TRAVEL TIME INFORMATION CALCULATION METHOD FOR EXPRESSWAY USING TOLL COLLECTION SYSTEM DATA

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SUMMARY

At present, travel time information is calculated from data measured by sensor installed in a road. Thus, travel time information can only be provided in a road equipped with a sensor. Therefore, this paper propose a travel time calculation method using a data obtained from magnetic tickets used with a toll collection system and verify proposed method by using actual data. When using magnetic ticket data, there are two big problems. One is that magnetic ticket data contains unusual data such as travel time of vehicles stopping in service area. The other is that very few data are obtained (for example : a road at night). The proposed method deals with these problems by using a statistical technique. Furthermore, this paper examines the method of predicting travel time by using one-day travel time patterns.

INTRODUCTION

In recent years, ITS-related research has been studied on a global scale. In Japan, there has been a lot of ITS-related research in areas such as VICS and AHS. ITS research aims for efficiency, safety, and convenience. In traffic control systems, research on traffic flow prediction and travel time calculation has been carried out to improve efficiency and convenience. Travel time information has been identified as particularly important data([1],[2]). Until now, travel time information has been calculated from sensor measurement results such as traffic counters and AVI systems installed on roads([3]). Thus, it has been difficult to obtain travel-time-information for roads that are not equipped with sensors. Thus, for roads not fully equipped with sensors, we propose a low-cost method for calculating travel time information by using data obtained from toll collection systems.

OBJECT ROAD AND PROBLEMS

The object road is a toll road that has a toll collection system. In this research, the object road is an expressway, which is also a toll road. Fig.1 shows the object road.

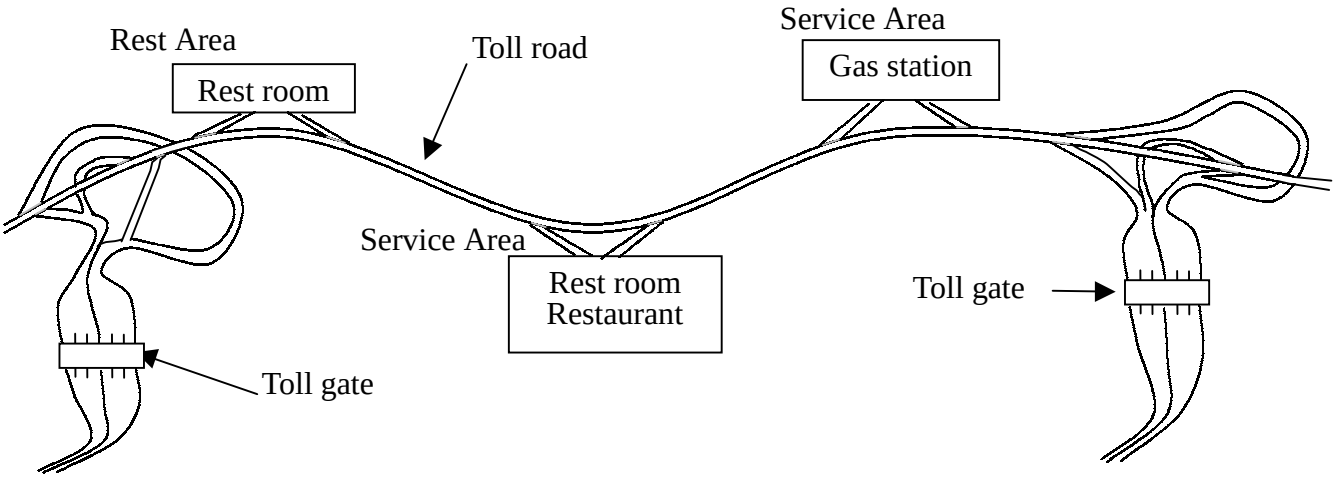

Fig.1 Object road

In Japanese expressways, toll is usually decided by mileage. A magnetic ticket is used in toll collection systems to decide the toll. We obtained toll collection system data from magnetic tickets. Toll collection system data include road entry/exit time data at toll gates, ID data of entered/exited toll gates, and kind-of-vehicle data (travel time can be calculated from toll gate entry/exit times).
Moreover, the object road includes service areas (hereunder, SA) and rest areas (hereunder, RA). When using toll collection system data, the following problems and must be solved.

