STATISTICAL METHOD FOR PRE-TRIP TRAFFIC CONDITIONS PREDICTION

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ABSTRACT

Traffic information on the Metropolitan Expressway network is supplied via various media. Current available real time information is associated with present traffic condition. However, current real time information is not suitable for pre-trip decisions as the information does not factor in the time interval to joining the expressway network and this is subject to considerable prediction errors. This research involved the proposal of a method for matching historic traffic data with real-time traffic data as a means of predicting the travel times and bottleneck status immediately prior to departure. The method was tested on major routes and producing satisfactory accuracy, and therefore demonstrating that the method has attained a deployable level of accuracy. We further propose an effective method of supplying this data to facilitate informed departure time decisions.

INTRODUCTION

Delays caused by chronic traffic congestion on the Metropolitan Expressway are a major problem. For this reason, it is important to take measures to reduce traffic congestion and develop transport networks. At the same time, it is important to provide road traffic information so road users can choose the optimal routes and time periods, thus dispersing transport demand.
Various kinds of information on the Metropolitan Expressway, such as information on traffic congestion and travel time, are provided via diverse media, including information boards, Internet and mobile terminals, so that drivers can use the information when making travel plans, just before they depart or when driving on the Expressway. Pre-trip information on traffic

congestion and travel time is provided via the Internet, mobile terminals and other media, but the information reflects conditions at the time of accessing the information. For this reason, the conditions of traffic congestion are likely to change by the time the driver actually reaches the Expressway. Therefore, it is necessary to provide pre-trip information that can anticipate possible changes in traffic volumes.

The scope of road traffic information is being expanded, and the types of road traffic information providers and tools are diversifying, but the content remains unchanged. In order to keep up with the changing demand, the content of the information provided needs to be refined.

This paper proposes and examines the applicability of a method of matching accumulated traffic data with data for the day of prediction to predict pre-trip road traffic conditions. It also proposes a method of providing information that may be effective in enabling drivers to decide departure time and make other choices.

OUTLINE OF THE PREDICTION METHOD

CONCEPT

Figure 1 illustrates the concept of this method which has to account for the fluctuations in the travel times. As shown, we focused on the fact that the fluctuations in travel conditions immediately prior to departure also affect traffic conditions expected in the near future and, by matching historic traffic data with real-time traffic data, a method of predicting traffic conditions after the present time was developed. The prediction method was developed for Route No. 3 Shibuya line in the inbound direction, and was verified on 9 other routes.

WHEN PREDICTIVE VALUES ARE GIVEN

Recent survey of Metropolitan Expressway users (see Reference (6)) showed that nearly half need pre-trip information one hour before they use the Metropolitan Expressway. The results of surveys conducted at the entry and exit points of the Metropolitan Expressway indicate that the average distance covered when the driver approaches the Expressway (distance between an on-ramp and the center of its destination zone) is 21 km. If half of the distance represents the distance to the entrance and the vehicle runs on surface streets at an average speed of 20 km/h, it takes about 30 minutes to get from the starting point to the Expressway.

From these results, it is assumed that drivers can easily reach the entrance of the Metropolitan Expressway if they have one hour. The authors decided to add an additional hour, to account for a possible change in departure time, and provide pre-trip information up to two hours ahead.

LOCATIONS RESEARCHED AND DATA USED

The prediction method was studied for the Yoga-Tanimachi section of Route No. 3 (see Figure 2). The following data were used.

- Period: One years and two months from June 1, 2002 to May 31, 2003
- Type: Five-minute data for each section, including travel time and number of vehicles running in the section (traffic density × length of section)
- Date of prediction: June 26 (Thursday) to June 29 (Sunday), 2003, August 28 (Thursday) to August 31 (Sunday), 2003

