

Research on Technology Used in Predicting Traffic Congestion for Navigation System

Toshihide YOFU*

Masakuni TSUGE**

ABSTRACT

Today, most vehicle navigation systems use a Vehicle Information Communication System (VICS), which provides drivers with traffic information for specific areas. VICS is extremely useful in keeping drivers informed of current traffic conditions in the area they are driving in, but drivers also require information on the traffic conditions of roads leading to destinations in other VICS areas and recommendations on alternative routes based on the information. The fact that VICS information can now be used by private companies has allowed Honda to provide information on traffic conditions up to the driver's destination and to conduct research on the prediction of the vehicle's travel time using recorded VICS data. This paper discusses the developed prediction method.

1. Introduction

In the evolution of navigation systems, a function that accurately guides you to your destination has been demanded. There has been research into innovative map databases and route calculation methods to create optimal routes^{(1), (2)}, and functions were provided to guide the driver along the optimum route in an easy-to-understand way. In 1996, the Vehicle Information Communication System (VICS)⁽³⁾, which had been in development for some time, was put into service, allowing us to provide drivers with real-time traffic conditions as well as optimum routes using that information.

Traffic conditions are monitored in each prefecture by the local police, and by road administrators such as the Japan Highway Public Corporation, for road units. The information is collected by the Japan Road Traffic Information Center, batch processed and edited by the VICS Center so the data can be supplied to navigation units with VICS receivers. The VICS receivers obtain data using optical and radio wave beacons, FM waves and other means (Fig. 1).

Normally, real-time VICS information is transmitted only in a given geographical area (Fig. 2), and it is not possible to obtain information beyond the current area. Therefore, there are cases where, at the time the information is received the system shows smooth traffic ahead, but when the vehicle reaches that area, it has become congested (Fig. 3). This results in inaccurate arrival times being given by the navigation system.

In 2002, VICS data was provided to the public, and it became possible for telematics service companies to provide users with secondary processed data. This has led to the possibility of not only providing VICS information from other areas, but also of providing an optimum route while predicting an accurate arrival time, and overcoming the issue mentioned above.

In this project, the authors verified whether it was possible to predict traffic conditions, such as congestion, on specific roads by analyzing VICS historical information.

