Chapter 86
The Self-Adapted Taxi Dispatch Platform Based on Geographic Information System

Yi-ren Ding, Jing Xiong and Heng-jian Liu

Abstract In order to improve the efficiency of taxi dispatching, we build a center-controlled, real-time management system. With the help of the real-time data collected by recorders in taxis and the wavelet neural network utilized to predict passenger current, the whole system can work more precisely. Besides, the exceptional situations are also taken into consideration in this system. Thus, the whole system is able to distribute taxis efficiently in any situation. Simulation results indicate that the wavelet neural network could make more accurate prediction than former methods and the self-adapting distribution strategy can increase load rate effectively.

Keywords Taxi dispatching · Passenger flow prediction · Dynamic model

86.1 Introduction

Taxi is and still will be an important part of city transportation system; it is a supplement of public transportation [1]. The improvement of the efficiency of taxi has taken paces with the help of vehicle GPS and center GIS control system. Take Taipei as an example, the taxi information sharing system established several years ago provides a platform for strangers who have the same destination to take one cab together, which improves the efficiency of the city transportation [2]. The system introduced in this passage, committed to analyzing the data from recorder in taxis, establishing self-adapted dynamic model in consideration of emergency, and predicting passenger flow in each road. The application will be given in passage.

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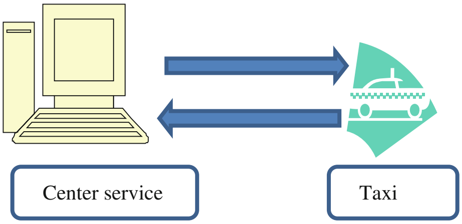

Fig. 86.1 System configuration

86.2 Geographic Information Management System

The real time information (route, amount of passenger) which comes from recorders in taxi is transmitted to the center. The management center not only receives the information of current passenger flow but also receives the location and state of every taxi. All information comes from taxi will be saved in server, which will be invoked as original data for real-time analysis, then updating dynamic model and giving guidance. It is an archetype of intelligent transportation cloud [3]. The FLEX[1] is used for building the interface and Java is applied for calculating. Besides, the MapGIS (see footnote 1) platform is utilized for map service (Fig. 86.1).

86.3 The Wavelet Neural Network

The wavelet neural network is one kind of the former dyke type models for prediction. The wavelet neural network, with the ability of self—learning and self-revising, is the most comprehensive and typical model of neural network. The learning processes of neural network are made up of forward propagating and counter propagating. Only if the result of first forward process didn‘t meet the expectation will the counter propagating interfere and revise weight in each neural cell, then the new results could be more precise. The advantage of wavelet in information process could be fully developed if it is used as transmit formula in neural network system. And it could overcome the nonlinearity and the interactive feedback attribute of taxi [4]. Based on published experiment, the accuracy of wavelet neural network model is better than GNF and NBRR model which are most common in use today [5] (Fig. 86.2).

The number x formula of wavelet transmitting is showed:

[1] Notifications

1 FLEX: A free and effective open source software platform produced by Adobe^{TM} for application development.

2 MapGIS: The first erect-style data center development platform in the world produced by ZONDY CYBER.

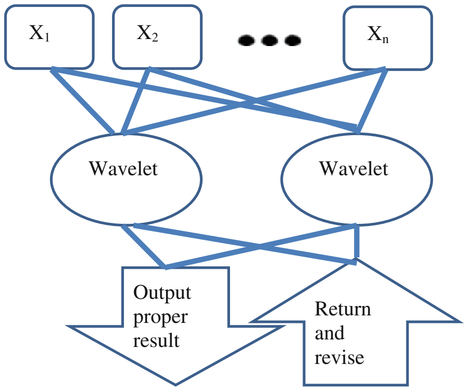

Fig. 86.2 Wavelet neural network

$$M_j = M_j\left(\frac{\sum_{i=1}^{k}\omega_{ij}x_i - a_j}{b_j}\right) \mathrm{j} = 1, 2, 3\ldots \tag{86.1}$$

$\mathrm{j} = 1, 2, 3\ldots$ are indicate factors in the wavelet formula. These factors are supposed to be modified only if the first output value exceeds the tolerable difference of expectation.

