System of supervision for bus states of all way running and arrival prediction

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Abstract

According to the needs of travelers for bus operation information, a bus operation information system based on GPS data is designed. The system uses LabVIEW as a software development platform to analyze and process the dynamic data of bus operation, predict the arrival time of the bus and manage the data with the database to facilitate the mobile phone users to understand the dynamic information of buses anytime, anywhere.

Keywords

Supervision boards of buses; arrival prediction; labview; GPS; Intelligent Transportation Systems.

1. Introduction

Since the 1980s, due to urbanization, motorization, population growth and changes in population density, traffic in the world has been congested.Congestion reduces the efficiency of transportation infrastructure, increases travel times, and increases air pollution and fuel consumption.Some developed countries such as Europe, the United States and Japan have invested a great deal of material and manpower in the research of public transport systems. Many countries have begun to use advanced information and communication technologies to locate and monitor public transport vehicles and provide abundant public transport information to improve public transport service levels[1].

Based on the detailed analysis of citizens' needs, this paper designs a bus running status and arrival forecasting system based on traffic management system.The server-based LabVIEW is used to extract, analyze and process the GPS data of vehicle location. The system is based on LabVIEW software development. The graphical interface simulation of LabVIEW is used to verify the reliability and accuracy of the design.The predictive system enables mobile phone users to get online information of buses on the Internet at anytime and anywhere, reducing the waiting time for travelers at the station and attracting more people to take the bus.

2. Data processing of the system

2.1 The composition of the system processes and functions

Through the data (including vehicle identification, vehicle route, GPS data) sent from the bus, the bus control center server designed a system to process these data and used virtual instrument technology to determine the dynamic information of bus operation. The main functions and processes are as follows:

After the server of the bus control center establishes a TCP connection with the car terminal, the GPS data sent by the bus terminal is received. Three processes written in LabVIEW quickly process the data. Process 1 to establish a connection, the received GPS coordinates according to the vehicle label arranged in the memory block 1. Process 2 reads the GPS coordinates of all the vehicles in the memory block 1. During the time period t, the direction of the vehicle is judged according to the changes of the coordinates and stored in the memory block 2 according to the label sequence. Process 3 reads the data in the memory block 1, and uses the longitude and latitude distance formula to determine the position of the relative line of the vehicle, and finds the vehicle closest to each platform, calculates the arrival time by determining the distance therebetween, read memory block 2 in the direction of each vehicle, correspondingly updated vehicle number, location, direction, arrival time to the database.

2.2 Determination of the location and orientation of bus based on LabVIEW

Since the Earth is an irregular ellipsoid, the distance between two points on the ground is calculated as the distance between two points on the ellipsoid. The Earth's equatorial radius and polar radius are used to accurately calculate the straight line distance d_i between two points on the earth.

$$d_i = \sqrt{[(x_i - x_0) * Ed(y)]^2 + [(y_i - y_0) * Ec(y)]^2} \quad (1)$$

Where R_0 is the equatorial radius of the earth, R_1 is the polar radius of the earth, (x_0, y_0) and (x_i, y_i) represent the latitude and longitude radian coordinates of any two points A and B on Earth, Ed represents the actual distance between two longitudes at a certain latitude, Ec represents the actual distance between longitudes with an equatorial difference of 1 degree.

Determination of vehicle location

Assuming that the latitude and longitude coordinate variable of the vehicle is positioned as (x_0, y_0) and the coordinate variable of the collection point on the route is (x_i, y_i), the subscript i of (x_i, y_i) represents the label of the collection point, and the distance expression d_i between two points is non-negative. In the running process of the vehicle, the latitude and longitude of the vehicle at a certain time is continuously compared with the latitude and longitude of all the collecting points on the route through the program, that is, the minimum value d_{min} of the d_i found by using the distance formula between two points on the earth. The collection point i is the location of the vehicle closest to this point and determines which two stations the vehicle is between.

Determination of the direction of the vehicle

After determining the location of the vehicle, the coordinates of the vehicle have changed over time. Determine the vehicle displacement changes in the two adjacent collection points to determine the vehicle's driving direction, that is, $\Delta d = d_i - d_{i-1}$, d_i for the above-mentioned distance between the collection point and vehicle. And then determine the trend of Δd. After at least two times of judgments in two consecutive time periods, if the two judgments result is inconsistent, continue to judge in the next time period to ensure that the entire process of driving direction is correct[4].

3. System arrival time forecast

In recent years, the prediction of bus operating time has become one of the focuses of research in the field of intelligent transportation. Many scholars at home or abroad have done a lot of research on bus arrival time forecasting. They make use of mathematical algorithms, Kalman filter model based on historical data and artificial neural network (ANN) model to predict bus arrival time[5].

This paper presents a statistical method to predict the arrival time of buses.

3.1 Prediction Model

Shown in Fig. 1, according to the actual operation of the bus, the entire line of the bus includes nodes, intersections, straight sections, platforms. Bus from $i-1$ to $i+1$ platform may cross the intersection and platform, so predict the arrival time of the bus not only with the bus travel time, but also with the route at the waiting time, the number of intersections and platform stop time[6].