* Tochigi R&D Center

** Honda Motor Co., Ltd.

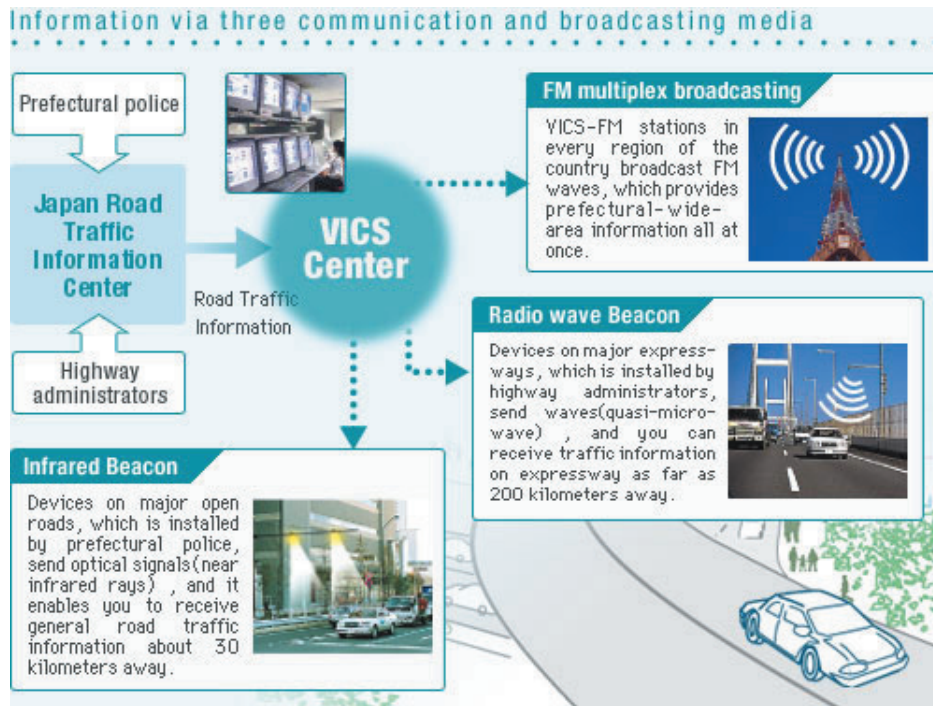


Fig. 1 VICS system schematic

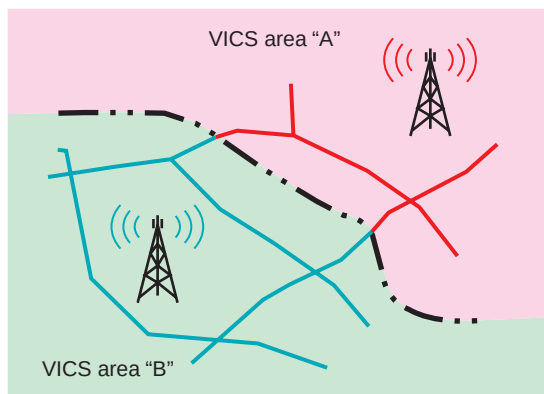


Fig. 2 Image of VICS areas

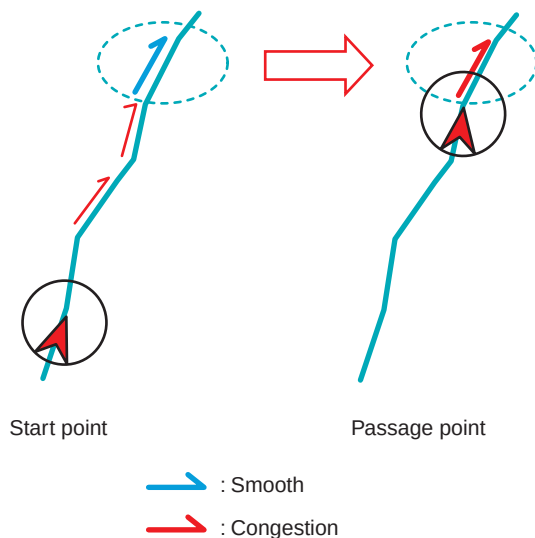


Fig. 3 Change in traffic status

2. Traffic Status Simulation

2.1. Verification Method

VICS establishes segments called "VICS links" for each section of road data, and for each link, the time (seconds) taken to pass through that link is provided (link passing time). Until now, methods to predict traffic conditions, such as congestion, have included those that simply determine conditions from historical data on days and time bands for an observed link, and those that carry out complex calculations from traffic flow over the observed link⁽⁴⁾⁻⁽⁷⁾.

In this project, the goal was to increase accuracy and make more efficient predictions, and the authors studied a method using searches of approximate values from historical data.

Creating a graph with time as the horizontal axis (24 hours) and link-passing time in an observed link as the vertical axis allowed researchers to calculate the passing time at an observed link every five minutes, when the VICS data was updated (Fig. 4). Here, the prediction base time t_b is set and the specific time period immediately prior to t_b is established as basic data to search (matching time width t_m) (Fig. 5). Calculations are made by

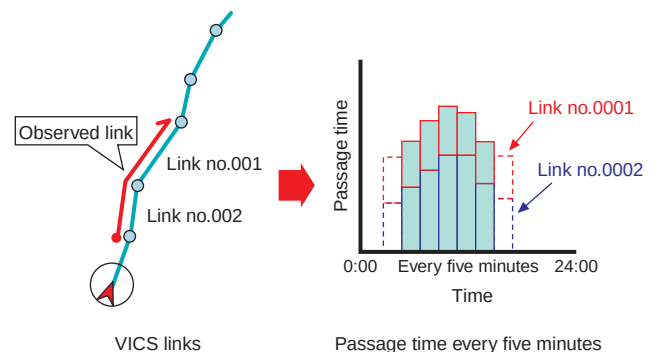


Fig. 4 Change in passage time in observed link

searching for approximate values that have the least difference among historical data. Because calculations with all historical data subject to the search would increase processing, the calculation range was limited to search time width, t_s , and calculations were carried out within that range. After searching approximate data series for those with the least differential (Fig. 6), the data after the extracted data series (predicted time) were set as the predicted value (Fig. 7).

In this method, the following major parameters are thought to cause fluctuations in accuracy.

