Turning Rate Estimation using UPLINK Information

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SUMMARY

In Japan, infrared beacons have been introduced and installed in urban road networks since 1993. Therefore we can not only get UPLINK information from each vehicles, which has in-vehicle units, but also gather traffic volume as usual. Meanwhile these beacons are arranged around 20m from exit of each direction, so we are able to observe turn of each vehicle. In this paper, in order to use these results for traffic signal control, we collected turn of each vehicle that has in-vehicle unit from UPLINK information and estimated turning rate using traffic demands.

INTRODUCTION

In Japan, more than thirty years have passed since traffic control systems were first put into operation. Until recently, these systems have contributed greatly towards making vehicular traffic flow smoother, safer and more convenient. Traffic control systems are now commonly used throughout urban areas in Japan. However, in recent years, the environment of most traffic control systems has changed remarkably, and in particular, the ceaseless growth and concentration of population resulting in more vehicles in urban areas has caused a constant increase of traffic congestion. Meanwhile it has become more difficult to build new roads to handle this serious problem. The primary aim of traffic control research in Japan is to maintain the smoothness and safety of the traffic flow, and improve methods of traffic signal control.

As for infrared beacons, 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 such various data as travel time, trajectories and vehicle types can be gathered.

In this paper, we knew our existing state of UPLINK data and traffic volume using beacons at first. Then we compared them and study a method for estimating. Finally, we estimated turning rate at intersections.

UPLINK INFORMATION

As for UPLINK information, which has already been stated in the reference[1]. 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.

TURNING RATE ESTIMATING

First of all, it is assumed X^l as estimates demand from link *o* to link *l*, X^s as estimates demand from link *o* to link *s* and X^r as estimates demand from link *o* to link *r*, there are relation between each link and each infrared beacon, which are shown in figure 1. For simplicity X^l is representation of all directions. Therefore, X^l is traffic demand, which is the origin point of beacon *o* and the destination point of beacon *l*. For simplicity we neglect subscriptions of time.

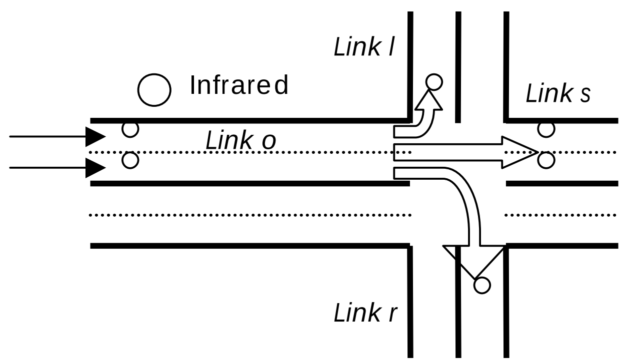

Figure 1; Location of Infrared Beacons on Network

We can only know the turn patterns of uplink data from vehicles with an in-vehicle unit (TPU) at each time zone. We CANNOT recognize all turn patterns of every vehicle (TPE). However traffic volume at each link is measured by using another function of infrared beacons. Accordingly, we will be able to estimate the TPE using the distribution of TPU. 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 TPU represents the TPE.

The traffic volume at destination link *o*, which could be observed by using the counting function of infrared beacons, is determined as X_o. If the p^{ol} is given the rate of traffic demand X^l can be written as follows.

$$X^l = X_l p^{ol} \tag{1}$$

If the p^{ol} is unknown, the TPU represents the TPE in assumption 2, estimated by

$$\hat{p}^{ol} = \frac{n_l^{ol}}{n_l} \tag{2}$$

n_l^{ol} : the observed vehicles on destination link *l* of the TPU in a time zone

n_l : the observed vehicles that lane gone through destination link *l*.

As the n_l^{ol} is the number of vehicles in the n_l, it follows the variance of (n_l, p^{ol}). Therefore the variance of p^{ol}

$$Var\left[\hat{p}^{ol}\right] = Var\left[\frac{n_l^{ol}}{n_l}\right] = \frac{1}{n_l^2} Var[n_l^{ol}] = \frac{p^{ol}(1-p^{ol})}{n_l} \tag{3}$$

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

$$Var\left[\hat{X}^{ol}\right] = Var\left[X \cdot \hat{p}^{ol}\right]$$
$$= E\left[\hat{p}^{ol}\right]^2 Var[X_l] + E[X_l]^2 Var\left[\hat{p}^{ol}\right] \tag{4}$$

and coefficient of variation is written as

$$\sqrt{Var\left[\hat{X}^{ol}\right]} \Big/ E(\hat{X}^{ol}) \approx \frac{\sqrt{Var(X_l)}}{E(X_l)} + \frac{\sqrt{Var(p^{ol})}}{E(p^{ol})}$$
$$= \frac{\sqrt{Var(X_l)}}{E(X_l)} + \sqrt{\frac{(1-p^{ol})}{n_l p^{ol}}}$$
$$= \frac{\sqrt{Var(X_l)}}{E(X_l)} + \frac{1}{\sqrt{n_l^{ol}}} \tag{5}$$

CONDITIONS

Date; from 6th December 1998.
Place; Infrared beacons installed in Kanagawa Pref., Japan
Data; UPLINK information and traffic volume using beacons.
Road Network; is shown in figure 2, there is an intersection.

