METHODS AND FUTURE PROSPECTS FOR INVESTIGATING TRAFFIC DATA USING INFORMATION TECHNOLOGY

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Abstract
The Ministry of Land, Infrastructure and Transport has been conducting road traffic censuses and has been carrying out a variety of surveys to obtain road traffic data to plan and administer roads. And to perform administration based on these data, the Ministry has announced performance indicators such as congestion loss indicators. Therefore, efficient collection of road traffic data needed to calculate these indicators is now growing in importance. This report introduces the precision and performance of road traffic data investigation methods using information technologies that have advanced spectacularly in recent years and describes future prospects for road traffic investigation.

Introduction
Background and Purpose
In Japan a road traffic census is carried out about every five years to investigate traffic...
volumes, travel speed, current road conditions and origin-destination data that are used widely for future road planning and day-to-day road administration. And traffic counters installed throughout Japan perform continuous observations that grasp year-round traffic volumes. In order to perform more efficient, effective, and transparent road administration that is based on outcome, it is becoming increasingly necessary to correctly evaluate performance of road administration and reflect this appropriately in project implementation. The Ministry of Land, Infrastructure and Transport published the Performance Plan for Road Administration 2003 and the Report on the Degree of Achievement of Road Administration in 2003 / Performance Plan for Road Administration 2004 that contain target values and current status values for seventeen performance indicators. Road traffic data are becoming increasingly important as the basis for the calculation of these performance indicators and the performance of appropriate road management based on these performance indicators. In particular, time loss due to congestion is cited as a main performance indicator of the smoothness of road traffic. It is calculated by the following equation that requires measured traffic volumes and travel speeds by time zone.

\[
CLT^L = \sum_t \sum_m \left( \frac{l_{tL}}{t_{tL}} - \frac{l_{bL}}{b_{tL}} \right) \times Q_{mL}^t \times N_{mL}^t
\]

- \(CLT^L\) : Time Loss due to Congestion on the section L
- \(t_{tL}\) : Travel Time on the section L at time t
- \(b_{tL}\) : Base travel time on the section L
- \(Q_{mL}^t\) : traffic volume of type m vehicles on the section L at time t
- \(N_{mL}^t\) : average of number of person in type m vehicles
- \(l\) : length of the section L

This report describes prospects for future traffic investigations based on comparisons of the precision, performance etc. of advanced methods of measuring traffic volumes and travel speeds that are now possible thanks to the development of information technology, focusing on road traffic censuses in particular.

**Traffic Volume and Travel Speed Investigations in Japan**

The Ministry of Land, Infrastructure and Transport has grasp traffic volumes through road traffic censuses and continuous observations by traffic counters. Road traffic censuses have been conducted to investigate traffic volumes, travel speeds and the current state of roads with national highways, prefectural roads, and regional roads throughout Japan divided into sections at about 35,000 sections. A road traffic census is extremely costly because it is mainly manual observations. Continuous observations are done by installing traffic counters incorporating both ultrasonic and loop coil methods to perform on-line measurements of the traffic volume of motor vehicles (normal trucks, busses, passenger cars, and small trucks) and point travel speed
throughout 24 hours (Fig. 1). They are installed primarily on national highways nationwide, but are limited to only about 500 locations.

• Combination of ultrasonic type and loop type
  – It can classify vehicle type.

Figure 1. Continuous Traffic Volume Observation System

Methods of Investigating Traffic Volumes Using Information Technology

With the progress of information technology, simple portable traffic counters that use terrestrial magnetism have been developed. Two installed magnetic sensors detect the change of the earth’s magnetic field that occurs as a motor vehicle passes, and it measures the traffic volume, point travel speed, and vehicle length by two sensors. It is installed in the center of a traffic lane to measure the traffic volume on that lane. The batteries installed inside these sensors have duration of about one week, so it can measure traffic volume continuously for a week.