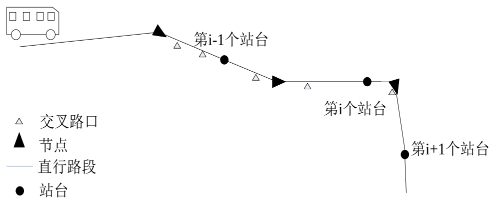

Fig. 1 Trip for a public bus

Predict the time from the current location to some platform by the superposition method.

$$T_{i+1}(t) = T_i(t) + T_l + T_w + T_d \tag{2}$$

$T_{i+1}(t)$ indicates the predicted time to reach the $i+1$ station prediction, and $T_i(t)$ indicates the time to reach the i station prediction. The bus driving time from the i station and to station $i+1$ is defined as T_l, the waiting time of the traffic light at the intersection is T_d, and the time spent by the vehicle at the i station is T_w.

(1) $T_i(t)$ time forecast. By forecasting the arrival time of the previous station, we can find the arrival time of the next station $i+1$. How many times the bus arrives, how many times it is superimposed.

(2) T_l time forecast. Analyze historical data and study the velocity distribution in different periods (early peak, late peak and off-peak), different holidays and different seasons. Using statistical methods to calculate the average speed of buses in a section of the road.

In a week cycle, the average speed of the bus distribution has a strong cyclical. The average speed distribution of buses for all routes is similar, and the average speed distribution from Monday to Friday is not the same as the weekends, with one day's peak and off-peak periods being different[7].

The background calculates the average speed of each section, the distance between each node is calculated by latitude and longitude coordinates of GPS, and the travel time of each section is obtained according to the distance and speed.

Suppose the bus line is divided into i sections, the length of the i section is L_i, the average speed of the section is v_i, and N is the number of nodes. The total travel time of the bus from the current position to a platform is

$$T_l = \sum_{i=j}^{N} \frac{L_i}{v_i} \tag{3}$$

(3)Prediction of queuing time at intersections. The queuing time for vehicles is not only related to the waiting time for traffic light but also to the number of intersections. According to intersection signal timing scheme, calculated as follows:

1) If the bus is reached before the red light is on, waiting time σ_j = red light time (sometimes including yellow light waiting time);

2) If the bus arrives when the red light is on, wait time σ_j = remaining time of red light;

3) If no red light is encountered, then σ_j = 0, queuing waiting time is considered in driving time.

The average delay time for an intersection is based on the average delay time for the vehicle passing through the intersection during the five-minute period to arrive at the delay time for all intersections from the current location to one of the stations:

$$T_d = \sum_{i=j}^{k} T_i \tag{4}$$

(4)Prediction of platform waiting time. The waiting time only takes into account the time spent on the bus at each station. Statistics of a period of time the average bus station in the residence time.

The average waiting time for all buses passing station A in an hour is

$$T_h = \frac{\sum_{k=1}^{N}(T_{dk} - T_{ak})}{N} \tag{5}$$

T_{dk} is the departure time of the Kth bus at station i, T_{ak} is the arrival time of the Kth bus at station i, and N is the number of stations passing through within an hour.

During the week of w, the average waiting time for buses at this station per hour is

$$T_i = \frac{\sum_{w=1}^{M} T_{hw}}{N} \tag{6}$$

The waiting time for the bus to pass the platform from the current location to the destination is

$$T_w = \sum_{i=j}^{k} T_i \tag{7}$$

3.2 Experimental results

Based on this model, a large number of experiments were done and a large amount of experimental data was obtained. Use quantitative and qualitative data to analyze arrival time accuracy.

In order to compare the accuracy of arrival time under various factors, an average absolute percentage error model was established.

$$MAPE = \left(\frac{1}{N}\sum_{k=1}^{N}\frac{|t(k) - t_m(k)|}{t_m(k)}\right) * 100 \tag{8}$$

$t(k)$ is the actual arrival time of the vehicle, $t_m(k)$ is the predicted arrival time, and N is the number of tests.

As shown in the figure, the results of the comparison of the three statistical methods are as follows: Figure (1) shows the result without considering the traffic situation, Figure (2) shows the result without considering the bus location information, Figure (3) shows the result considering the situation above. As can be seen from the error rate in Figure (4), the third case has the highest level of accuracy.

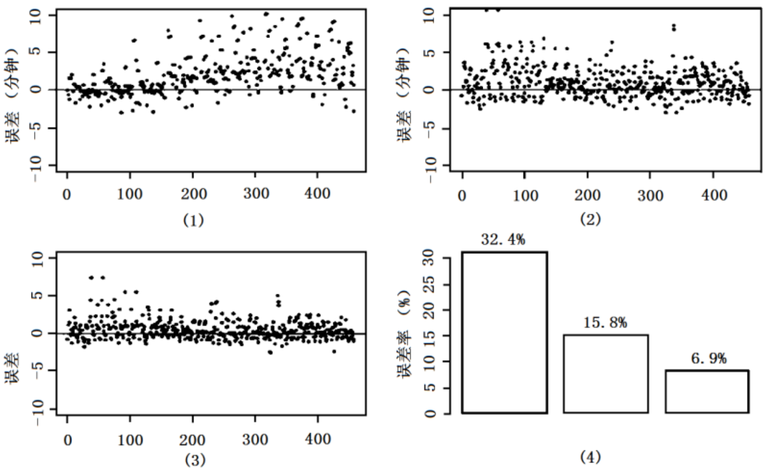

Fig.2 Results for Bus Arrival Prediction

This study uses GPS data and FCD data to effectively consider the traffic conditions, signal delay, platform and waiting time, which improves the accuracy of the results.

4. Conclusion

In this paper, the precise location of GPS and server-side accurate calculation can determine the operating position of the bus on the route, and accurately predict the arrival time. It not only facilitates the travel of passengers, but also provides convenience for citizens and bus companies to supervise the running status of each bus, reduces the waiting time for passengers at bus stations and attracts more citizens to choose bus trips.

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