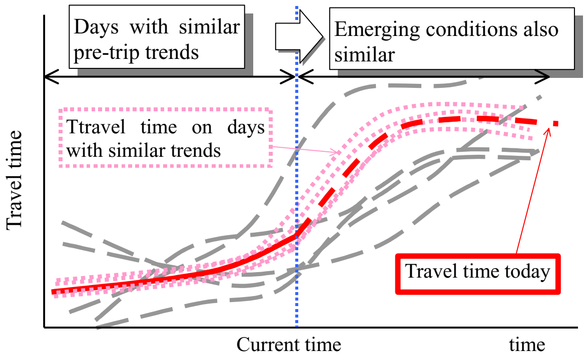


Figure 1 Method Concept

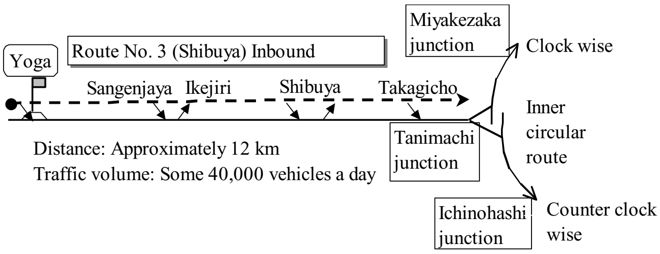


Figure 2 Route Covered in the Study

PREDICTION METHOD

Figure 3 gives an overview of prediction procedures.

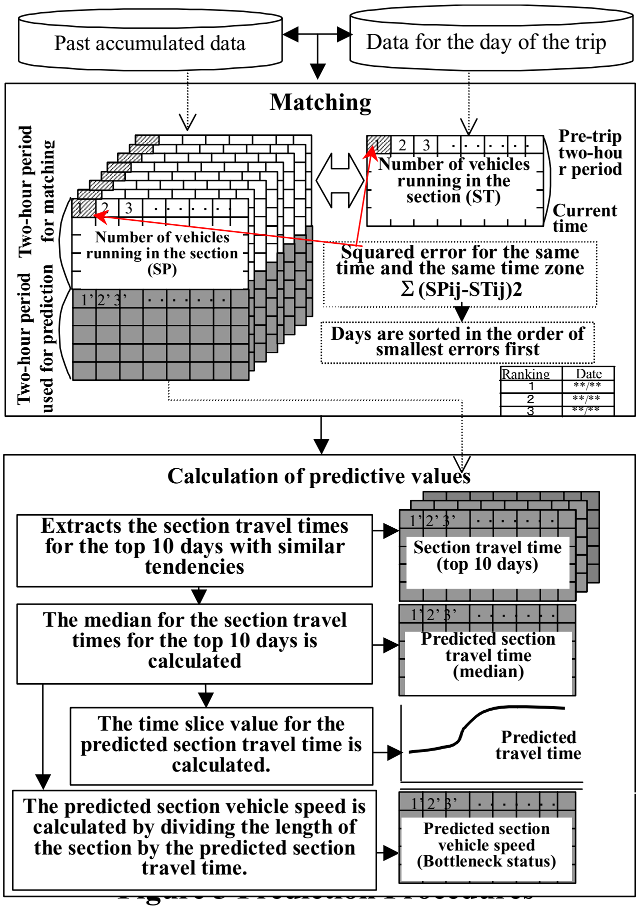


Figure 3 Prediction Procedures

PAST DATA

The authors classify accumulated data into three categories: weekdays, Saturdays, and Sundays and use data accumulated over one year.

DATA USED FOR MATCHING

To match historic data with real-time data, vehicle speed data for each section, travel time, number of vehicles running and other factors were compared.

For data matching, the authors use data on the number of vehicles running in the section (traffic density × length of section), which involves the factors of distance and traffic volume in addition to vehicle speed and makes it possible to pinpoint the condition of upstream vehicles.

MATCHING

For data matching, the accumulated daily squared error for the number of vehicles running in each section at the same time was calculated using historic data and real-time data, and days with small errors were extracted as showing similar tendencies.

SCOPE OF MATCHING

Since Route No. 3 inbound is affected by upstream traffic congestion on the Inner Circular Route, this was also taken into consideration when deciding the spatial scope of matching. As a result, for the scope of matching, the adjoining section of the Inner Circular Route was added to the Yoga-Tanimachi section (17 sections, 12.0km). Specifically, the section leading up to the Ichinohashi junction (2 sections, 1.3km) was added for the inner route of the Loop and the section leading up to the Miyakezaka junction (2 sections, 1.4km) was added for the outer route (see Figure 4).

