EMPIRICAL APPLICATION OF AUTOMATIC VEHICLE IDENTIFICATION DEVICES IN A TRAFFIC SURVEY CONDUCTED IN A SIGHTSEEING AREA

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Abstract

This document is a report on the usability of automatic vehicle identification devices that are capable of gathering traffic data (traffic volume, travel time, etc.) in traffic surveys conducted in sightseeing areas. The report is based on results obtained through the empirical application of such devices. The accuracy of automatic vehicle identification devices is improving dramatically due to developments in image processing and other technologies. Conducted together with a performance evaluation, the empirical application confirmed that gathering of highly precise data is possible. It should be noted that the automatic vehicle identification devices used in this project were developed based on the following specifications: Detection rate of 95% or more, recognition rate of 95% or more, and maximum speed of 140 km/h.

Introduction

Traffic surveys are conducted for the purpose of collecting data on traffic volume, travel time, and other items for a particular purpose. Survey methods typically used in current traffic surveys include counting by people and use of traffic counters for traffic volume, and sampling using vehicles onto which a probe device has been installed for travel time.
Automatic vehicle identification devices gather information from the license plates of vehicles. This makes it possible to ascertain traffic volume and to calculate travel time by matching license-plate information obtained between several points. Practical application of such devices is already taking place, and both detection rate (percentage of actually moving vehicles that are measured) and recognition rate (percentage of license plates that are read) are increasing due to advancements in image processing and other technologies. Thus, progress is being made toward making highly accurate surveys possible.

The automatic vehicle identification devices used in this project were developed based on the following specifications: Detection rate of 95% or more, recognition rate of 95% or more, and maximum speed of 140 km/h.

**Purpose of this report**

It is not a custom to take long holidays in Japan, so many people take holidays in a few specified periods. This means that in many sightseeing regions of Japan, sightseeing traffic is extremely concentrated, transforming the pleasure of sightseeing to the distress of traffic congestion. In Japan, the appearance of the natural surroundings varies greatly in the spring, summer, fall, and winter, and enjoying seasonal scenery is a firmly established custom, but in scenic regions, the costs of both land and of road development are high, and for this reason, the level of roads, parking areas, etc., cannot handle the traffic volume during busy periods.

It is important to accurately assess traffic conditions in these areas to improve the level of roads and to provide appropriate guidance to traffic, and for this reason, detailed traffic data on a time axis must be obtained. Another effective measure is to survey traffic volumes, required travel times, and other traffic data, plus customer attraction range, congestion time, and other sightseeing behavior.

The automobile identification numbers used to perform surveys permit license plate information to be collected: an extremely effective way to perform surveys that include such sightseeing behavior.

This report presents survey output obtainable by installing systems to observe license plate information in specified areas of such tourist regions, and describes the verification of the precision of an actual survey through a comparison with visual observations.

**The automatic vehicle identification device**

**Outline of the automatic vehicle identification device**

The automatic vehicle identification device photographs only license plate of passing vehicles; obtains the vehicle’s registration, type, purpose, and license number (Figure 1); and records this data in a built-in CompactFlash storage device together with the time of vehicle’s passing. An infrared ray LED light is installed on the top of the device that allows surveys to be conducted at night.

This device can be installed on road sign poles or road-lighting poles so it requires only
extremely small-scale work. For this corroborative introduction, temporary poles were installed and the devices were attached to the poles. In this way, the automatic vehicle identification devices can be installed as desired by the observer.

This system can be controlled using an ordinary laptop computer, even with a wireless LAN (Figure 2). Furthermore, zoom and gain can be adjusted easily while watching camera images (Figure 3). In this way even a person without expert knowledge can easily operate the system using an ordinary personal computer.

A characteristic of the automatic vehicle identification device

A system of this kind has been introduced as a working system with existing technologies, but the following are characteristics of the automatic vehicle identification device.

1) Special characteristics of the characters used as license plate information in Japan

Japan license plate information is presented by, in addition to numerals, Chinese ideographs and the Japanese phonetic alphabet. These are used to identify vehicle registration and vehicle purpose. Optical character recognition (OCR) for the English alphabet and numerals can be a relatively simple technology when used for limited letters and numbers, but to recognize Japan’s license plate information, extremely advanced recognition technology capable of high-speed response is needed.

To meet this need, this automatic vehicle identification device has been provided with technology capable of 95% precision, achieved by improving its pattern recognition technology based on a Chinese ideograph image data base.

