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Traffic Congestion Warning Model Based on GIS \ GPS \ GPRS \ RFID Technology

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Abstract: To get the road network in the vehicle's location, speed, direction and a series of information, it innovative RFID-based dynamic access, GPRS (General Packet Radio Service) two-way communications. GPS real-time positioning and GIS path tracking system of the dynamic traffic conditions can be received from information flow, data flow, timely mutual transmission and accurate identification of different vehicles. Thus, through a summary of the above information and combining GIS geographic information system, we can obtain city status in real-time traffic information. It used BP-GM hybrid model to predict traffic way and changed previous single model for efficient and accurate prediction of future time. In order to achieve travel warning and traffic congestion route, quantitative research results and timely feedbacks were used for coming period of road network conditions to prevent the occurrence of massive congestion. *Copyright © 2013 IFSA.*

Keywords: Congestion warning, BP-GM hybrid model, Access flow rate.

1. Introduction

First, as the economic and social development and the constant expansion of the city, urban traffic congestion problems are to the fore. Today its existence has seriously affected the socio-economic development, at the same time, many urban areas of our country began to expand, increasing road construction and vehicle travel. Urban transport has entered a stage of rapid development. However, many cities in urban traffic began to emerge many cities in China generally encountered in the development process of urban traffic congestion. Gradually, it expanded the size of cities, gave transportation heavy pressure. A large number of people travelled and frequently exchanged goods, so that urban transport was facing heavy pressure. Secondly, as the rapid growth of motor vehicles, road traffic was increasing. In recent years, the number of private cars in many urban areas has increased every year, and showed increasing growth trends, leading to the city's traffic congestion more severe. So how to accurately predict and solve traffic congestion is particularly urgent [1-3].

2. Research Significance

With the rapid growth in the number of motor vehicles and urban road traffic conditions, most of the urban trunk road traffic flows were in saturated or supersaturated. Increasing traffic caused motor congestion problems and made some sections for a long period of saturation. In this paper, an area of the city, through the establishment of congestion warning systems, it had the ability to access urban vehicle information and calculated the entire traffic flow to provide real-time data to support early warning. And the mixed-model approach is two models, which will be integrated traffic forecast and factor analysis to warn overall traffic congestion. Thus can effectively analyze the upcoming congestion and already congested road. The road network information and timely feedback to the nearby vehicle can avoid the congestion, thereby avoiding massive congestion and improving the efficiency of the whole regional transport network [4-5]. Early warning systems and traffic analysis model for the improvement of urban traffic congestion has important realization value.

2. Working Principle of the System

To predict the dynamic traffic conditions, all vehicles need to collect specific information, driving conditions and other information at any time. In this paper, real-time traffic forecasts proposed a RFID-based dynamic access, GPRS (General Packet Radio Service) two-way communications. GPS and GIS can forecast system architecture to predict the future time local traffic conditions, enabling the vehicle traffic congestion warning on travel and dynamic route guidance (Fig.1). At the same time, it can also enable the data stream and command stream of two-way transmission and execution [6-7].

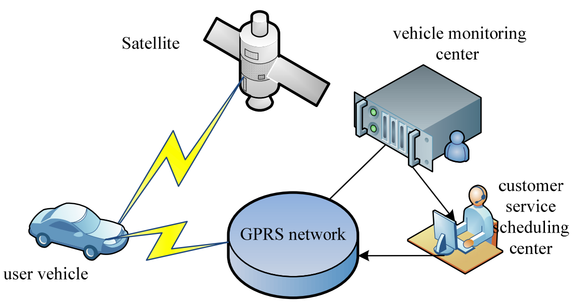

Fig. 1. System schematic diagram.

Meanwhile, in order to simplify the construction, operation and maintenance of the monitoring system, it used a distributed terminal interconnection model. Its system organization was the monitoring center, vehicle monitoring systems constituted two sub-systems. The vehicle monitoring system is actually a GPS signal receiver, which receives GPS satellite positioning signals to be calculated by the current vehicle location coordinates, and the coordinates of the position transmit the GPRS network data to the monitoring center, then the monitoring center process this data and calculate the vehicle's current position, speed, direction of travel and other dynamic information.

Monitoring center is responsible for vehicle monitoring system and various wireless data exchange between different types of data validation, centralized storage and processing. Real-time information is grasped for all vehicles. Comprehensive information of all kinds is used to predict future traffic conditions, so as to achieve vehicle dynamic path planning.

2.1 Monitoring Center

Monitoring center consists of intelligent control module, real-time database and the main processing unit, shown in Fig. 2.