In order to take into account the volume of traffic flowing from the upstream of the section subject to prediction, a method covering Route No. 3 (the subject route) and its upstream (Tomei Expressway, 12 sections, 18.5km) was studied. In the section “Verification of the Prediction Method” below, however, a method of including the upstream section only for the Route No. 3 is used for the reason of data collection.

Judging from the variation in travel times for the extracted days due to the time of matching and other factors, the authors also decided that the temporal scope of matching should be two hours.

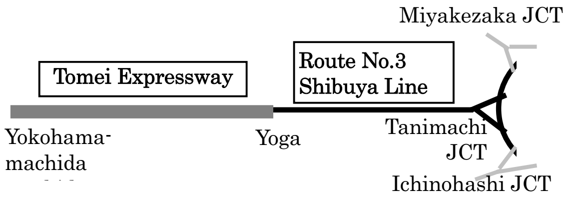


Figure 4 Spatial Scope of Matching

METHOD OF CALCULATING PREDICTIVE VALUES

From the results of matching, the top 10 days that showed similar tendencies were extracted. For these top 10 days, the median of travel times for five-minute periods for a given section was calculated as the predicted travel time for the section. These medians were added up by time slices method (tracing the trajectory with the passage of time) to obtain the predicted travel time for the Yoga-Tanimachi section. The reason the medians for the top 10 days were used instead of those for the days that show the most similar tendencies is that there is variation in travel time even among the top 10 days, indicating that specific data may still remain for the 10 days.

The predicted travel time for a given section and the length of the section were used to calculate the vehicle speed for the section, which was used as a predictive value for traffic congestion.

VERIFICATION OF THE PREDICTION METHOD

EVALUATION METHOD

In order to evaluate the applicability of the prediction method, prediction accuracy levels were analyzed for nine routes of the Metropolitan Expressway (see Figure 5). Prediction accuracy levels were analyzed for 10 days, and predictive values for six two-hour periods starting between 6:00 a.m. and 8:00 p.m. were covered in the analyses (see Table 1 and Figure 6).

A focus group survey conducted by the Metropolitan Expressway Public Corporation (see Reference (6)) show that the permissible prediction error for pre-trip information is ±10 minutes, and therefore, this was used to evaluate the predictions.

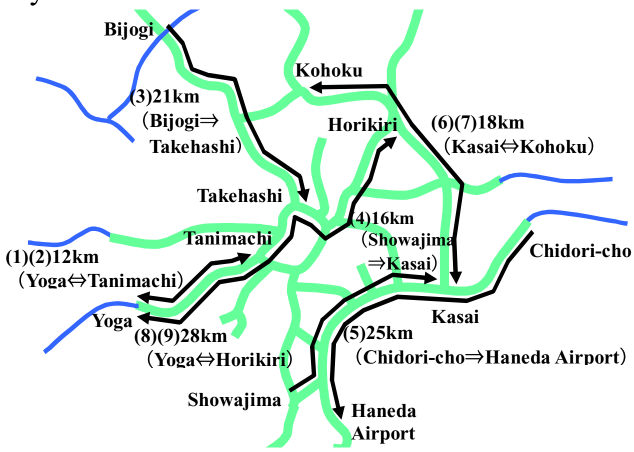
This method’s predicted values for the inbound line of the Expressway No. 3 (Shibuya Line) were compared with real-time information provided by the Metropolitan Expressway telephone service (hereinafter referred to as instantaneous values) and statistical data on average travel time provided via the Metropolitan Expressway Public Corporation’s Web site (see Figure 6). In this context, an instantaneous value is the sum of the travel times for subsections at the time of access. Statistical data is the median travel times calculated taking into account the characteristics of travel times for particular days of the week and seasons observed over the past several years.