- (1) The time width that was the basis for the search (matching time width t_m)
- (2) The time width that was subject to the search (search time width t_s)
- (3) The historical data group that was subject to the search (period, time, etc.)

In this simulation, all historical data were divided into periods. Search processing was carried out for every five minutes, and predicted values were obtained at 15-, 30-, 45-, and 60-minute intervals. The predicted values were then compared to the actual values, and the differences between these values were quantified into the mean square deviation, and evaluated.

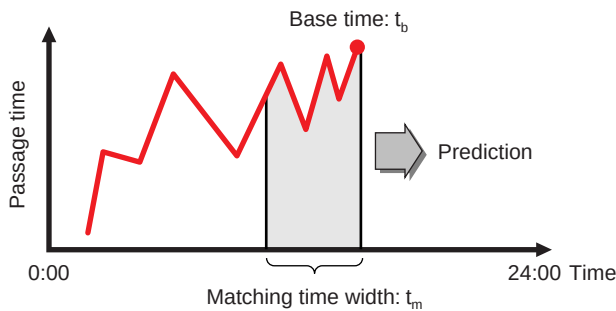


Fig. 5 Traffic status simulation procedure

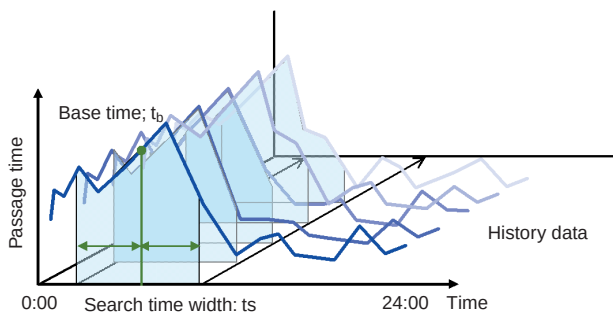


Fig. 6 Passage time each hour

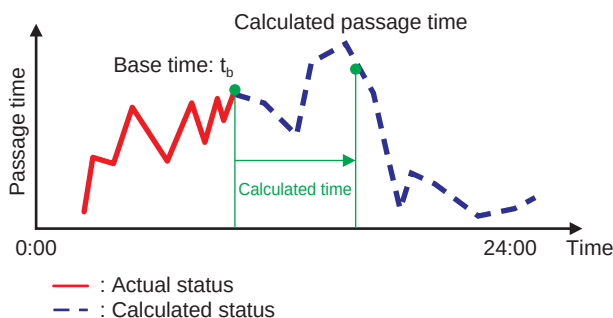


Fig. 7 Image of traffic status simulation

2.2. Subject Roads

When every VICS link is subject to predictions and searching, some links without apparent features, such as uncrowded roads, are included, and it was expected that data search quantity and processing load would be large. Therefore, it was decided to limit the subject links to those between a link where congestion easily occurs (immediately before and after an intersection, etc.) and the next link where congestion easily occurs. Looking at the level of congestion, several links are set in one series.

This paper introduces a verification example of National Highway 1 from the area around the intersection of the Akabanebashi Minami in Tokyo Minato Ward, to the area around Shirokane 1 intersection.

2.3. Verification of Prediction Simulation Parameters

First, as one parameter in prediction simulations, short (15 minutes, which is 3 points) to long (120 minutes, which is 24 points) matching time t_m ranges, which are the base data units for searching, were compared, with the reference point of the time subject to prediction t_b . The results showed that whichever has the shortest matching time width t_m has the smallest error, regardless of the prediction time.

The search time width t_s is another parameter, as the historical data within t_s is subject to search. Verification was made of the effect of the search time t_s range on accuracy. A simulation was implemented from a short t_s of 40 minutes to a longer t_s of 240 minutes. The results showed that there was no great error change due to search time width t_s , and that the effect was small. In the actual prediction simulations, it was learned that it was possible to reduce the calculation load by setting the previously mentioned matching time width t_m , and at the same time, making the t_s range small.

Finally, to investigate whether there was any effect due to the period of the historical data, which was the third parameter, the historical data were divided into 4 data groups by period.

- (1) The past year (March 2001 through February 2002)
- (2) The past 3 months (Dec 2001 through Feb 2002)
- (3) The past 1 month (Feb 2002)
- (4) The same month one year previously (Mar 2001)

Historical data would be an important factor if it was possible to achieve accuracy when the amount of data was small. This has a direct effect on processing load when making predictions on the national level.