The method of modifying is called gradient-corrected.
Weights modifying process:
Modify weight of each level: $\omega\mathrm{k} + 1\mathrm{nj} \;=\; \omega\mathrm{knj} \;+ \Delta\omega\mathrm{k} + 1\mathrm{nj}$
Modify the factors in the number I neural cell:

$$\mathrm{ai} + \mathrm{lj} = \mathrm{aji} + \;\Delta\mathrm{aji}\; + \mathrm{l};\;\; \mathrm{bji}\; + \;1\; = \;\Delta\mathrm{bij}\; + \;1 \tag{86.2}$$

In this formula $\Delta\omega\mathrm{k} + 1\mathrm{nj}, \Delta\mathrm{aji} + 1, \Delta\mathrm{bij} + 1$ are obtained by gradient-corrected method [3]:

$$\Delta\omega_{nj}^{k+1} = -\sigma\frac{\partial e}{\partial\omega_{nj}^{k}}; \Delta a_j^{i+1} = -\sigma\frac{\partial e}{\partial a_j^{i}}; \Delta b_j^{i+1} = -\sigma\frac{\partial e}{\partial b_j^{i^{\circ}}} \tag{86.3}$$

After the model is established, to increase the speed and efficiency of learning of neural network, the pretreatment is necessary. We use linearization method to narrow the range of data, then the possibility of successful prediction is likely to be improved [4, 6]. Linearization formula:

$$\mathrm{Xi}\; = \;(\mathrm{x}\; - \min(\mathrm{X}))\;/\max(\mathrm{X})\; - \min(\mathrm{x}) \tag{86.4}$$

Table 86.1 Exceptional situations

Name	Anomalies	Example
One-time output anomaly	A place with unusual output passenger for one time	A train station right after long holiday
One-time input anomaly	A place with unusual input passenger for one time	An international auto show
Long time anomaly	Unusual passenger flow for long time	New shopping mall

86.4 Exception Handing

It is an effective method to find regular fluctuation of passenger flow through the result of wavelet neural model. However, the exceptions caused by unexpected events cannot be predicted by the model. Besides, due to the accumulation of data, the abnormal data may influence the short-time prediction of passenger flow. Therefore, manual adjustment is required when the abnormal data is detected, and the cause of anomaly should be investigated and analyzed [7].

We classify exception into three categories (Table 86.1).

86.4.1 The One-time Output Anomaly and The One-time Input Anomaly

In these two situations, the anomalies would last for one day or several days, usually accompanied with the abrupt appearance and fast disappearance. Holidays, festivals, celebrations and grand activities always contribute to the situations. The method to detect the anomaly is called growing-rate threshold. In general, the cycles of statistics are set each 6 h, one day, and three days. If the growth rate exceeds the threshold of each time cycle, the system will inform managers to change the auto-dispatch to manual-dispatch and then experts are informed to investigate the causes.

86.4.2 Long-time Anomaly

The changing rate of data in long-time anomaly situation is not as sharp as one-time anomaly. But the difference is that the passenger flow will never come back to the former level. Like the new shopping mall put into use, it will lead the long-standing change in passenger flow which is different from one-time anomaly. In this case, the cycles of statistics are 15 days, one month, three months and one year. When the long-term anomaly is detected, the old data will be cleared and