RESULTS OF PREDICTION

Of the cases verified, Figure 7 compares the predictions for travel times and the condition of traffic congestion with actual measured values for Route No. 3 (inbound) on Thursday, June 26. The figure suggests that the predictive values are almost consistent with the actual ones in terms of the tendency of travel time to increase or decrease and the length of congestion.

Figure 8 shows the results of prediction by route, time zone and day of the week. According to this figure, even if accidents and construction work are taken into consideration, an overall average accuracy level of 80% or higher is attained. By route, an accuracy level of 80-90% is almost achieved, but the accuracy and the Horikiri-Yoga section of Route No. 6 (9) is somewhat low, at around 60%. This route was affected by the new route that came into service (Central Circular Oji Route), and only five months of accumulated data was available for matching. This lowers the accuracy level due to the lack of similar days ie. smaller database.

By time, the accuracy level for the early morning periods starting at 6:00 and 8:00 a.m. is high, and by contrast, that for the evening is somewhat low. By the day of the week, the accuracy level for Sundays, Mondays and Thursdays exceeds 80%, but that for Fridays and Saturdays is somewhat low. The reason for low accuracy levels for the evening periods, as well as Fridays and Saturdays, is that the variation in travel time is greater than for other time periods and other days of the week.



Number	Route	Length
(1)	Route No. 3 (Yoga -Tanimachi)	12km
(2)	Route No. 3 (Tanimachi - Yoga)	12km
(3)	Route No. 5 (Bijogi - Takebashi)	21km
(4)	Bay Shore Route (Showajima - Kasai)	16km
(5)	Bay Shore Route (Chidori-cho – Haneda Airport)	25km
(6)	Central Circular Route (Kasai -Kohoku)	18km
(7)	Central Circular Route (Kohoku - Kasai)	18km
(8)	Route No. 3 (Yoga) - Route No. 6 (Horikiri)	28km
(9)	Route No. 6 (Horikiri) - Route No. 3 (Yoga)	28km

Figure 5 Routes Analyzed

Days	June 26 (Thursday) to June 30 (Monday), August 25 (Monday) and August 28 (Thursday) to August 31 (Sunday), 2003
Time zones	6:00-8:00, 8:00-10:00, 10:00-12:00, 12:00-14:00, 16:00-18:00 and 18:00-20:00 (including accidents and construction work)
Prediction period	Two-hour period from each hour (every five minutes; 24 samples per case)