- Difficulty of removing unusual data
- Difficulty of supporting road sections where only few data are available

In this research, we propose a method for calculating travel time taking into account these problems. The data of the Kan-Etsu Expressway (from Hanazono to Nerima) were used to verify the validity of the proposed method. The travel time information is for regular drivers who drive at normal speeds.

REMOVAL OF UNUSUAL DATA

This chapter explains a method for removing unusual data from travel time data calculated from toll collection system data. We consider the following cases to be where

travel time is unusual.

(TYPE-I)Extremely short travel time data (travel time of motorcycles traveling in congested conditions, and so on.)
(TYPE-II)Extremely long travel time data (travel time of vehicles that stopped for a long time in SA or RA for rest purposes, and so on.)
(TYPE-III)Data deviating somewhat from the distribution of travel time data (travel time data of drivers who like driving at high or low speed, and so on.)
Fig.2 shows an example of unusual data.

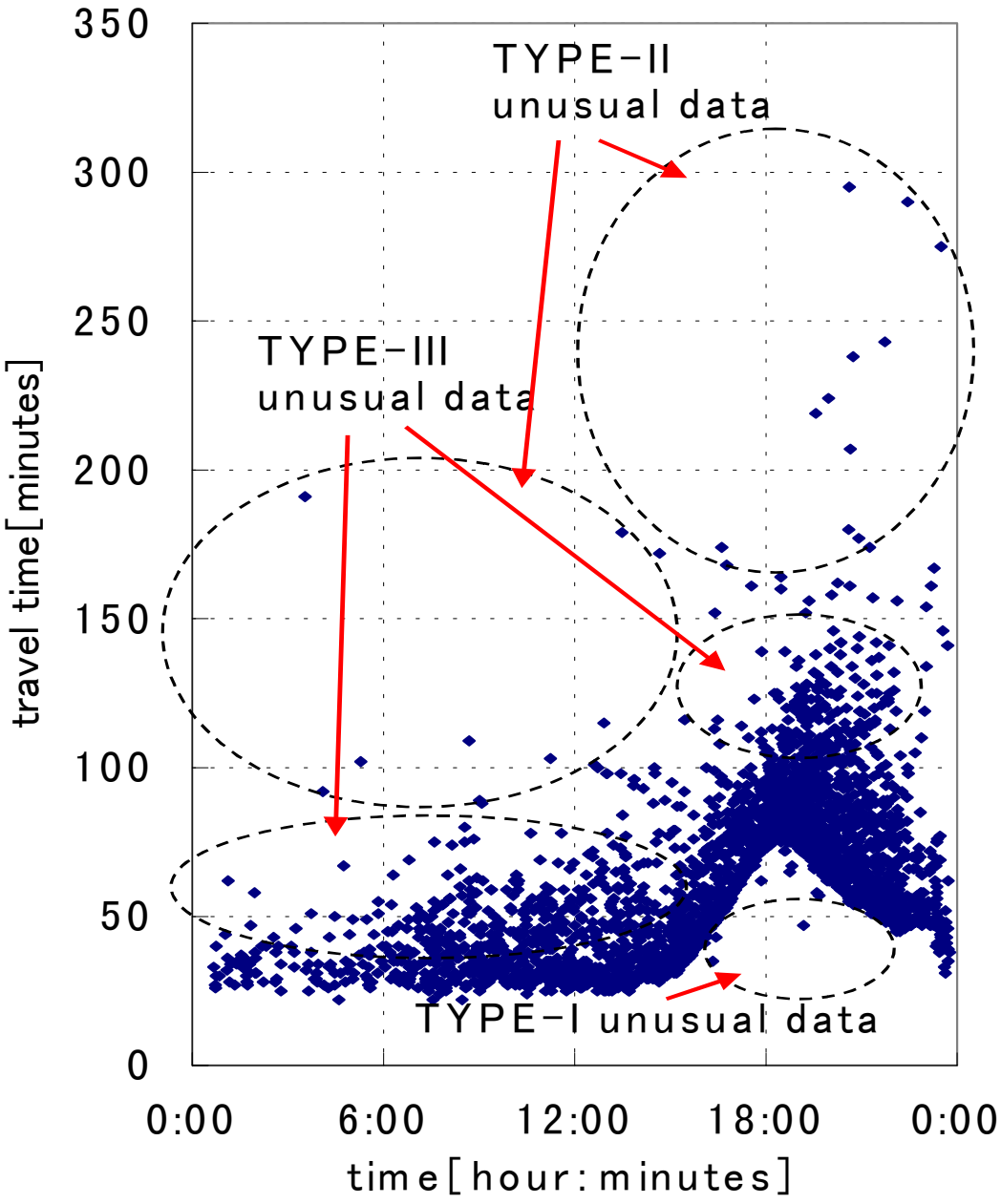

Fig. 2 Example of Unusual Travel Time Data

With regard to unusual data of (TYPE-I), it is enough to remove motorcycle's travel times. (TYPE-II) unusual data can be removed by performing frequency analyses. For (TYPE-III) unusual data, unusual data that should be removed can be determined from cluster analyses. After that we can remove (TYPE-III) unusual data. In this method, we used Otsu's Method[4] to calculate the threshold for cluster analysis.

COUNTERMEASURE FOR FEW AVAILABLE DATA

This chapter explains a countermeasure when there are few available data. The following are typical cases.

Case I: There is little traffic on the road (roads that always have low traffic flow volume)
Case II: Road at night (low traffic flow)
Case III: Traffic flow volume on the main road is high, but few data are available for the targeted section

Case I can be handled by using travel time of non-congested case as travel time information. We can calculate travel time information by the following method in Case II and Case III.

(a) Use travel time information by calculating the moving average of travel time data
(b) Use travel times of other sections for calculating travel time information of the target section.

For (a), if unusual data are included, travel time information is greatly influenced by unusual data because few data are available. Therefore, we used method (b) for Case II and Case III in this study.

CALCULATION OF TRAVEL TIME INFORMATION

First of all, we regard the average value of travel time data after removing unusual data as travel time information. In this case, we can calculate travel time information for the target road that consists of several roads where it is possible to calculate travel time information. Fig.3 shows an example of calculating the average value of travel time data using actual data, after removing unusual data.