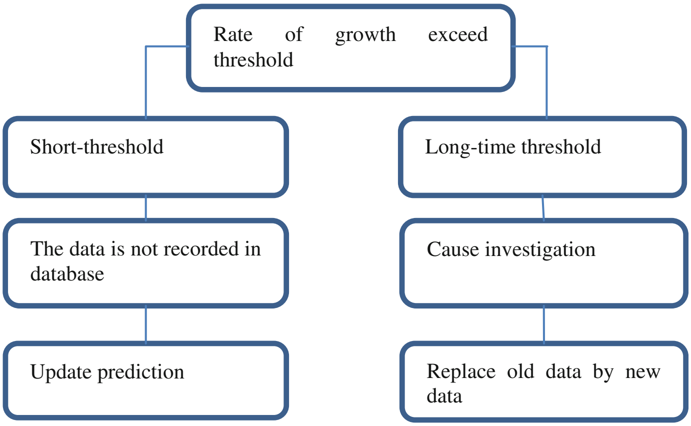

Fig. 86.3 Exceptional handling process

train the newly collecting data in model. And this data replacement makes the prediction more accurate (Fig. 86.3).

86.5 Real-time Self-adapting Dispaatching

The passage above simply introduces the system configuration, prediction formula and exception handling, the key part of system is to dispatch taxi by the result that is calculated by the model and the real-time data. Real-time dispatching is made up of three core parts: the model of passenger flow prediction, the real-time statistic data, and the "back much better repair" policy. This policy means to predict potential amount of passengers according to the difference between statistic number and prediction number.

Because of the uncertainty of the passengers amount, and the wavelet neural model can only predict the total amount of passengers, the system obtains many unsatisfactory results during tests. We find that even the amount of total passengers has been predicted precisely by wavelet network model, the passenger flow fluctuate in every period—the surge in rush hour. And the increase of passengers in rush hours makes counteraction on steady phase. So the prediction should be adjusted by the data we collected in 1 day.

Assuming Pn is the passenger prediction in one period, T means the total amount of passenger before time Pn, S means total prediction number, Xn means the impact factor.

$$P_n = S * X_n * \left(\sum_{i=1}^{n-1} P_{n-1} \right) / T \tag{86.5}$$

After the passenger flow prediction in current period is obtained by using GPS locating the position of every taxi, then we can give guidance to empty taxis. As the suggestion given by construction bureau, the rational rate of utilization of taxi is 70 %. And the rate of utilization approximately equals to the ratio of the amount of passengers and the number of taxis in one time period [8, 9]. Because the system has not been put into use, in the example followed, we assume that the rational ratio of passenger and taxi is 10.