Table 1 Periods and Time Zones for Which Accuracy Levels Were Analyzed

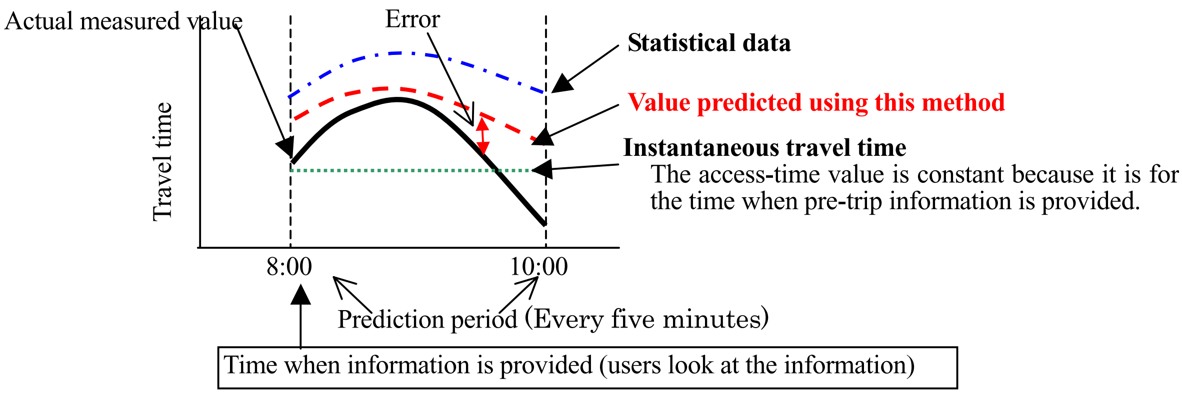


Figure 6 Conceptual Diagram of Evaluation of Predictive Values

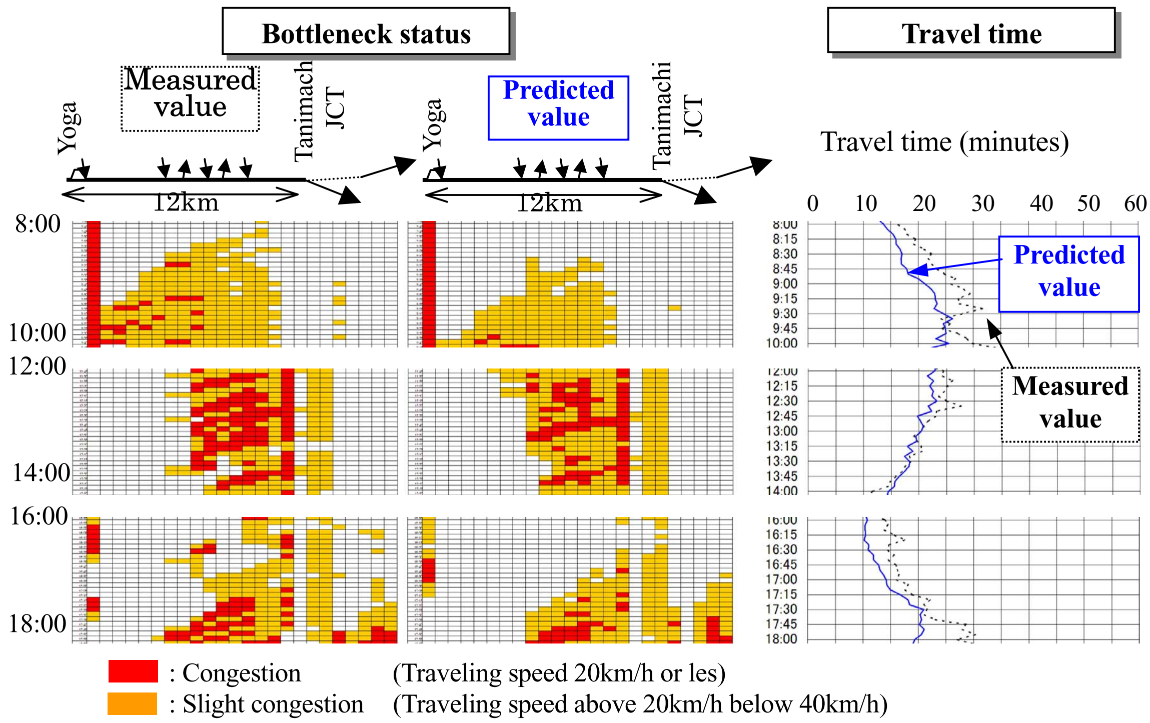


Figure 7 Comparisons of Traffic Congestion and Travel Time

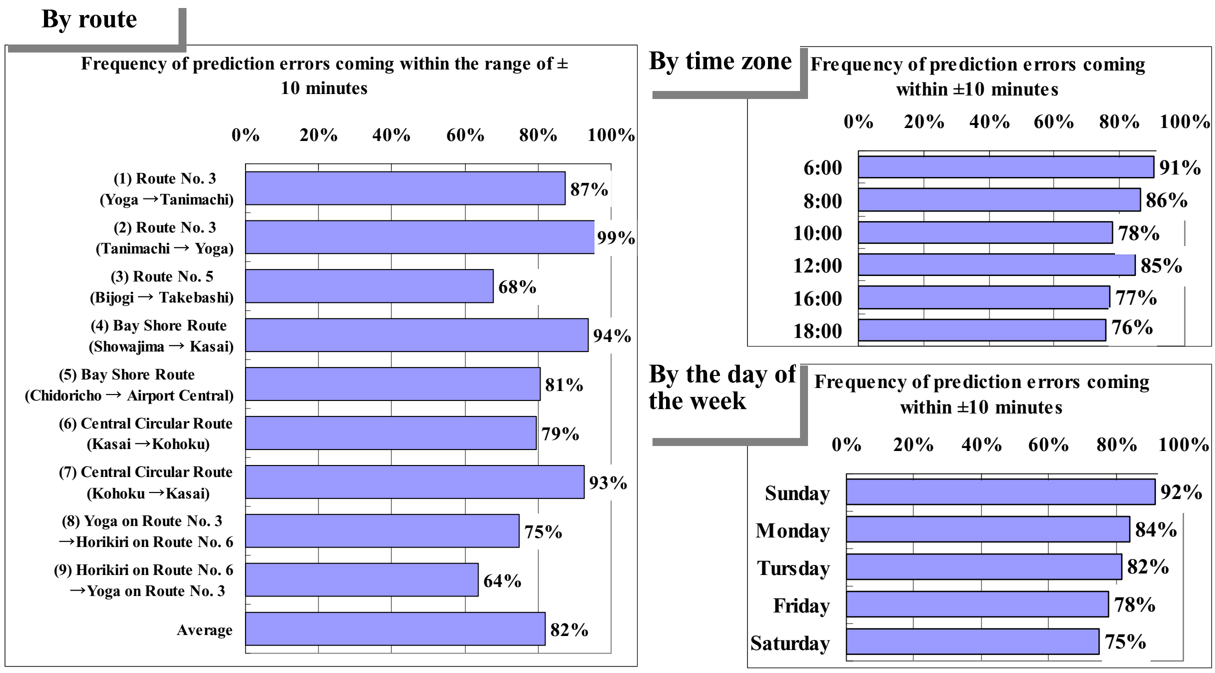


Figure 8 Results of Prediction

COMPARISON WITH CURRENTLY PROVIDED DATA

Figure 9 and Table 2 compare the value predicted using this method with statistical data and instantaneous travel time currently provided by the Metropolitan Expressway Public Corporation for Route No. 3 (inbound) on two specific days. According to these figure and table, the predictive values obtained using this method accurately reflect the fluctuations in travel time during the two-hour period and attain the highest accuracy level. The statistical data have a high accuracy level in the morning, but the accuracy level for the afternoon, which sees