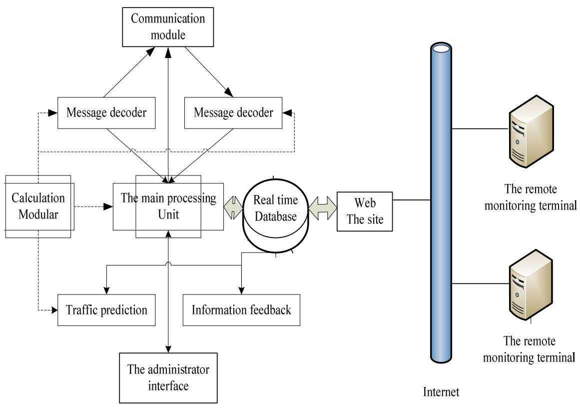

Fig. 2. Monitoring center architecture diagram.

2.2. Vehicle Monitoring System

Vehicle monitoring system consists of vehicle monitoring terminal modules, car RFID devices, GPS receiver, GPRS communication module, display, keyboard, and alarm indication unit. Vehicle monitoring system is responsible for vehicle real-time acquisition of RFID tags and other vehicle information vehicle type, vehicle sensors and real-time acquisition through GPS position, speed information, and fault information. The GPRS communication module with real-time data monitoring center can exchange information and upload data, as well as real-time traffic conditions monitoring center received information feedback. It also accepts various types of information of the monitoring center to achieve real-time instruction query tasks, shown in Fig. 3.

2.3 System Workflow

Step one: Using the monitoring facilities of the vehicle to detect the running direction;

Step two: At this point, RFID reader sends vehicle type information and vehicle identification information to the monitoring center. Then, monitoring center sends vehicle monitoring and control system instructions to the car through GPRS network information platform.

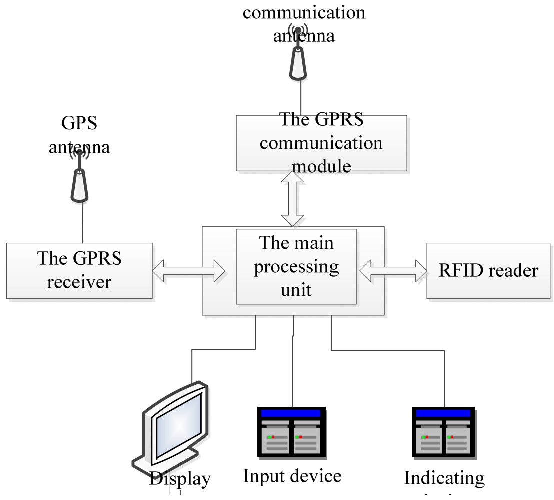

Fig. 3. Vehicle monitoring system.

Step three: When opening the vehicle monitoring system, it collects real-time GPS location, speed information and fault information by GPS, GIS and sensors. Then it exchanges real-time data with the monitoring center through GPRS communication module;

Step four: The monitoring center receives the information from the vehicle monitoring system after passing the information to the monitoring center of the computing platform. Computing platforms begin data processing and measure the current position of the vehicle, driving speed, driving direction, such as dynamic information, and connecting with the GlS system on the electronic map in the form of intuitive show. Vehicles of the current situation calculate the current traffic conditions and predict the future traffic for a period of time through the main processing unit;

Step five: When computing platforms predict that traffic congestion will happen in a road, the monitoring center will send this information in a timely manner to the area inside the vehicle monitoring system, to realize traffic warning;

Step six: If you predict that the road is without traffic congestion, the system returns to step one.

3. System Implementation

System implementation includes architecture, communication protocol design, research, development of various subsystems and system commissioning phases.

3.1. Communication Protocol

A set of binary message as the basic data structure of the wireless communication protocol can be used to realize the monitoring center, vehicle monitoring system, RFID tag information data two-way communication between the main bodies. Every body can take the initiative to push data, the request and passive executive command, which can realize the early warning, route guidance etc of multilevel cooperative and independent disposition.