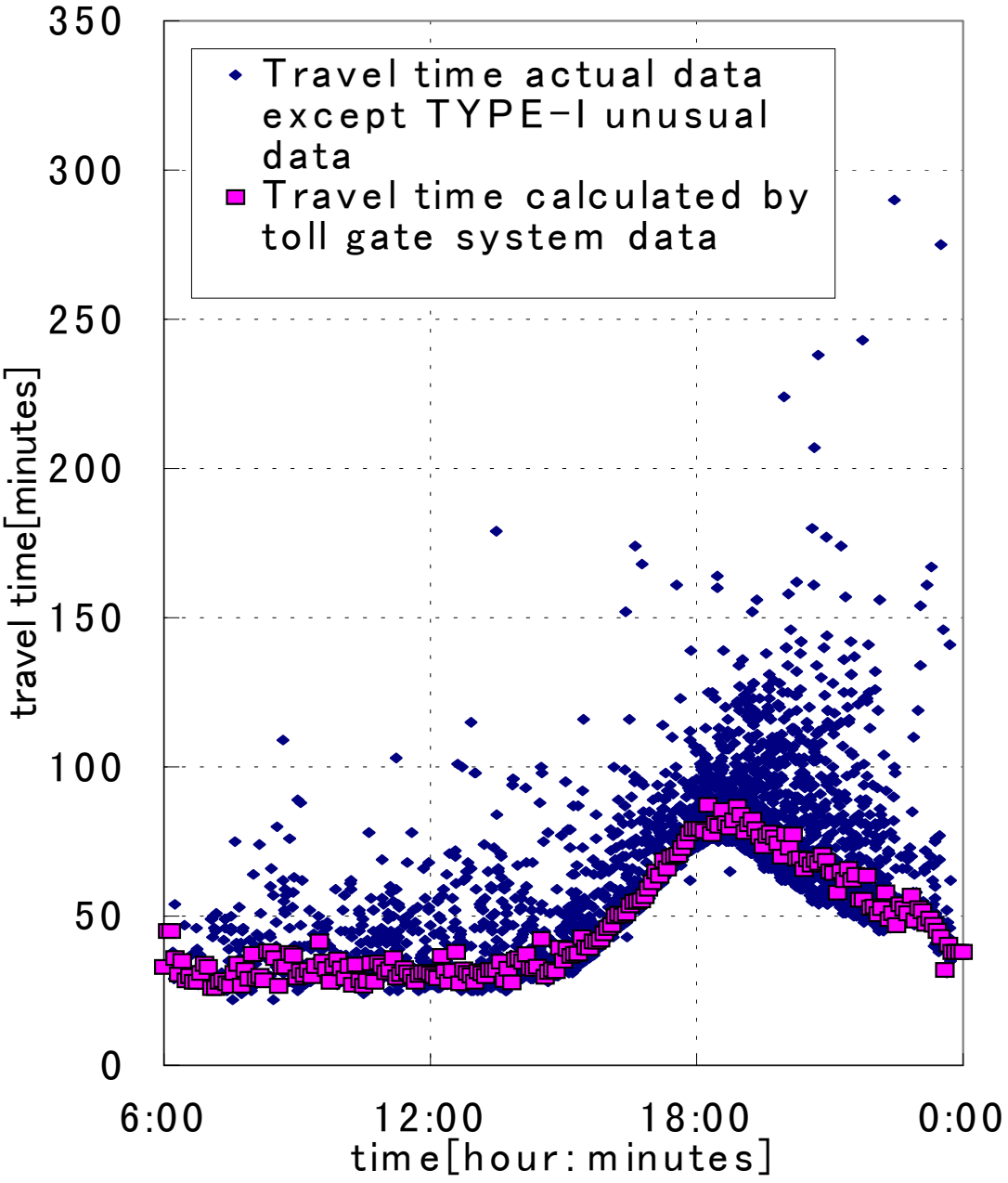

Fig.3 Example of Calculating Average Value of Travel Time Data After Removing Unusual Data (Using Actual Data of the Kan-Etsu Expressway)

From Fig.3, it is clear that removal of unusual data has been performed satisfactorily, and that the calculated average value of travel time is sufficient as travel time information. Fig.4 shows a comparative result with this travel time and travel time calculated from traffic-counter data.