greater fluctuations in travel time, declines. The instantaneous travel time have a high accuracy level when they are provided, but if fluctuations in travel time become large, the accuracy level falls with the passage of time.

A look at the accuracy level at the time of prediction indicates that some of the predictive values obtained using this method attain an accuracy level comparable to or higher than that for instantaneous travel time, suggesting that they can be utilized as information for vehicle drivers running on the Expressway, including information boards that display travel time.

From the results of the above prediction, it can be said that data obtained using this method compare favorably not only with statistical data but also with real-time data, making it possible to provide information that shows future tendencies.

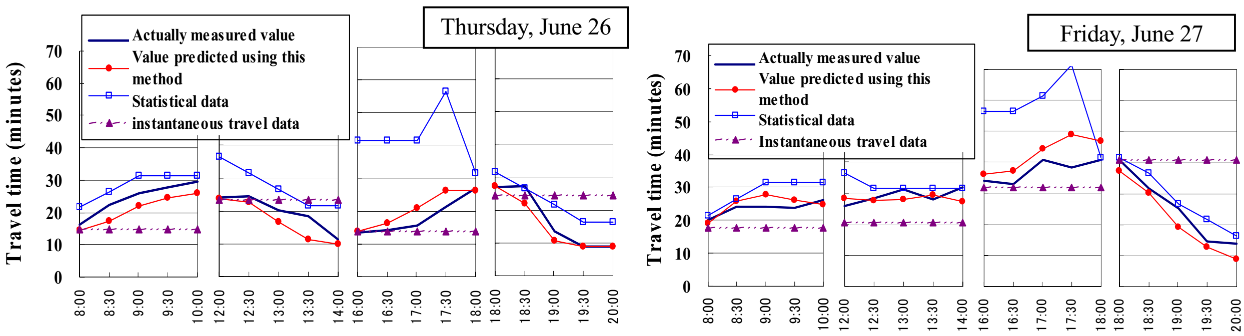


Figure 9 Comparisons with Currently Provided Data (Route No. 3)