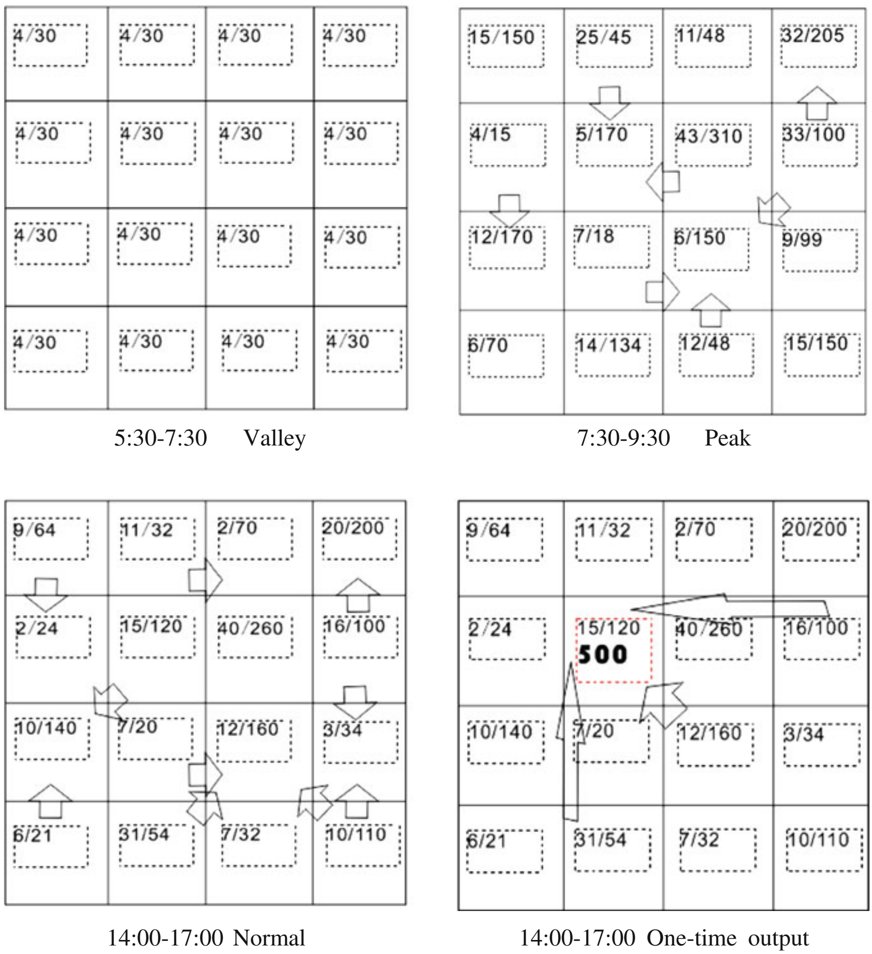

Fig. 86.4 Passenger, taxi and dispatching situation in city one

Table 86.2 Rate of load in three cities

Rate of Load	Valley time (%)	Peak time (%)	Normal time (%)	Anomaly in normal time (%)
City 1	65	94	75	86
City 2	60	90	68	55
City 3	39	82	50	45

86.6 Example of Application and Contrast

86.6.1 One Particular Simulation

In order to test the superiority of our system, we create three simulated cities and each city is tested for three times with different original status. Take city A for example, to simulate the rush hour and normal hour, we suppose there are 16 fixed blocks in the city and the numbers of passenger range from 500 to 2,500. The data is recorded in representative time, and it includes the number of potential passenger, the number of taxi, the number of people who took taxi and people who failed to take taxi in each block. To compare the efficiency of rate of load, city A will simulated under three different management modes.

Mode1: Using self-adapted dispatching system.
Mode2: Using normal dispatching system.
Mode3: Without using dispatching system.
The X/Y in the graph means: amount of taxi in the area/passenger prediction in the area.
The arrow means the guidance given to the taxi.
The bold number in fourth picture means a one-time output anomaly; the number of real passenger is over 4 times larger than prediction.The following pictures show the dispatching process in self-adapted management system (mode 1) (Fig. 86.4), (Table 86.2).

Table 86.3 Rate of load in each simulation

	Mode 1 (%)	Mode 2 (%)	Mode3 (%)
City A	80	68	54
	83	69	60
	80	74	62
City B	86	74	62
	81	69	65
	82	70	59
City C	78	69	58
	78	63	53
	77	65	53
Average	80.6	69	59.6
Standard deviation	2.83	3.60	4.33

Through this simulation, we obtain the results of rate of load in different management modes. In mode 3, the rate of load is always lower than that of mode 1 and mode 2. In mode 2, though the rate of load surpasses that in mode 3 a lot, it decreased sharply when an anomaly appears. In city 1, with the help of self-adapted management system, not only the rate of load is the highest, but also the fluctuation is the tiniest, and the advantage of stable is particular significant when anomaly happens.

86.6.2 All Simulations

City B is supposed to have 25 blocks and City C is supposed to have 36 blocks. Each city is tested three times with different original status.

The following table shows the average rate of load in each simulation that we have done (Table 86.3).

86.7 Conclusion

With the help of our system, three goals are achieved. Firstly, managing taxi cab in center controlled method. Secondly, predicting the amount of potential passenger precisely. Thirdly, providing proper suggestions to taxi. Simulation result shows that the self-adapted management improves the rate of load by approximately 10 %, it provides better Stability. Center controlled system and cloud system is the tendency of management system. The communication technique and GIS platform contribute a lot to establishing this system. However, this system only predicts and monitors the passengers who take taxis. The next step of studying should refer to the system which could control all public transportation system. In that way, the efficiency of city transportation could improve much more.

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