Estimating Traffic Demand using Uplink Information from Infrared Vehicle Detectors

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SUMMARY

Currently, various traffic conditions are measured by using different detectors such as loop-coil and so on. In Japan, infrared vehicle detectors (IRVD) were introduced and installed in urban areas since 1994. This vehicle detector has two functions, one is counting vehicle numbers, and the other is transmitting traffic information to each driver. In this paper, in order to estimate an OD matrix, we gathered and stored uplink information from infrared vehicle detectors in Yokohama, Japan.

INTRODUCTION

Since we have become an advanced information-oriented society in recent years, traffic signal control systems, road traffic information provision systems, two way communication between road, vehicle and car navigation systems using satellite communication are spreading. It is necessary, therefore, to correctly analyze and estimate traffic phenomenons and conditions. Additionally traffic phenomenons are dynamic and traffic conditions are changeable. Under these circumstances infrared vehicle detectors, one of the methods of detection have been installed along ordinary roads. The function of this detector is to provide two-way communication between vehicle and driver in addition to the conventional method. The movement of each vehicle which carries a car navigation system, can be caught by using two-way communication, so as various information such travel time, routing and vehicle types can be gathered. In this paper, we propose an estimation method , to investigate the characteristics of the detector, analyze information on the detector, and use these to put together concerns about reducing traffic jams and O-D estimating.

O-D ESTIMATING

Fist of all, it is assumed as X^{od} as estimates O-D demand from link *o* to link *d*, there is relation between each link and each infrared vehicle detector, which is shown in figure 1. Therefore, X^{od} is traffic demand which is the origin point of detector *o* and the destination point of detector *d.* For simplicity we neglect subscriptions of time.

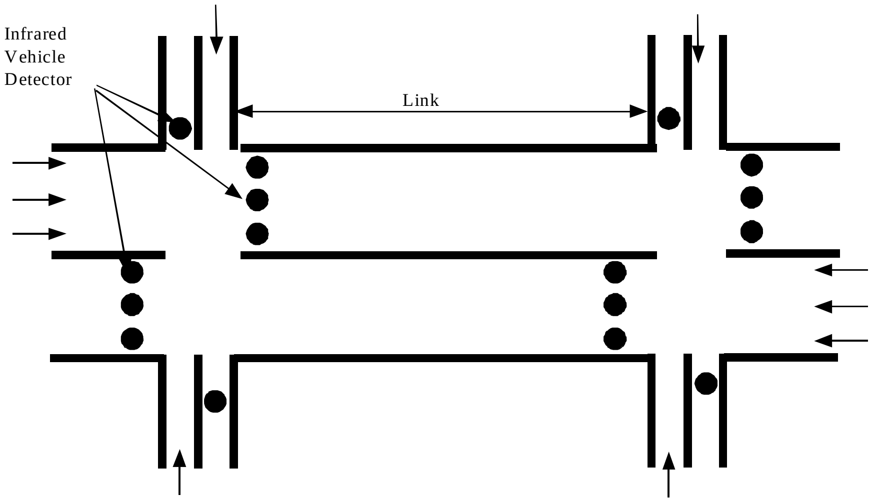

Figure 1 Location of Infrared Vehicle Detectors on Network

We can only know the O-D patterns of uplink data from vehicles with an in-vehicle unit (ODPU) at each time zone. We CANNOT recognize all O-D patterns of every vehicle (ODPE). However traffic volume at each link is measured by using another function of IRVD. Accordingly, we will be able to estimate the ODPE using the distribution of ODPU. In this section we propose a estimating method which is based on the follow assumptions.

Assumption 1 : There is no measurement error in traffic information which is traffic counting and two way communication between infrared vehicle detector and in-vehicle unit

Assumption 2 : The ODPU represents the ODPE.