Figure 2. Simple Portable Traffic Counter Using Terrestrial Magnetism

The precision of this simple portable traffic counter is shown in Figure 3. This figure compares the measurement values obtained manually and using the simple portable traffic counter, with those obtained by a video system considered to be the true values and reveals error rate during different time zones. In all time zones, the error rate is within 5%, showing that both manual observations and traffic counter observations are capable of almost equal observation precision.
Table 1 shows the merits and demerits of applying the simple potable traffic counter. As Table 1 shows, use of the simple traffic counter would contribute to reducing costs because its use lowers the cost per investigation location from about 160,000 yen by about 2/3 to 110,000 yen. But a demerit of the simple potable traffic counter is about distinction of motor vehicle categories. During past traffic censuses, investigators could measure traffic volume by four vehicle categories—large trucks, busses, small trucks, and passenger cars—by noting their license plates, but a simple potable traffic counter can only distinguish between two categories—large and small vehicles—because it distinguishes vehicles by their length. And because pedestrians and motor cycles do not change the magnetic field as they pass through an observation point, they cannot be counted. Therefore, when a simple traffic counter is used to investigate traffic during an actual road traffic census, the investigation locations must be chosen considering these facts.

<table>
<thead>
<tr>
<th>Merits of using simple potable traffic counter</th>
<th>Demerits of using simple potable traffic counter</th>
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<tbody>
<tr>
<td>Can be used for several days (1 week continuously) of measurements at low cost.</td>
<td>Only two categories of vehicles (large and small) can be distinguished.</td>
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<td>Manual observation: 160,000 yen (12 hours of on weekdays/holidays: total of 24 hours)</td>
<td>Track data is recorded electronically, tabulation work is sharply lowered and tabulation time sharply cut.</td>
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<td>Simple portable traffic counter observation: 110,000 yen (for a week, excluding initial cost)</td>
<td>It is not necessary to worry about safety or obtaining space at investigation locations.</td>
</tr>
<tr>
<td>Because data is recorded electronically, tabulation work is sharply lowered and tabulation time sharply cut.</td>
<td>Obtaining equipment imposes an initial cost (about 500,000 yen/unit)</td>
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<tr>
<td>It is not necessary to worry about safety or obtaining space at investigation locations.</td>
<td>It is necessary to restrict traffic for a short time to install or to remove the equipment</td>
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Table 1. Merits and Demerits of the Simple Traffic Counters

Travel Speed Investigation Methods Using Information Technology

Travel speed investigations during past road censuses were performed by having investigators...
in the passenger seat of passenger cars recording the time required to pass through the borders of census sections, increasing the cost of manual observations.

The development of information technology has sharply cut the cost of GPS devices that can be used to specify locations. If these GPS devices can be used to record the time required for vehicles to pass through census sections to investigate travel speed, recorders sitting in passenger seats are unnecessary, permitting the cost to be lowered. GPS devices include car navigation systems, PDA equipped GPS, portable type used for angling and mountain climbing, and cell phones equipped GPS, and the cost and performance of each type varies (Table 2, Fig4).

<table>
<thead>
<tr>
<th>Device Name</th>
<th>Position Data Source</th>
<th>Portability</th>
<th>Approximate Instrument Cost</th>
<th>Power Source</th>
<th>Recording Time Capability of a Single Unit</th>
<th>Speed Pulse</th>
<th>Direction Censor</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPS ANTENNA FOR PDA</td>
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<td>KEITAI-SITE GPS</td>
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<tr>
<td>SAFETY RECORDER</td>
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<tr>
<td>GPSMAP76</td>
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<td></td>
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<tr>
<td>Geko201</td>
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</tbody>
</table>

Table 2. Performance of Portable GPS

Figure 4. Various GPS devices
Generally the car navigation type uses car speed pulses obtained from the motor vehicle and a gyro-sensor that detects direction in addition to GPS signals to constantly clarify the location based on the independent navigation method. Therefore, it can specify the location with high precision under high viaducts and in tunnels where GPS signals might be blocked. But the introductory cost is high and it cannot be easily installed in and removed from vehicles. On the other hand, although the precision of a portable GPS device is low under viaducts and tunnels that block GPS signals, it can be installed and removed easily. With regard to road traffic census that investigates travel speed in about 35,000 sections for stipulated time periods, it is very expensive to install expensive devices in all investigation vehicles. It is, therefore, necessary to introduce portable GPS devices that can be cheaply and easily installed then removed from a motor vehicle.