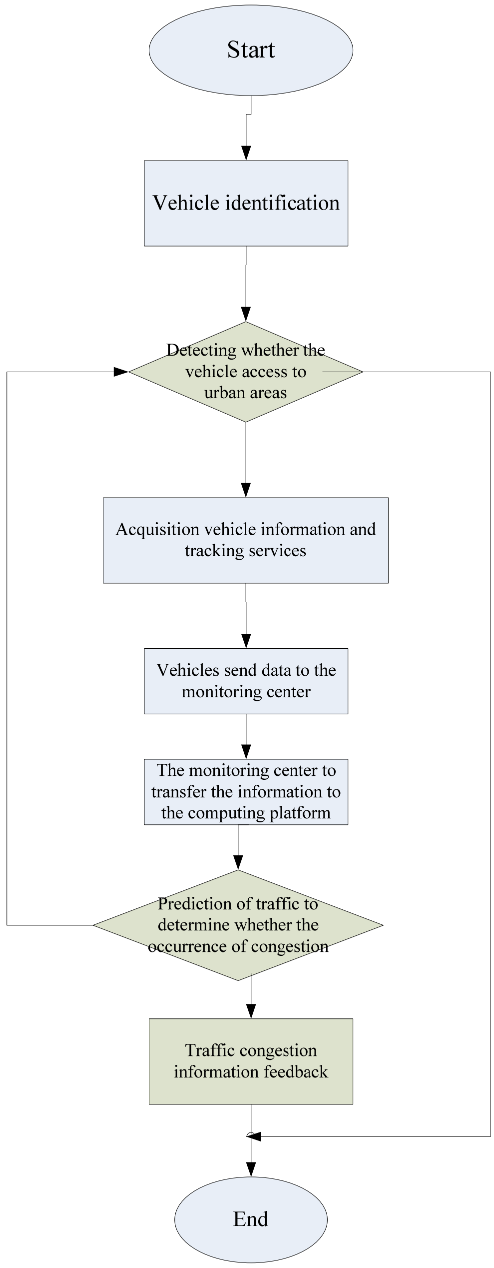

Fig. 4. System work flow chart.

Monitoring center and vehicle monitoring system protocols are divided into upstream (Vehicle Monitoring System → control center), down (monitoring center → Vehicle Monitoring System) and privileged commands (control center → vehicle monitoring system, change the vehicle monitoring system working mode, changing vehicle monitoring system status, forced restart etc.) three categories. Vehicle monitoring system is divided into five modes: initialization, normal, sleep, errors and debugging. Load balancing aspects of the communication is divided into normal, fast, instant, urgent four priority levels. Agreement is not only effective realization of a single control center for multiple vehicle monitoring system prioritized monitoring, but also remote local dynamic configuration state data transfer cycle. For safety, data communication at all levels is made up of a variety of optional 256-bit key encryption algorithm. In condition monitoring, the protocol supports many common physical vehicle information (GPS coordinates, speed, direction, vehicle vibration acceleration) and so on.

3.2. Vehicle Monitoring System

Vehicle monitoring system is a multi-function embedded automotive system, its structure and installation are shown in Fig. 5.

RFID communication module is responsible for the state data and control commands exchange with RFID tags; GPS module and satellite communication are responsible for real-time acquisition, speed and direction data; GPRS wireless communication module and the monitoring center realize data and command interaction; The LCD module is responsible for providing the driver status and alarm information; The processor module and data are responsible for coordinating control modules command processing.

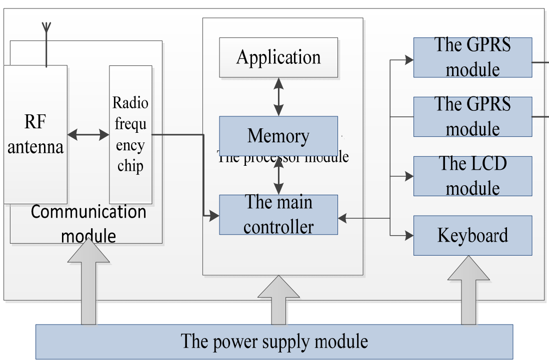

Fig. 5. Vehicle monitoring system structure.

3.3. Design of the Monitoring Center

The monitoring center' basic framework is mainly composed of communications unit, real time database, Web GIS and visualization subsystems such as monitoring interface.

By the use of c # network flow to achieve the function data communication unit, SQL server is adopted to establish the relational database. The database between each table is associated with the package ID. Based on SharpMap class library development of Web GIS by extracting GPS_ DATA in the table of latitude and longitude information to real time location tracking, historical track recreate and set the route planning. Monitoring mainly includes Web GIS interface, real-time and historical DATA query, vehicle status. It not only uses .net and Javascript to implement the information integration technology, but also uses Ajax technology to realize the page refresh.

4. Traffic Congestion Warning System Implementation

4.1. Mixed Traffic Prediction Based on BP-GM

A hybrid model structure for mixed traffic prediction based on BP-GM is shown in Fig. 6.