The traffic volume at destination link *d* which could be observed by using the counting function of IRVD, is determined as X_d. If the p^{od} is given the rate of traffic demand X^{od} can be written as follows.

$$X^{od} = X_d \, p^{od} \tag{1}$$

If the p^{od} is unknown, the ODPU represents the ODPE in assumption 2, estimated by

$$\hat{p}^{od} = \frac{n_d^{od}}{n_d} \tag{2}$$

n_d^{od} : the observed vehicles on destination link *d* of the ODPU in a time zone

n_d : the observed vehicles that lane gone through destination link d

As the n_d^{od} is the number od (OD traffic demand) of vehicles in the n_d, it follows the variance of (n_d , p^{od}). Therefore the variance of p^{od}

$$Var\left[\hat{p}^{od}\right] = Var\left[\frac{n^{od}}{n_d}\right] = \frac{1}{{n_d}^2} Var[n^{od}] = \frac{p^{od}(1-n^{od})}{n_d} \qquad (3)$$

Estimated OD traffic volume $\hat{X}^{od}$ is calculated as $\hat{X}^{od} = X_d \cdot \hat{p}^{od}$ by setting $\hat{p}^{od}$ that is estimated by eqn (3) into p^{od} in eqn (1). If the X_d and p^{od} are independent in the variance of $\hat{X}^{od}$ and the traffic volume X_d is followed by Poisson distribution, $E[X_d] = Var[X_d] = X_d$ are defined, and $Var\left[\hat{X}^{od}\right]$ is written as

$$\begin{aligned} Var\left[\hat{X}^{od}\right] &= Var\left[X \cdot \hat{p}^{od}\right] \\ &= E\left[\hat{p}^{od}\right]^2 Var[X_d] + E[X_d]^2 Var\left[\hat{p}^{od}\right] \\ &= {p^{od}}^2 Var[X_d] + E[X_d]^2 \frac{p^{od}(1-p^{od})}{n_d} \\ &= X_d p^{od}\left\{p^{od} + \frac{X_d}{n_d}(1-p^{od})\right\} \end{aligned} \qquad (4)$$

EXPERIMENT SYSTEMS

The experiment system configurations shown as Figure 2.

THE CHARACTERISTICS OF AN INFRARED VEHICLE DETECTOR

An infrared vehicle detector has two functions. One would measure traffic volume similar to today's conventional detectors. The second would collect vehicle identification numbers and transmit detailed traffic information, which includes vehicle identification numbers, previous-passing detector numbers, origin-passing detector numbers , car types, travel time and more, to individual drivers, by communicating directly to the in-vehicle units their cars are equipped with.

CENTRAL SYSTEMS

Central Systems are composed of the traffic information host computer, traffic information front-end processors and information monitors, all combined with the LAN (Local Area Network). The traffic information host computer is connected to existing traffic control systems so traffic congestion information and other data can be transferred. The function of the traffic information front-end processor is to receive such uplink information as vehicle identification numbers from infrared vehicle detectors, then calculate travel time matching these identification numbers. Additionally, it should collect downlink information edited by the traffic information host computer and send that data to each infrared vehicle detector.

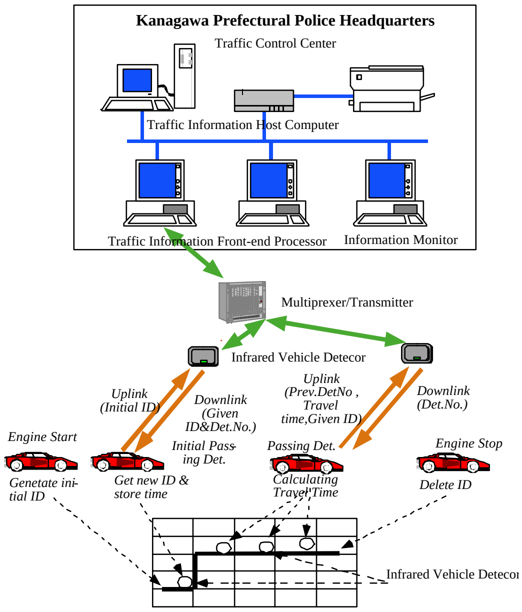

Figure 2 Experiment System Configuration and Communication Sequence

ANALYZING

USING DATA

Conditions of using data are as follows.
Date; from 22nd March 1998, to 3rd April 1998, 14 days.
Place; All infrared vehicle detectors (about 1,100) installed in Kanagawa Pref., Japan
Data; Uplink information

UPLINK INFORMATION

Uplink information consists of vehicle identification numbers, present passing detector numbers, previous-passing detector numbers, previous-passing prefecture numbers, origin-detector numbers, car types, travel time, and others.

PRIMITIVE ANALYZING DATA

For the uplink information from all infrared vehicle detectors, more than 15,000 to 17,500 cases per day are counted, and have been increasing every month. Not only does this data contain valid information, but it also involves a lot of errors and incomplete data. Therefore erroneous data such as abnormal present-passing detections, abnormal previous-passing detections, abnormal origin detections and others, are discarded from a variety of view points. We got valid data, which amounted to 40% of the raw data, finaly expand data up to 70% using a method which can repair incomplete data.

