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The Analysis of Space-time Characteristics of Bus Operation and Energy Consumption based on ArcGIS

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Abstract

Based on the actual bus operation data, energy consumption data, space-time data of bus operation dada and energy consumption data was integrated through Access database and ArcGIS software. Through the classification statistical analysis, the space-time characteristics of bus operation and energy consumption were concluded, and the relationship between bus operation and energy consumption was also discussed. All the work provides a scientific method for quantitative assessment of bus energy consumption.

Keywords: Bus operation; Energy consumption; Space-time characteristics; ArcGIS

1. Introduction

Quantifying energy consumption of bus is not only the key to promote 'oil to gas' bus plan, but also the basis of reducing energy consumption and traffic pollution. There are many factors related to bus energy consumption. Among them, bus operation state is the most essential factor affecting bus energy consumption [1]. But how to quantify the correspondence relation between bus operation state and bus energy consumption scientifically and accurately has been the bottleneck of evaluating bus energy consumption.

For a long time, the calculation and analysis of bus energy consumption are mostly from the macro perspective. By analyzing energy consumption from lifecycle perspective, Tang et al. [2] and Li et al [3] obtained the relationship between bus lifecycle cost and vehicle mileage ratio as well as the cost of energy. But the calculation method of lifecycle cost is based on default assumed in the different operating condition, which lead to more predicted error. In fact, there are a lot of real-time factors involving the actual bus energy consumption during running process, such as road type, real-time traffic condition, vehicle load rate and so on [4-5]. Therefore, related scholars began to study the relationship between energy consumption and the real-time bus operation status. Researchers found that vehicle energy

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consumption differs with different road type [4-6]. Ma [7] and Du [8] proposed that bus test line to evaluate energy consumption should be confirmed by actual proportion of different road type based on the clustering analysis method. Liu [9] used 'running time per thousand kilometers and per thousand vehicles' to quantify the effect of traffic congestion on energy consumption and pointed out that the vehicle fuel consumption quota should be increase when road is congested. In addition, related research found that with different cities, different time, different load ratio condition, the bus energy consumption are also different from each other [4]. Therefore, factors such as traffic condition and so on should be incorporated to public transportation energy consumption calculation system.

In the specific operation of transport energy consumption calculation system, two methods have been widely used: 1) measure fuel consumption value of test vehicle with different speed and then calculate the weighted average fuel consumption value; 2) measure fuel consumption value according to the different standard operating conditions and then calculate the energy consumption value. On the basis of these two methods, subsequent studies incorporated energy consumption per kilometers and energy consumption per kilometer with ten thousand passengers into energy consumption calculation system [10-12]. But there are still huge differences between experimental operating conditions and the actual operating conditions. Lin [13] built a car energy consumption model base on real-time vehicle operating data and real-time fuel consumption, which provides ideas for energy consumption calculation for bus.

An energy consumption calculating method was proposed in this study based on actual bus operating data and fuel consumption data. It aims to integrate the temporal and spatial characteristics of bus operating process and explores the relationship between actual operating process and energy consumption, which can provide a scientific reference for energy consumption estimation of any bus line.

2. Methodology

Data preprocessing was conducted using Access local data base and ArcGIS software. The statistical analysis of space-time characteristics of bus operation and energy consumption were conducted based on MATLAB software.

2.1. Data source

Data were collected by on-board diagnostic (OBD) system and global position system (GPS) fixed on bus in Beijing: Controller Area Network (CAN) data and GPS data. CAN data include vehicle instantaneous fuel injection volume, torque and vehicle mileage. Among them, vehicle instantaneous fuel injection volume can be used to analyze the instantaneous energy consumption; GPS data includes vehicle speed and location information. The GPS data can be used to match the corresponding road properties after matched with map information by Arcgis. In this paper, a total of 172800 pieces data of 47th bus during four days were used to do statistical analysis in Beijing. The length of 47th bus line is 15.15 km, which covers Haidian, Xicheng and Fengtai District and includes a total of 24 stations.

2.2. Method of data preprocessing

After matching map information by ArcGIS software, the bus operating track could be divided into highway, arterial road and subsidiary road, three levels, which increases the space information. Then, the road type information was integrated with corresponding real-time speed information and fuel consumption information, which increased the time information. All those formed the initial space-time database. Then the outliers of fuel consumption and speed data were removed and further formed valid space-time database. Finally, according to the valid space-time database, average speed and accumulated fuel consumption of different road types were calculated. In order to guarantee the data representation, data with same time property were further processed to get weighted average value.

2.3. Space-time database of bus operation