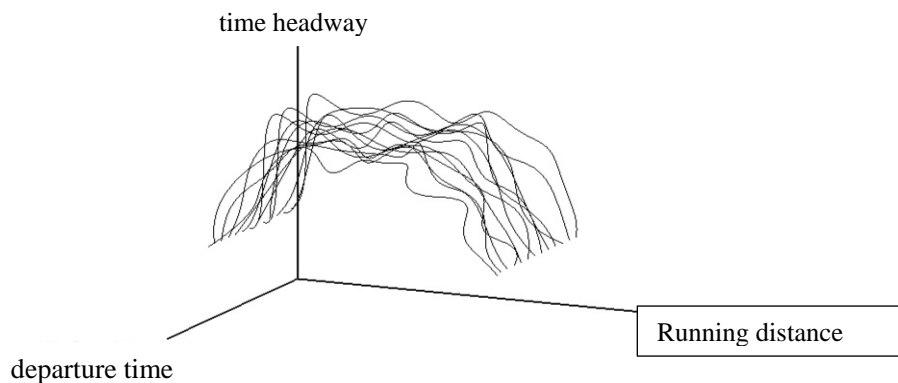


Figure 2 Curves of result

4. Conclusions

The conclusions can be drawn from the curve based on the coordinate system of the number of passengers in bus. Firstly, in the situation of the same departure time but different running stops, when the number of passengers in bus reaches a peak or a large value, there is a large passenger flow in corresponding stop. Secondly, in the situation of different departure times but same running stops, when the number of passengers in bus reaches a peak or a large value, the bus departs at a certain time will face a large passenger flow in the stop.

The conclusion can be drawn from the curve based on the coordinate system of the speed. In the situation of different departure times but same running stops, when the speed is higher, the bus departs at a certain time didn't face the traffic congestion between these two adjacent stops.

The conclusion can be obtained from the curve based on the coordinate system of the time headway. In the situation of different departure times but same running stops, when the time headway is less, the bus departs at a certain time didn't face the traffic congestion between these two adjacent stops.

Based on the analysis on data, it is feasible to predicate that the bus departs at what time may face the larger or smaller passenger flow and traffic congestion at which stop, so as to optimize the arrangement of departure interval.

This study plays a guiding role in controlling the number of shifts in the urban bus scheduling. The operation period of bus company is constant, according to the departure interval calculated, so the number of shifts for every day can be obtained. It means that the sum of all departure intervals is equal to the operational period. If there are n departure intervals, there will be $n-1$ shifts. The minimum vehicles of each bus route can be obtained by calculating the real-time number of running vehicles.

5. The Significance of Optimizing Urban Bus System

Urban bus plays an important role in the development of politics, economy, cultural education, science and technology and so on, also a necessary part in the construction of a city. To develop urban public transportation is an effective measure to alleviate the traffic congestion, as well as the necessary requirement to improve the living environment and promote the sustainable development, playing a significant role in enhancing urban function and balancing urban and rural development. As a component of urban infrastructure, urban public transportation holds an important position in China's urban construction and social life. Due to that it is directly related to the living quality of urban residence and it has an overall and leading influence on urban economy, it is necessary to promote the development of urban public transportation.

With the increasing number of vehicle ownership, people's demand for transportation becomes higher, and the factors hindering the smooth traffic also become diversified. There are more families can afford household vehicles when the demand for transportation is increasing. It will bring negative impact on urban public transportation, whether public bus, subway or taxi and online car-hailing. However, nowadays, the urban public transportation cannot provide sufficient comfort to passengers, no matter hardware or software. If the intellectualization and comfort of urban public bus system are still not improved, people will inevitably prefer to self-driving, which is not conducive to the development of public transportation in urban transportation. If the studies are strengthened to transform urban bus to become intellectualized one, such as the optimization of departure interval and vehicle allocation in this paper, the bus system can become more independent. By virtue of intellectualized information publish platform, passengers can know real-time information of public transportation. In addition, the construction of infrastructure for public transportation shall be intensified to further enhance passengers' comfort and satisfaction. In this way, more and more people will choose urban bus and abandon private car, which can meet the requirement of energy conservation and emission reduction and advance the priority of public bus for people. It can further solve the problem of traffic congestion, enhance the utilization rate of urban transportation resources, reduce urban transportation pollution, save urban land resources,

perfect the construction of urban basic public services, promote the growth of urban economy and enhance the well-being of urban residence.

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