Travel-time Measuring System for Efficient Traffic Information Service

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OVERVIEW: Traffic control systems for automobile traffic are being set up that allow more advanced traffic signal control according to traffic conditions and provide drivers with the real-time traffic information that they need to make their own driving decisions. The traffic information required by the driver includes traffic regulations, degree of congestion, parking space availability and so on, but the need to know "How long will it take to get to my destination?" is high. The Ooita Prefectural Police Headquarters introduced a travel-time measurement system in 1999. That system employs a travel-time estimation algorithm to calculate the required travel-time from vehicle information obtained by a travel-time measurement terminal (AVI: automatic vehicle identifier: automatic vehicle number reading equipment) and traffic volume information obtained by vehicle sensors. Traffic volume information is already being collected over wide areas, so travel times can be calculated accurately for all areas within Ooita City. The travel-time information calculated by this system will, in the future, be made widely available to users via the VICS (vehicle information and communication system) service, information boards, the Internet, facsimile, and other such media. Hitachi, Ltd., on the other hand, has developed an advanced map information system, which may in future develop into a traffic information management platform. We have also implemented a system that can effectively search for and display traffic information for automobile drivers.

INTRODUCTION

FOR accurate measurement of traffic congestion conditions, the Ooita Prefectural Police Headquarters have actively promoted the expansion of the traffic volume sensor system. Congestion information is used in the cycle splitting control and offset control of traffic signals. In the traffic control room, on the other hand, road maps and congestion information are displayed

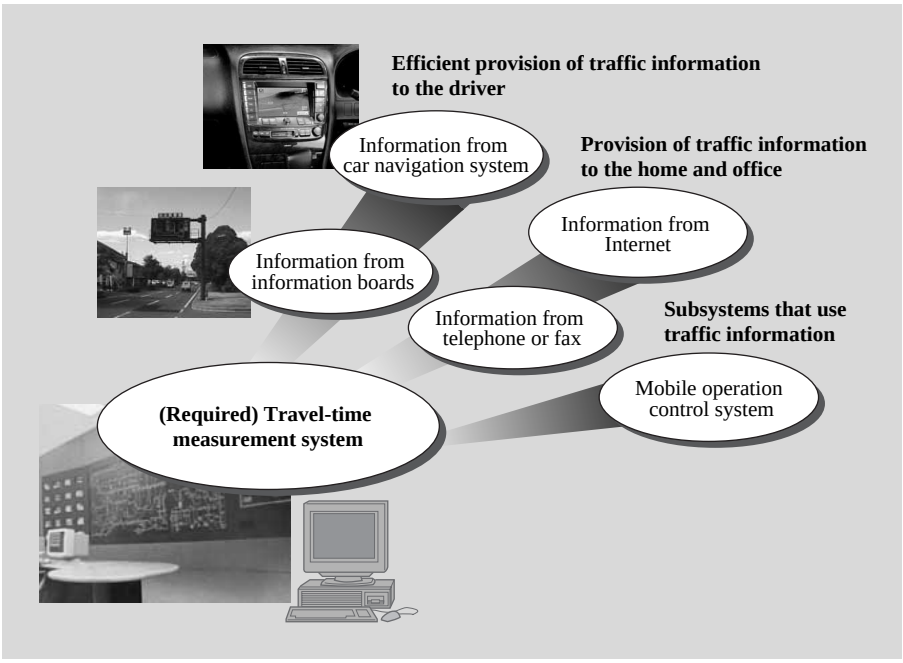

Fig. 1— The Ooita Prefectural Police Headquarters Traffic Information Service.
Travel time and various other types of traffic information are provided to the user via different media.

on a large multiple-view display to serve as an information source for telephone inquiries, radio broadcasts, etc.

In future, Ooita Prefectural Police Headquarters is planning to set up a system for actively providing the collected congestion information and other traffic information to city residents and drivers. The travel-time measurement system developed by Hitachi, Ltd. and delivered in 1999, which is the beginning step of that plan, makes highly accurate traffic information calculation possible.

Here, we briefly describe that system and its special features.