RESULT OF UPLINK INFORMATION

RESULT OF BETWEEN UPLINK INFORMATION AND TRAFFIC VOLUME

The uplink information and traffic volume are compared in a point. As a result from figure 3, they aren't related. The rate of the vehicles with in-vehicle units is 0.2% in this area.

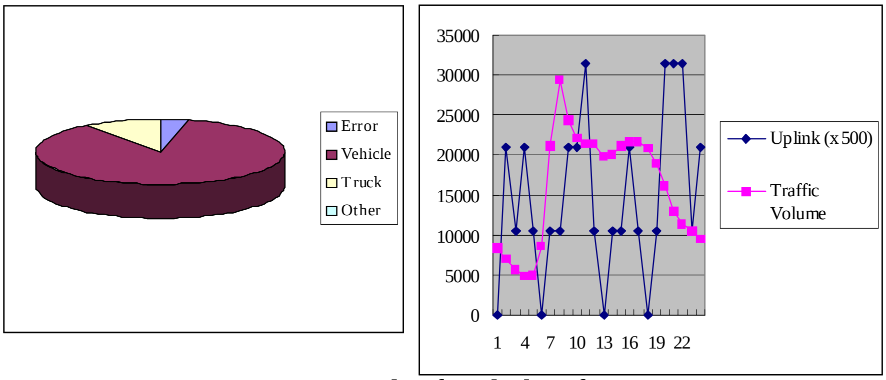

Figure 3 Result of Uplink Information

RESULT OF CAR TYPES

The left-hand figure 3 expresses the percentage of car types. 80% of the total are ordinary vehicles. Most in-vehicle units are used for personal use.

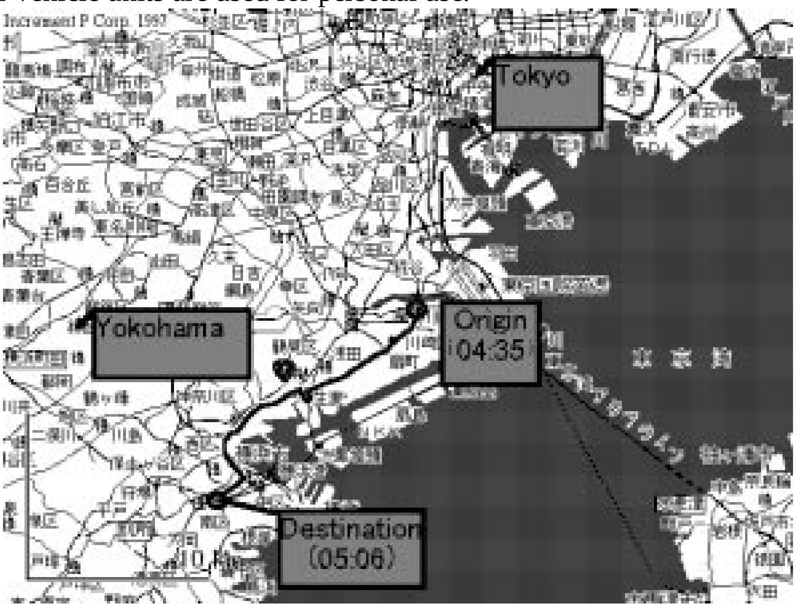

Figure 4 Sample of Tracing of Uplink Information

RESULT OF TRACING DATA

This trip shows a tracing vehicle which the most uplink information in 22nd March 1998. In this sample expresses the distance between origin and destination which is 23.2km and the travel time is 29 minutes. Furthermore, all vehicles trips are drawn in a similar manner.

CONCLUSIONS

In this paper, we analyzed the uplink information of infrared vehicle detectors, and some of the uplink information was complemented. As well as the uplink information is useful because of estimating OD, traffic demands and travel time easily.

As a result, we propose the following concerns regarding the future.

- It will be necessary to check on abnormal information, regarding tracing data of each vehicle.
- The density of IRVD is scattered and the number of uplink information is very small in the present condition of our country.
- It will be required to pick up tracing errors geometrically using digital map data.

After this, we can estimate an OD matrix and accurate prediction of traffic arrival flows.

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