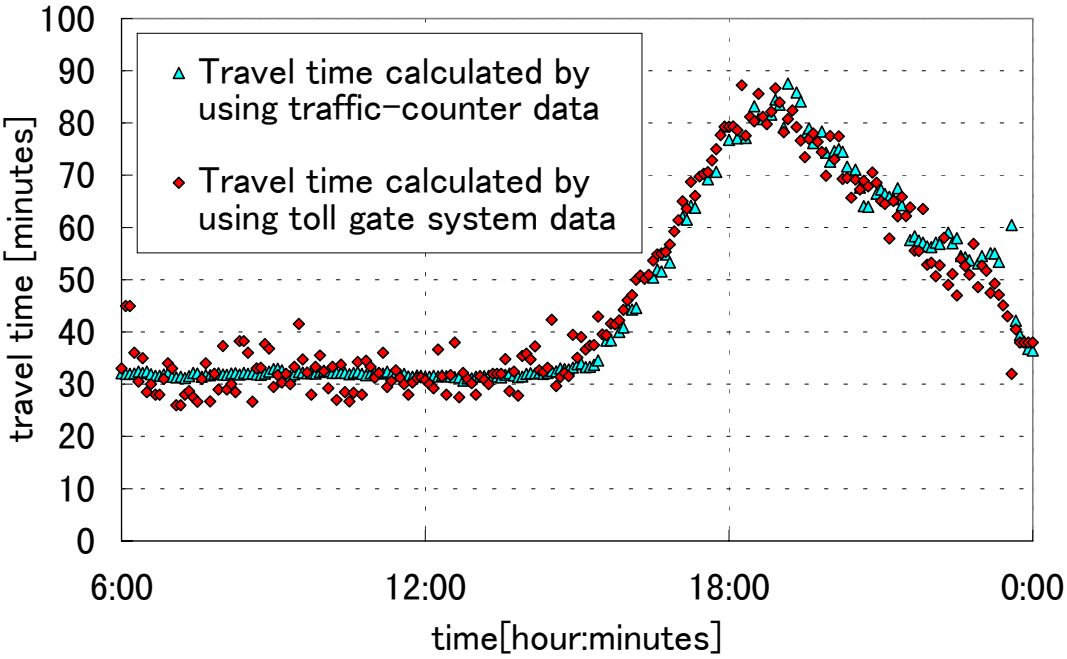

Fig.4 A comparative result with travel time by toll collection system data and by traffic-counter

Figure 4 clearly shows that the error between travel time by toll collection system data and by traffic-counter data is small. In fig.4, when we calculated travel time from traffic-counter data, we considered changes of road conditions in the diachronic (time series). Thus, travel time in fig.4 is past data (this travel time is obtained when a vehicle has passed through the exit toll gate). It seems reasonable to assume from these results that travel time calculated from toll collection system data is useful as actual data.

TRAVEL TIME PREDICTION METHOD

In chapter 5, we proposed a method of calculating travel time from actual data obtained from a toll collection system. However, these values are only past values and not equal to the travel time that driver will experience from start point to destination point in the future. Thus, the predicted travel time value is ideal as travel time information. In the next phase, we propose a travel time prediction method. In this research, we use a prediction method based on one-day travel time patterns. We first accumulate travel time data over several weeks or several months and determine a daily travel time pattern. We make a different pattern for every day of a week including weekend. In Japan, it is necessary to prepare travel time patterns for dates that are multiples of 5, during which road traffic flow volume is typically high. Next, travel time is predicted by selecting a travel time pattern by using an actual travel time value up to the current time on the day. With this method, when a target road consists of several sections, it is possible to use a time-slice calculation. Here, we consider a section to be a road between one toll gate

and another. A time-slice calculation is method of the sum of section travel time taking changes of road conditions in the diachronic into consideration([3]). Until now, this method used an accumulated past-travel-time-data that was calculated by traffic-counter data. However, if we can predict a future travel time of several-section, we can predict travel time by this method which use a prediction data instead of an accumulated data. Fig.5 shows time-slice calculation method outline.