SYSTEM STRUCTURE

The structure of the Ooita Prefectural Police Headquarters traffic control system is illustrated in Fig. 2.

In this system, information on traffic conditions is collected from traffic volume sensors (vehicle sensors) and travel-time measurement terminals (AVIs; automatic vehicle identifiers), both are installed on the road. That information is used by the central travel-time measurement equipment and the total travel-time processing equipment to calculate the travel time. The calculated travel times are displayed on the control room monitors (which are also used by the total travel-time processors) for monitoring and some of them are displayed on the existing multi-view system for checking by the entire control room staff. In addition, the travel times for the important road sections are displayed on the roadside information boards for the benefit of the driver. Of that equipment, Hitachi, Ltd. has developed and delivered the central travel-time measurement equipment and total travel-time processing equipment, which are important to the accuracy and use of the information that is provided.

Vehicle Sensor and Traffic Signal Control System

The vehicle sensor uses reflected ultrasonic waves to detect the presence of vehicles directly beneath the sensor so that the number of vehicles that have passed the sensor and the time that they remained under the sensor (dwell time) can be measured. Because it is relatively inexpensive and can also be used for traffic signal control, it has been widely introduced. In the signal control system, the number of vehicles that pass in a five-minute period (5-minute traffic volume) and their dwell times (i. e. , the percentage of the 5-minute

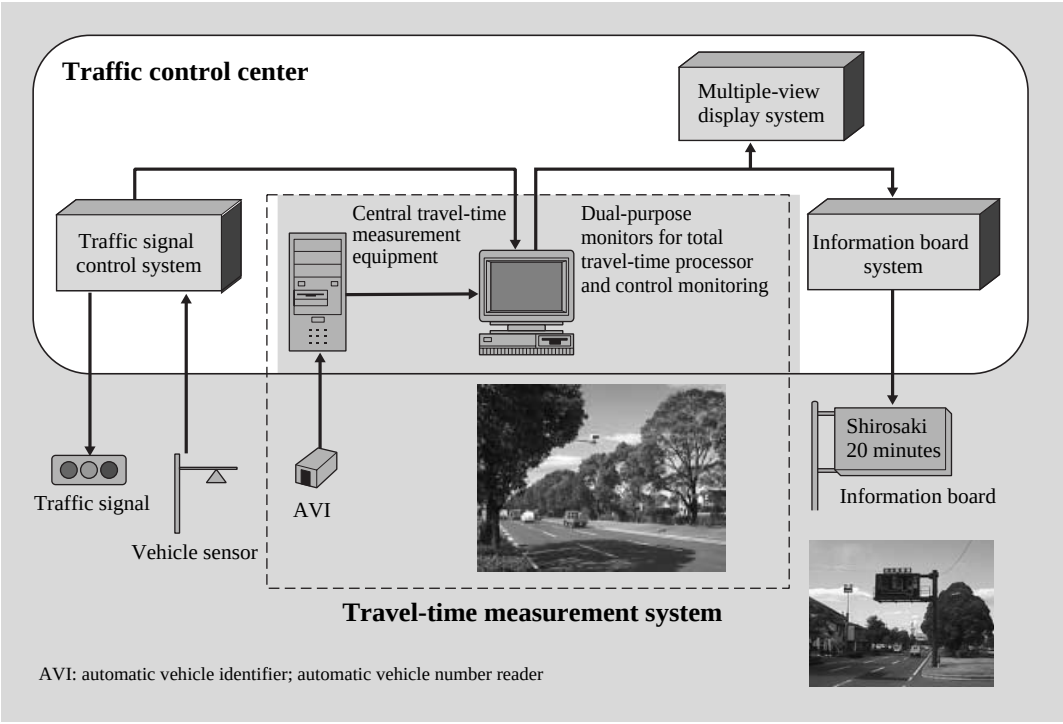

Fig. 2— Configuration of the Travel-time Measurement and Information Display System.
The travel time is calculated on the basis of the information from the vehicle sensor system and the AVI and the result is displayed on the monitor, multi-view display, and traffic information boards.

period that the vehicle was under the sensor) are measured and the data is sent to the total travel-time processor.