In verification of this parameter, there was a tendency for slightly fewer errors when using (1) historical data from the past year, which has the longest period among the 4 data groups. However, it was learned that, in general, there was little effect due to the difference in periods.

From the results of verifications of these three major parameters, this prediction simulation indicated error sixty minutes later with approximately 12% to 13% better than when not making predictions, as shown in Fig. 8.

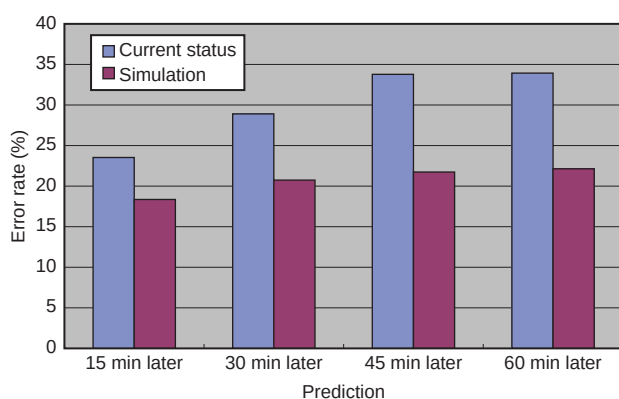


Fig. 8 Result of traffic status simulation

3. Conclusion

To actually provide prediction information using VICS historical data, initially there was concern that it would be necessary to have prediction simulation that searched and analyzed large amounts of data. However, in this evaluation, a variety of prediction parameters were verified, making it possible to greatly reduce data load. At the same time, it was learned that predictions closer to reality can be obtained by comparing this with “the application of current information to arrive time, as it is”, such as normal VICS information. The results of these verifications are currently being applied to congestion predictions provided by Honda’s information provision service, internavi Premium Club. The arrival time at the next link series is determined from the predicted passing time, and by repeating one after the other calculations of passing time after the arrival time, detailed predictions can be made for the whole course. A new initiative is to have the VICS Center collate travel data recorded by navigation systems, concerning roads where VICS information is not provided, process the data, and redistribute it to the navigation systems. This is known as the Probe Information Service, and it started in 2003. At present, due to the data quantity issue, this data is not subject to data prediction simulations. However, by collecting enough data for prediction verifications, and by making technological studies to further increase accuracy, in the future it should be possible to achieve a service that predicts traffic conditions on almost all roads heading to a destination.

References

- (1) Shibata, J., Tenmoku, K., Shimoura, H.: Development of a Stochastic Route Searching Algorithm, Sumitomo Electric Industries, Vol. 143, p. 164-173 (1993)
- (2) Uekawa, A., Goto, Y., Umezu, M., Furusawa, H., Nakahori, I.: A Fast Method for Route Calculation Using Area Route Data Base, IEEE Transactions on Electronics, Information and Systems, Vol. 120-C, No. 4 (2000)
- (3) Vehicle Information Communication System Center (<http://www.vics.or.jp>)
- (4) Ueno, H., Ohba, Y., Kuwahara, M.: Shoyojikanrekiyoho wo Mochiita Sokoshoyojikan Yosoku Model no Kenkyu, Dai 22 Kai Kotsu Kogaku Kenkyu Happyokai Ronbunshu, Japan Society of Traffic Engineers, p. 169-172 (2002) (in Japanese)
- (5) Horiguchi, R., Katakura, M., Kuwahara, M.: A Development of a Traffic Simulator for Urban Road Networks: AVENUE, Dai 13 Kai Kotsu Kogaku Kenkyu Happyokai Ronbunshu, Japan Society of Traffic Engineers, p. 33-36 (1993) (in Japanese)

- (6) Yoshii, T., Kuwahara, M., Morita, H.: SOUND: A Traffic Simulation Model for Oversaturated Traffic Flow on Urban Expressways, Kotsu Kogaku, Vol. 30, No. 1, p. 33-41 (1995)
- (7) Akahane, H., Oguchi, T., Oneyama, H.: Kotsu Simulation Model Kaihatsu no Hensenkei, Gijyutsu Shiryo 37-5 (2002) (in Japanese)

■ Authors ■



Toshihide YOFU



Masakuni TSUGE