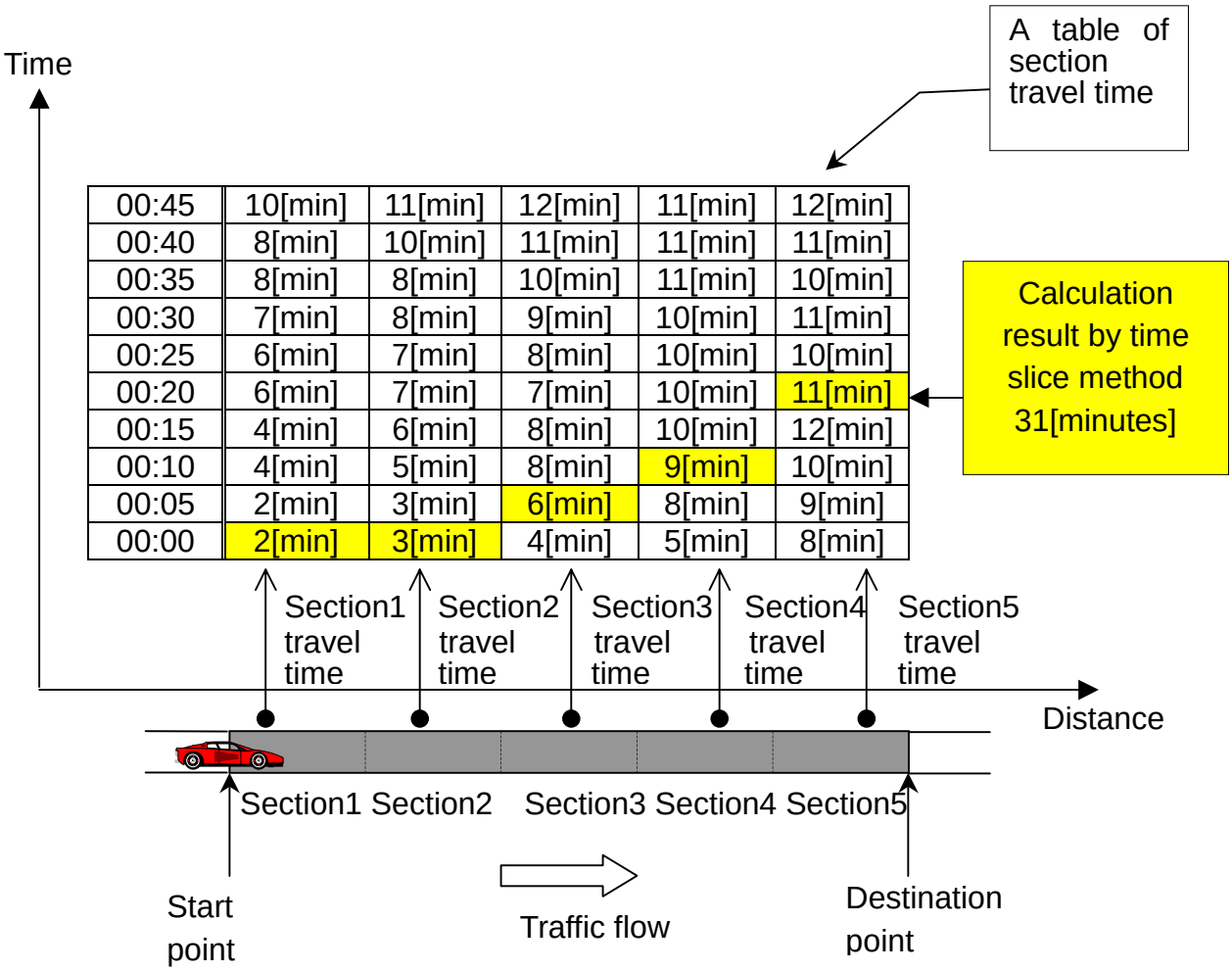

Fig.5 Outline of time-slice calculation method

Using travel time prediction method based on travel time patterns, we can predict travel time from start point to destination point in the future. Fig.6 outlines this prediction method.