For these reasons, various devices were installed in investigation vehicles and their positioning precision verified in order to study the possibility of introducing portable GPS devices to road traffic census travel speed investigations. For precision verification comparison purposes, a car navigation type was also used for the positioning. The items compared to verify their precision were the measured data reception rate and average position error.

First, the precision verification was done in census section 1057 from Sangenjaya to Kamiizumi-cho on National Highway Route 246 that is under a viaduct on the Metropolitan Expressway where it is assumed that GPS signals are blocked. Figure 5 and Table 3 show the reception results.

According to Figure 5 and Table 3, the five types of portable GPS devices achieved data reception rates less than 50%. Only one, the PDA type, achieved a higher reception rate, but it is assumed that this is a result of the high precision of its antenna. This result shows that under urban viaducts and other places where there is a high likelihood of GPS signals being obstructed, it will be difficult to investigate travel speed using portable GPS devices.
Next a similar precision comparison was done in a suburb where there is low possibility of the GPS signals being blocked. The results are shown in Figure 6 and Table 4. The section was done is part of the former National Highway No. 17, census section 11029 from Sakuragi-cho to Yoshino-cho.

![Figure 6. Data Reception in a Suburb (R17, Section 11029)](image)

Table 3. Data Reception Rate of GPS Devices Under a Viaduct (R246, Section 1057)

<table>
<thead>
<tr>
<th>GPS Devices</th>
<th>Distance from the center line of the road (m)</th>
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<tbody>
<tr>
<td></td>
<td>Min.</td>
</tr>
<tr>
<td>Car navigation</td>
<td></td>
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<tr>
<td>Safety Recorder</td>
<td></td>
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<td>PDA + GPS</td>
<td></td>
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<tr>
<td>Keitai-site GPS</td>
<td></td>
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<tr>
<td>Geko201</td>
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<tr>
<td>GPS map76</td>
<td></td>
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</tbody>
</table>

Figure 6 and Table 4 shows that in a suburb where there is little possibility of GPS signals being blocked, the data reception rate is extremely good at a level higher than 90%. The data reception rate of the Geko201 was extremely low, because according to its specifications, if it accumulates a certain fixed number of data, it begins to thin the data, but this problem can be avoided by frequently recovering its data. It is possible to calculate the travel speed if the investigation reveals the time required to pass through the boundaries of a section at an average section length of 6km from its start point to its end point. Therefore, there is a high possibility of using this method in suburbs where it is possible to receive more than 90% of the data.
In addition to the above, similar investigations were done under various conditions, but under viaducts, in tunnels, and among tall buildings where there is a high likelihood of blockage of the GPS signals, the data reception rate was reduced. But among the approximately 35,000 census sections, within 30% sections were included DID (Densely Inhabited District) and urban area that are likely under viaducts or among tall buildings. Because positions can be clarified with extremely high precision using portable GPS costing only a few tens of thousand of yen per unit in the other sections, there is a very high possibility of using these devices for travel speed investigations.

Table 4 Data Reception Rate in a Suburb (R17, Section 1025)

In Conclusion

The study has shown that if simple traffic counters using terrestrial magnetism, portable GPS devices etc. are operated and their investigation locations selected according to the merits and demerits of each device, there is a high possibility that these devices can be applied to road traffic censuses and will acquire good quality data cheaply and efficiently. The next road traffic census is scheduled for 2005 when it will be necessary to decide on more detailed operating methods.

Various kinds of devices that use information technology to increase the efficiency of traffic investigations are spreading in Japan. Trucking companies and car rental firms are installing GPS devices capable of even measuring acceleration in tens of thousands of vehicles in order to perform driver safety evaluations. Cell phones are now equipped with GPS antennas increasing the possibility of using them for travel speed investigations or for origin-designation investigations. The use of these devices that have already spread to the private use market and of the data they provide will dramatically increase the efficiency and precision and cut the cost of past investigations. Future studies of the potential for the use of new IT devices in traffic investigations should be carried out.

References

1) Masatoshi UETA, Road Management Practice Utilizing Probe Vehicles, 10th ITS World Congress, 2003.