2) Tabulation based on vehicle registration and vehicle type

Japanese license plate information includes information about passing vehicles: vehicle registration, vehicle type, purpose of use, and registration number. It is possible to accurately grasp the characteristics of each passing vehicle by obtaining these kinds of information. In a sightseeing region for example, it is possible to use the results of analyzing the vehicle registration of vehicles visiting the region to assess its tourist attraction range.
In this way, automatic vehicle identification devices can be used to perform analyses of information obtained from license plates.

**Empirical application in measurement of congested periods at a sightseeing area**

**Outline of the observation method**

A characteristic of sightseeing areas (places of scenic beauty, etc.) is that concentration of traffic during limited time periods causes congestion and other problems. In such sightseeing areas, ascertainment of traffic volume and travel time is extremely important when implementing effective traffic countermeasures.

In implementing the empirical application, a survey was conducted around Mt. Tsukuba in Ibaraki Prefecture, which is a sightseeing area that is grappling with such traffic problems. Specifically, the survey involved placement of 22 automatic vehicle identification devices in a total of 10 major places that were located on the normal route and a circumventing route leading to the sightseeing area. These devices were set up for 17 days (Figure 4).

**Data obtained by observations**

(1) Traffic volume and required time

This survey was able to collect a variety of data that included fluctuations in traffic volume and travel time. For example, by aggregating fluctuations in the travel time of each section, it was possible to clearly identify the section and time periods that cause congestion (Figure 5).

The results have shown that there are periods of the day when the required time from point 02 to point 03 and the required time from point 05 to point 10 are very long. This result indicates that it is possible to show detailed quantitative data about delays that occur during congestion by obtaining continuous required time data that is harmonized with feelings of the region’s people.
(2) Traffic movement

It is also possible to survey traffic movement by matching license plate information. Here is an example of the study of the flow of vehicles entering the Tsutsujigaoka Parking Area. A total of 1,700 vehicles/day enter the Tsutsujigaoka Parking Area, with 80% of these accessing the area by the normal route. And among those entering the Tsutsujigaoka Parking Area from Nishiodori Street, 550 vehicles/day enter by the normal route and 40 vehicles/day enter by the alternate route, indicating that only 7% of vehicles enter by the alternate route.

In this way clarifying the utilization of access routes can contribute to improving methods of providing future route information.

(3) Utilization of the parking area

The utilization of the parking area and the time vehicles remained inside it were successfully calculated from results obtained from automatic vehicle identification devices at the entrance and exit of the parking area.

An examination of the state of utilization of the parking area on November 18 (Sunday) when it was congested indicates that the number of vehicles entering the parking area soared beginning about 8:00 a.m. and that it was almost filled to capacity by about 10:30. Then the number of vehicles in the parking area remained close to its upper limit from 10:30 a.m. to about 3:00 p.m., indicating that it had reached the limit of its parking capacity (Fig. 7). And the calculation of length of time parked in the area performed by matching the times each vehicle entered and exited from it revealed that almost half remained 2 hours or less, indicating that their owner’s activity was relatively short period sightseeing (Fig. 8).
Tabulation based on vehicle registration and vehicle type

Tabulating the vehicle registrations of vehicles using the Tsutsujigaoka Parking Area revealed that about half were from Ibaraki Prefecture followed by many from Chiba, Saitama, Tokyo etc.

This shows that Tsukubayama is a day-trip sightseeing area that attracts visitors from a range of approximately 100 kilometers, and that it is visited by vehicles driven from the center of Tokyo. In this way, it is possible to hypothesize the range of attracting visitors by road by tabulating license plate information.

Verification of the precision of the automatic vehicle identification device

Precision verification method

The precision of the automatic vehicle identification device was verified by making a video recording and visually observing the four survey points shown in Table 1 for a period of two hours. Treating the measurements made by direct visual observations based on the video images as the correct values, the precision of the automatic vehicle identification device and the direct visual observations were compared.