Network Conditions

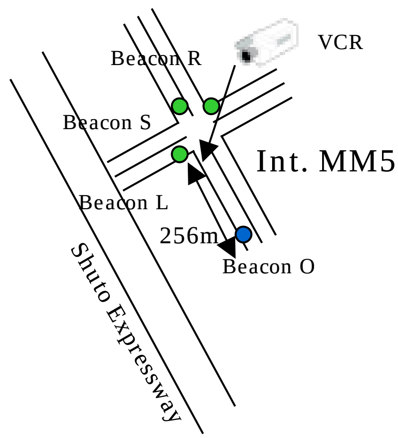

Figure 2: Road Network

Measured traffic volumes at stop line are measured using VCR. Measured traffic volumes and UPLINK information are measured by each beacons. The beacon *O* is located 256m upstreem of stop line.

Measured Traffic Volume And Uplink Information At Each Intersection

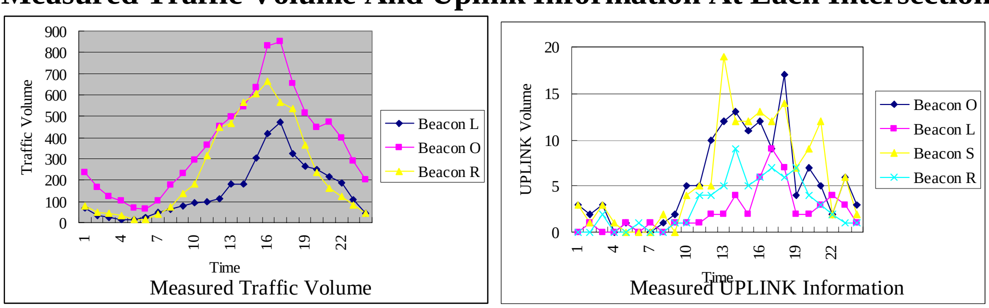

Figure 3: Result of measured traffic volume and measured UPLINK infromation

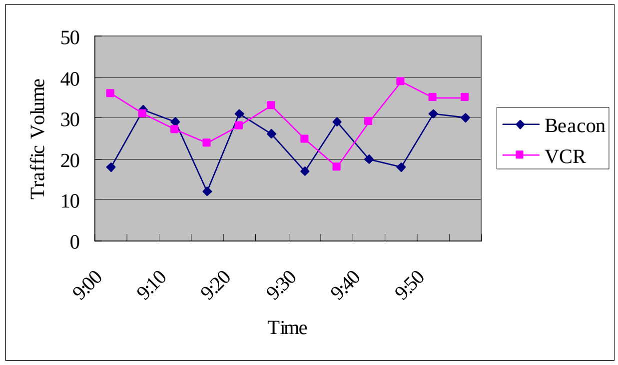

Figure 4: Traffic Volume at the MM5 using beacons and VCR in 9 a.m.

RESULT OF ESTIMATED TURNING RATE

Using eqn.(1) and eqn.(2), estimated turning distribution and measured number is as follows;

On condition that, estimated turning distribution rate is calculated by using whole day of UPLINK information. Following measured traffic volumes are measured from VCR.

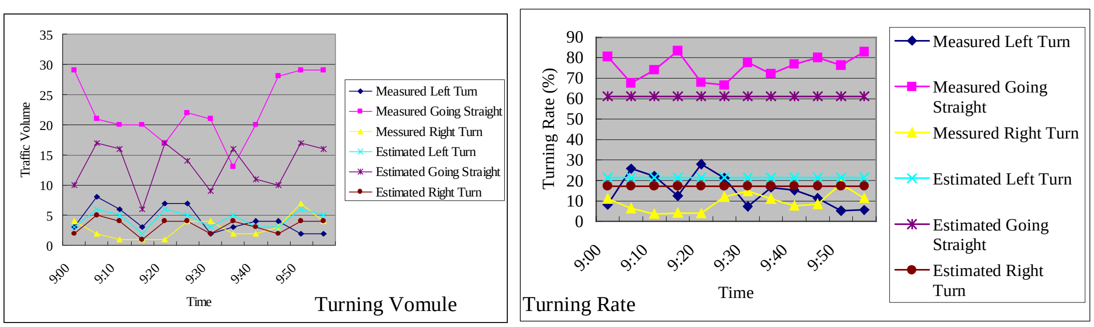

Figure 5: Turning Volume and Rate at Intersection of the MM5

COMPARISON

In Japan, there are 70 million registered cars and 0.7 million cars of them have in-vehicle unit in the middle of 1998. As for UPLINK information, it is almost insufficient. But in this paper, some part of UPLINK results are nearly enough for estimating turning distribution rate.

When we compare between measured traffic volumes and UPLINK information in figure 3, the UPLINK information is around 1.5 % of measured traffic volumes. From figure 5, in spite of small UPLINK information, the estimated traffic volumes are nearly the measured traffic volumes. However the estimated traffic volumes are smaller than the measured traffic volumes. Because beacons coundn’t measure traffic volumes correctly and each measured locations are different.

CONCLUSIONS

In this paper, we estimated turning rate. As well as the uplink information is useful because of estimating turning rate.

Finally, we will make an algorithm for traffic signal control using UPLINK information.

REFERENCES

[1] Mashiyama. Y, Kuwahara. M, Yoshii. T., Niikura S. and Oda T., "Estimating O-D Matrix using Uplink Information from Infrared Vehicle Detectors", IEEE IV98, Stuttgart, Germany, 1998

[2] Kuwahara. M, Mugikura T., Niikura S. and Oda T., "Estimating OD matrix using Beacon Information", 1997