AVI

The AVI photographs the number plate of passing vehicles, performs image recognition to obtain the vehicle number, and sends the obtained number data to the traffic control center via telephone lines. The passing of individual vehicles can be known, so this is highly accurate information. This equipment was installed in 12 locations in the city.

Central Travel-time Measurement Equipment

The central travel-time measurement compares the vehicle number data that is obtained at two places, one upstream and one downstream in the traffic flow, and measures the travel times for each vehicle from the difference. By averaging the vehicle travel times, the travel time (AVI measured travel time) for that section of road can be calculated. These calculations are currently being made for eight sections.

Total Travel-time Processing Equipment

The total travel-time processing equipment combines the AVI measured travel-time data obtained from the central equipment and the vehicle sensor information obtained from the signal control system central equipment and uses a proprietary algorithm to estimate the travel times for 126 sections in real-time.

This system can also be used for monitoring in the traffic control room, as the calculated travel times can be displayed on digital maps. Furthermore, this data can be sent to an information board system for display on traffic information boards that are installed along the road.

In this way, operators and drivers can obtain real-time traffic information to be used as a basis for decisions in itinerary planning, route changes and so on.

TRAVEL-TIME ESTIMATION METHOD

The installation conditions for the AVI and vehicle sensors that provide the data for measuring travel time differ greatly from road to road and the operating conditions also vary from day to day. For those reasons, we developed technology that makes it possible to always select the optimum method among various calculation methods prepared for various conditions. The various calculation methods are shown in Fig. 3.

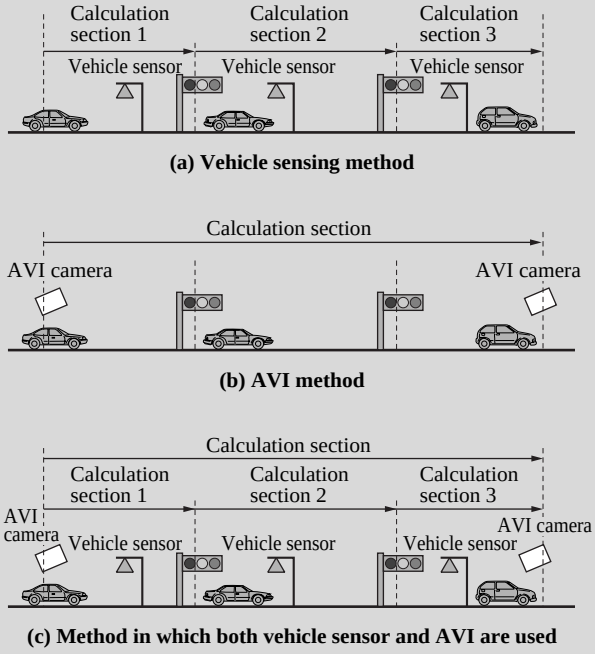

Fig. 3—Travel-time Calculation Methods.
A method is selected and applied according the sensor installation conditions and operating conditions to improve the travel-time calculation accuracy.

Vehicle Sensing Method

From the 5-minute traffic volume and dwell times obtained from the vehicle sensors and the known lengths of vehicles, the speed of the vehicles directly under the sensors is calculated. From the calculated speeds and the length of the road section, the travel time for that road section is calculated. In Ooita Prefecture, the installation of the vehicle sensor system is progressing and in most cases multiple sensors have been installed within single sections. These multi-sensor sections are being used to investigate the degree to which the output of individual sensors reflects the traffic conditions.

This method can be applied to routes on which the vehicle sensors have been installed with a certain density. For Ooita City, most of the main routes within the city can be covered.

On the other hand, the accuracy of the vehicle speeds calculated by the vehicle sensors deteriorates at times of extreme traffic congestion, when the roads are emptied, or when a vehicle is parked below the sensor. In such cases, those conditions can be detected by using the speed limits and a database of past data and then excluded from the results, thus maintaining accuracy.