Table 1: Survey points

<table>
<thead>
<tr>
<th>Survey point</th>
<th>The observation date</th>
<th>The observation time</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>01 Nishioodori Iriguti</td>
<td>2006.11.21(Tue)</td>
<td>9:30～11:30 (2h)</td>
<td>Four traffic lanes with little traffic</td>
</tr>
<tr>
<td>04 Jinjya Iriguti</td>
<td>2006.11.21(Tue)</td>
<td>12:30～14:30 (2h)</td>
<td>Two traffic lanes with little traffic</td>
</tr>
<tr>
<td>05 Kazekaeshi Toge</td>
<td>2006.11.21(Tue)</td>
<td>15:00～17:00 (2h)</td>
<td>Two traffic lanes with little traffic</td>
</tr>
<tr>
<td>08 Purple line Iriguti</td>
<td>2006.11.22(Wed)</td>
<td>14:00～16:00 (2h)</td>
<td>Two traffic lanes with little traffic</td>
</tr>
</tbody>
</table>

Results of the verification of the precision

(1) Comparison of 2-hour values

The comparison of 2-hour values revealed that the visually observed values are positioned between 0.991 and 1.048 (-0.8% to +4.8%) and the values observed by the automatic vehicle identification devices between 0.958 and 0.997 (-4.2% to -0.3%) respectively of the values observed by the video cameras at each location.

The automatic identification device failed to monitor all vehicles, because some of the vehicles that actually passed the observation locations could not be identified.

These results failed to clearly verify the superiority of the automatic vehicle identification device.
(2) Results of observations per unit of time

Based on results of tabulation at 10 minute intervals, the traffic volume obtained by video observations is represented on the horizontal axis to prepare and compare a distribution chart based on observation results obtained by visual observations and by the automatic vehicle detection devices.

The visually observed values are positioned on an almost 45º line above the video observed values, but as the traffic volume by unit of time increases, scattering tends to increase. The values observed by the automatic vehicle identification devices indicate traffic volume that is a little lower than the positive values obtained by the video cameras, a tendency that can be seen below the 45º line.

This shows that regardless of the low impact of the traffic volume on observation precision obtained by mechanical observations, although the visual observations ensure precise observation up to a certain traffic volume, as the traffic volume increases the precision of the observations fall.

![Figure 10: Comparison of visual observations and video](image10)

![Figure 11: Comparison of AVI and video](image11)

(3) Evaluating by the error rate

The RMS error is used as an index to evaluate precision of observation methods. Data used to calculate the index are values observed at 10 minute intervals. And Abs.RMS, that represents the estimated error as an absolute value, evaluates the average discrepancy with actual values regardless of the values of the data. And %.RMS represents the estimated error as a percentage.

(Estimation equation)

The RMS errors include one that represents the absolute value of the error (Abs.RMS) and one that represents the ratio of the absolute error to the actual value (%.RMS). The RMS error calculation equation is shown below.

\[
\text{Abs.RMS} = \sqrt{\frac{\sum (Pi - Ai)^2}{n}} \quad \text{%.RMS} = \frac{\text{Abs.RMS}}{\bar{A}}
\]
Ai, A: traffic volume observed by video cameras and average of this traffic volume  
Pi: traffic volume by observation methods  
N: number of samples  
l: subscript that represents rank  

(Results)  
Examining the calculated values has confirmed that  
Abs.RMS for visual observations and for automatic vehicle identification device observations are 6.06 and 5.65 respectively and that %.RMS for visual observations and for automatic vehicle identification device observations are 0.11% and 0.08% respectively, confirming that the automatic vehicle identification devices obtain more precise data.  

Tabulating the %.RMS error by traffic volume rank (broken down by 20 vehicles) reveals that from both visual observations and observations based on automatic vehicle identification device, as the traffic volume rises, the absolute value of the error also rises. Representing this error as a percentage indicates that at a traffic volume of less than 80 vehicles/10 minutes, visual observations and observations by automatic vehicle identification device show the same tendencies, but at traffic volume of 80 vehicles or more/10 minutes, the error of the visual observations tends to increase. And observations by automatic vehicle identification device show a tendency for the error to be flat even as the traffic volume rises.  

This is assumed to be a result of the fact that in the case of mechanical observations, vehicles may be overlooked at a constant rate regardless of the traffic volume, while in the case of direct visual observations, although high precision is ensured during time periods with low traffic volumes, when the traffic volume is high, the precision declines.

**Conclusion**

The data obtained from the automatic vehicle identification devices supplied important information for studying traffic countermeasures by, for example, making it possible to ascertain the constantly changing travel time.

Furthermore, the performance evaluation demonstrated that, in locations where equipment setup conditions were favorable, the devices maintained accuracy that surpassed the detection rate of 95% or more, which was established in the device specifications. Thus, it reinforces the view that there are no problems in practical application of these devices.

In the future, work will be geared toward further application of these devices in practical operations so that they may contribute to the gathering of available traffic data.