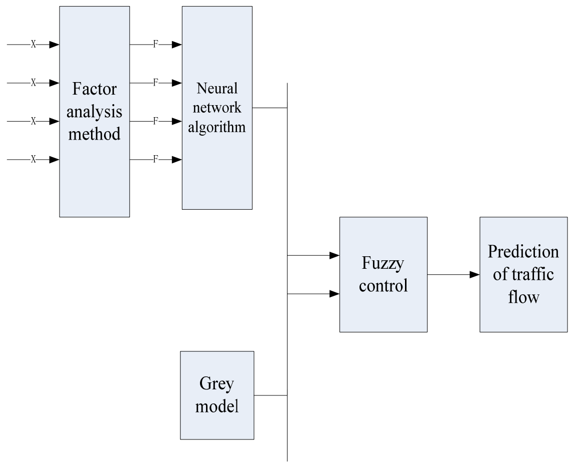

Fig. 6. Hybrid Model Structure.

4.2. Neural Network

Neural network (Neural Networks, NN) consists of a lot of simple processing units (called neurons) widely connected to each other to form a complex network system. It reflects many basic features of the human brain function, which is a highly complicated nonlinear dynamic learning system.

At present, it has developed dozens of neural networks, such as Hopfield model, Feldmann connection type. Network model, which is widely used, is the multilayer perceptron neural network. Its structure is shown in Fig. 7.

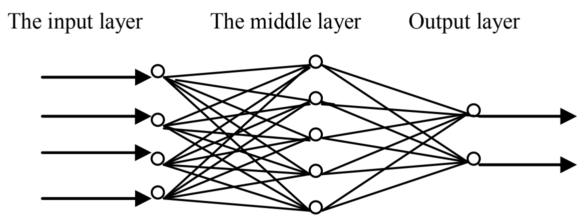

Fig. 7. BP neural network model.

BP algorithm not only has the input layer nodes and the output layer nodes, but also has one or more hidden layer nodes. Input signal is first spread to the hidden layer nodes forward. Then, under the action of the hidden nodes, output signal is transmitted to the output node. At last, the output is given. Nodes of the excitation function usually choose S function, such as

$$f(x) = \frac{1}{1 + e^{-x/Q}} \tag{1}$$

Layer of neurons state only affects the next layer of neurons. In forward propagation, the input information from the input layer through the hidden layer can handle step by step, and then to output layer. Each layer of neurons state only affects the next layer of neurons. If the output value of the output layer is not ideal, it will turn to back propagation, and will return error signal along the original connection channel. By modifying the weights of each neuron, the error signal is minimal.

Any network contains n nodes, each node' characteristics is Sigmoid type. To keep things simple, assuming that the network has only one output, which is y, the output of any node i is o_i. It is equipped with N sample (x_k, y_k) (k=1,2,3,…,N), node j's output is

$$net_{jk} = \sum_i W_{ij} O_{ik}$$

And error function is defined as

$$E = \frac{1}{2}\sum_{k=1}^{N}(y_k - \hat{y}_k)^2 \tag{2}$$

For the network actual output, definition

$$\delta_{jk} = \frac{\partial E_k}{\partial \text{net}_{jk}}$$

and $O_{jk} = f(\text{net}_{jk})$, where

$$\frac{\partial E_k}{\partial W_{ij}} = \frac{\partial E_k}{\partial \text{net}_{jk}} \frac{\partial \text{net}_{jk}}{\partial W_{ij}} = \frac{\partial E_k}{\partial \text{net}_{jk}} O_{ik} \tag{3}$$

When *j* is for the output node, $O_{jk} = \hat{y}_k$

$$\delta_{jk} = \frac{\partial E_k}{\partial \hat{y}_k} \frac{\partial \hat{y}_k}{\partial \text{net}_{jk}} = -(y_k - \hat{y}_k) f'(\text{net}_{jk})$$

If j is not output node, there is

$$\delta_{jk} = \frac{\partial E_k}{\partial \text{net}_{jk}} = \frac{\partial E_k}{\partial O_{jk}} \frac{\partial O_{jk}}{\partial \text{net}_{jk}} = \frac{\partial E_k}{\partial O_{jk}} f'(\text{net}_{jk})$$

$$\begin{aligned} \frac{\partial E_k}{\partial O_{jk}} &= \sum_m \frac{\partial E_k}{\partial \text{net}_{mk}} \frac{\partial \text{net}_{mk}}{\partial O_{jk}} \\ &= \sum_m \frac{\partial E_k}{\partial \text{net}_{mk}} \frac{\partial}{\partial O_{jk}} \sum_i W_{mi} O_{ik} \\ &= \sum_m \frac{\partial E_k}{\partial \text{net}_{mk}} \sum_i W_{mj} = \sum_m \delta_{mk} W_{mj} \end{aligned} \tag{4}$$

$$\begin{cases} \delta_{jk} = f'(\text{net}_{jk}) \sum_m \delta_{mk} W_{mj} \\ \dfrac{\partial E_k}{\partial W_{ij}} = \delta_{mk} O_{ik} \end{cases}$$

If there is an M layer, the first M only contains output node, and the first layer is or the input node. The BP algorithm is:

The first step is to select the initial weights of W.