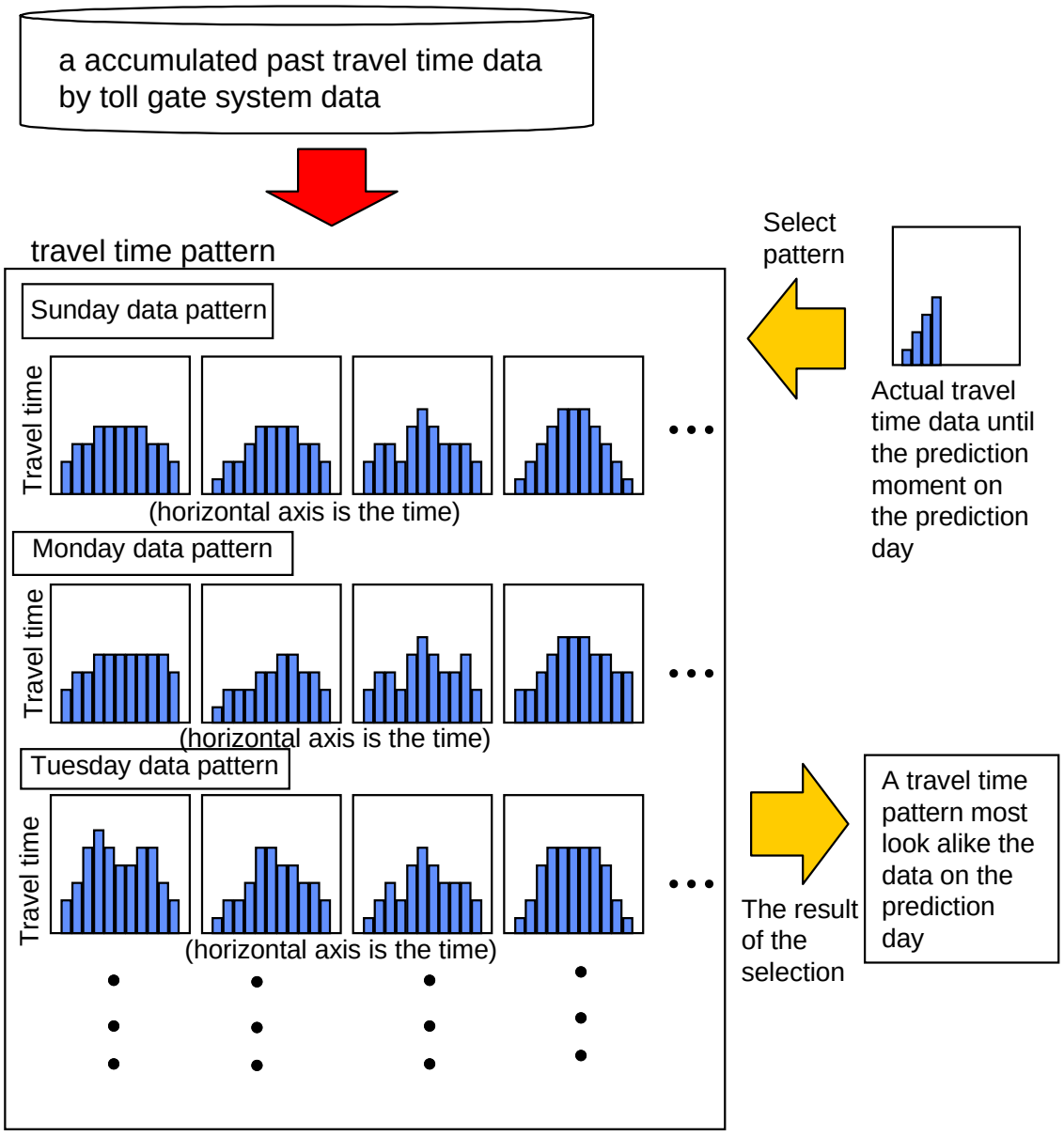

Fig.6 Outline of travel time prediction method using a travel time pattern

This travel time prediction, method is currently being verified using actual data. However, we have already a problem to be solved as below:

-Several patterns which look alike are possibly selected when we predict a travel time in the morning and noon (in early time zone).
-In selecting a pattern, we should also consider the weather, an event.

A countermeasure to the above issues is being developed.

CONCLUSIONS

This paper proposes a method for calculating travel time information using data obtained from a toll collection system using magnetic tickets. We verify the proposed method by using actual data. With this method, we can calculate travel time information at low cost on roads that are not equipped with sensors. Furthermore, we propose a travel time prediction method using travel time patterns and examine its validity. The proposed prediction method still has problems to be solved which are now under study.
In the future, we would like to develop a travel time prediction method and continue to study other travel time calculation methods aimed at higher utility value.

ACKNOWLEDGEMENTS

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