Item	Predictive value	Statistical data	Instantaneous travel time
Overall percentage of prediction errors coming within ±10 minutes	95%	75%	78%
Percentage of prediction errors at the time of prediction coming within ±10 minutes	100%	67%	100%
Percentage of prediction errors half an hour after the time of prediction coming within ±10 minutes	100%	83%	100%
Percentage of prediction errors one hour after the time of prediction coming within ±10 minutes	100%	75%	67%
Percentage of prediction errors one and a half hours after the time of prediction within±10 minutes	75%	67%	75%
Percentage of prediction errors two hours after the time of prediction within ±10 minutes	100%	83%	50%

Table 2 Accuracy Level Comparison Table

EFFECTIVE DATA PROVISION METHODS FOR DEPARTURE TIME DECISIONS

The aforementioned prediction results were used to test effective methods of providing the data to facilitate informed departure time decisions. Figure 10 shows travel time and traffic congestion data provided on the Internet, etc. As illustrated, measured values up to the time of issue and predicted values are shown in a continuous time series. This means that even infrequent road users can ascertain clear times and select their departure time accordingly. Providing average travel times obtained from historic statistical data (40th -60th percentile value) simultaneously is a useful service for frequent road users allowing them to ascertain whether travel times are likely to be longer on the day in question.

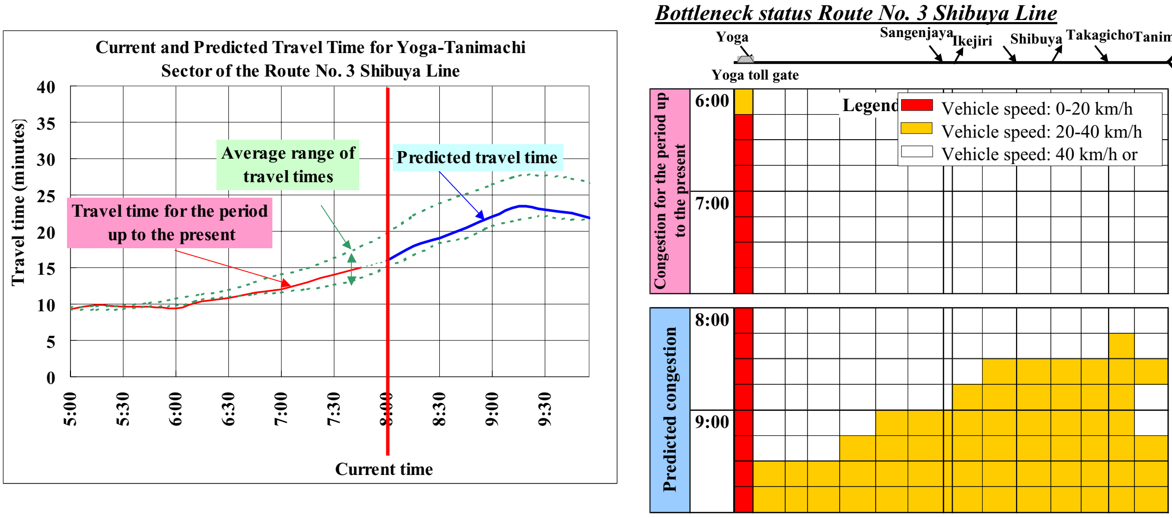


Figure 10 Image of Data Provided

CONCLUSION

This paper has devised a prediction method that matches historic road traffic data with real-time road traffic data in order to provide drivers with travel time and traffic congestion information before they depart. Verification of the method for major routes of the Metropolitan Expressway indicates that a high accuracy level was attained for all the routes. Furthermore, values obtained using the method are more accurate than the statistical and instantaneous travel time currently being provided as pre-trip information. We would like to propose this method as it is highly efficient as well.

Issues to be addressed in the future include expanding matching criteria and time zones in an effort to further raise the accuracy level of prediction. To put the method to practical use, it is necessary to provide information at the time of an accident and develop a specific system for providing information in such cases as when trip sections are selected at random.

ACKNOWLEDGEMENTS

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