The second step is to repeat the following process until convergence:

A. for k = 1 to N

a) Calculate O_{ik}, net_{jk} and $\hat{y}_k$ value (process);

b) Each layer from M to 2 reversing calculation process (reverse);

B. on the same node j ∈ M, calculating δ_{jk}.

The third step, revising weight, $W_{ij} = W_{ij} - \mu \frac{\partial E}{\partial W_{ij}}, \mu \rangle 0$, among which $\frac{\partial E}{\partial W_{ij}} = \sum_k^N \frac{\partial E_k}{\partial W_{ij}}$.

5. Grey Prediction

Grey prediction refers to the development and change of the characteristic value of system behavior prediction. It contains both known information and uncertain information of prediction system, namely to change within a certain scope. Grey process is related to the time prediction.

A variable X(0)={X(0)(i), i=1,2, ..., n} is as a forecast object of nonnegative drab. In order to establish the grey prediction model, original data sequence is as follows: first to generate an incremental sequence:

$$X^{(1)} = \{X^{(1)}(k), k=1, 2, \ldots, n\}, \tag{5}$$

Among which:

$$X^{(1)}(k) = \sum_{i=1}^{k} X^{(0)}(i) = X^{(1)}(k-1) + X^{(0)}(k)$$

For $X^{(1)}$ to establish the following bleaching in the form of different equations: $\frac{dX^{(1)}}{dt} + aX^{(1)} = u$.

The above is GM (1, 1) model.

The bleaching solution of differential equation for the discrete (response):

$$\hat{X}^{(1)}(k+1) = (X^{(0)}(1) - \frac{u}{a})e^{-ak} + \frac{u}{a}$$

or (6)

$$\hat{X}^{(1)}(k) = (X^{(0)}(1) - \frac{u}{a})e^{-a(k-1)} + \frac{u}{a}$$

$$B = \begin{bmatrix} -\frac{1}{2}(X^{(1)}(1)+X^{(1)}(2)) & 1 \\ -\frac{1}{2}(X^{(1)}(2)+X^{(1)}(3)) & 1 \\ \ldots & \\ -\frac{1}{2}(X^{(1)}(n-1)+X^{(1)}(n)) & 1 \end{bmatrix} \quad (7)$$

$$Y_n=(X_{(0)}(2), X_{(0)}(3),\ldots, X_{(0)}(n))^T$$

$$\hat{X}^{(1)}(k)=\sum_{i=1}^{k}\hat{X}^{(0)}(i)=\sum_{i=1}^{k-1}\hat{X}^{(0)}(i)+\hat{X}^{(0)}(k) \quad (8)$$

$$\hat{X}^{(0)}(k)=\hat{X}^{(1)}(k)-\sum_{i=1}^{k-1}\hat{X}^{(0)}(i)$$

Because $\hat{X}^{(1)}(k-1)=\sum_{i=1}^{k-1}\hat{X}^{(0)}(i)$,

So

$$\hat{X}^{(0)}(k)=\hat{X}^{(1)}(k)-\hat{X}^{(1)}(k-1).$$

6. Conclusions

With the continuous improvement of living standards, the expanding of the city, the continuous improvement of car ownership, urban road congestion problem became more and more serious. The current research on early congestion warning mechanism is not very perfect. Based on GIS/GPS/GPRS/RFID technology to jointly establish early warning system, it can get the vehicles position, speed and direction. In addition, it can also be combined with the geographic information system and the vehicular communication system to set a condition of road traffic network accurately and timely indeed. This system can give traffic processing good feedback, so as to realize two-way transmission of the information flow. Meanwhile, it also has changed the past a single flow prediction model to predict traffic way. Through the BP-GM hybrid model to forecast the number of cars in the future period of time, this kind of prediction method eliminates the limitations brought by the single model, enhanced the reliability of the predicted results. This paper fundamentally established a set of perfect traffic warning system, scientifically avoided some congestion, guaranteed the smooth traffic. Of course, there also exists some shortage, it hasn't been able to realize the reasonable distribution of the traffic and route choice. In the later study, the system will continue to improve.

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