AVI Method

The vehicle plate number data received from the upstream and downstream AVI is stored and the vehicle number data for the downstream end (arriving vehicles) is compared with the data from the upstream end (departing vehicles). The travel time for each vehicle is calculated from the difference between the departing and arriving times. When the vehicle count exceeds the specified number for a fixed time period (5 minutes), the travel times of the vehicles are averaged and the AVI measured travel time is calculated. In this way, travel time can be measured directly with the AVI method, which has the merit of high accuracy.

One problem is that, if a vehicle takes a route other than the assumed route, stops along the way or makes a detour, the data is incorrect and cannot be used. Such invalid data is eliminated by statistical methods.

Another problem is that if the measurement section is long (actually, the present system includes sections that are from 4 to 8 km in length), errors occur in the measured travel times when there are extreme changes in traffic conditions, such as at the beginning and ending of the morning and evening congestion periods. That happens because the travel time of the vehicle that arrives downstream is calculated and regarded as the present travel time, but the current conditions cannot be reflected in the results when the conditions that exist at the time the arriving vehicle passes differ from the current conditions. To improve the accuracy of these results, we developed a method in which the vehicle sensor and AVI systems are both used together (Fig. 3-c) .

Use of Both Vehicle Sensor and AVI Systems

Because many vehicle sensors are installed within an AVI section, we divided the AVI sections into subsections and the vehicle sensor method is applied to those subsections. From the fact that the vehicle sensors reflect the traffic conditions directly under the sensors, close tracking of the current conditions is possible. Making use of this fact, we developed a method in which it is judged that the AVI measured travel time does not well represent the current conditions if the difference between the sum of the subsection travel times obtained from vehicle sensor information alone and the AVI measured travel time is large, and a weighted average of the AVI measured travel time and the vehicle sensor measured travel time is used as the result. The weighting of the values changes dynamically with the difference between them. While the AVI measured travel time, which generally has a high degree of accuracy, is given priority, the travel time estimated from the vehicle sensor information, which has a high degree of real-time quality, is used to compensate for the time delays involved in the former method.

CONTROL ROOM MONITOR

The calculated travel-time information is monitored by operators via the control room monitors and sent out to concerned stations. Therefore, control room monitor's ease of use is an important item in system development.

Map Database

Previously, deformation maps were most often used for traffic condition monitoring, but in this system the digital road map (DRM) of the Japan Digital Road Map Association is employed. The DRM is the map data format used by car navigation systems. At this time, the mainstream car navigation systems are those that are compatible with the VICS (Vehicle Information Communication System) and can receive and display real-time traffic information. In Ooita Prefecture, partial operations have started in 2000. Accordingly, system portability and uniformity will be preserved in future VICS operations as well.

Map Display Technology

Ease of use was achieved by making the read time for sections in the map display area nearly zero through high-speed map display processing to realize excellent response to map manipulation.

Travel-time Information Management

Centralized management of the travel-time information on the control room monitors was made possible by incorporating functions such as (1) the display or non-display of the travel time for any route section, (2) starting or stopping the provision of information to information boards, and (3) searching for past travel-time data.

Expansibility

The information layers that are superimposed on the map are used to provide degree of congestion, congestion length, traffic regulation, parking space availability information in addition to simple travel-time information layer. In this way, this function can be expanded when managed information is added in the future. An example of the screen display is shown in Fig. 4.

Fig. 4—Example of Control Room Monitor Display. By superimposing section travel times on the digital road map, information provision and management are integrated.

CONCLUSIONS

We have briefly described a travel-time measurement system for automobile traffic as well as the travel-time measurement methods and the control room monitor functions that it features.

With the increasing importance of on-board information for automobiles, we believe that the effective provision of useful traffic information to the driver will also continue to increase in the future. The system described here will serve as the core of a traffic information provision system that will provide information over various types of media that may be developed in the future. In future work, we will aim for the construction of an information system that is organically linked with this system.

Finally, we would like to express our deep gratitude to everyone in the Ooita Prefectural Police Headquarters Traffic Regulation Department for their guidance in the development of this system.

REFERENCES

(1) K. Yamane, et al., "Development of Travel Time Estimation System Combining License Plate Recognition and Ultrasonic Vehicle Detectors," ITS 6th World Congress, Toronto, Canada (1999).

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