Methods of Modifying UPLINK Information and OD Estimation

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SUMMARY

Recently we have many types of two-way communication methods between traffic management center and vehicles, for instance, cellular phone, radio beacons and infrared beacons. In Japan, in order to communicate information between them point-to-point, infrared beacons were introduced and installed in urban areas. The function of this beacon is to provide two-way communication between vehicle and driver in addition to the conventional method. In this paper, in order to estimate an OD, we gathered and stored UPLINK information from infrared beacons, then we modified it using road network.

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, and vehicle and car navigation systems using satellite communication are spreading. It is necessary, therefore, to correctly analyze and estimate traffic phenomenon and conditions. On the other hand, traffic phenomenon are dynamic, and traffic conditions are changeable. Under these circumstances, infrared beacons, one of the methods of detection have been installed along ordinary roads. The function of this beacon 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 information as travel time, trajectories and vehicle types can be gathered. In this paper, we investigate the characteristics of the beacon, analyze UPLINK information from the beacon and modify UPLINK information using digital maps. Finally, we estimate OD.

UPLINK INFORMATION

As for UPLINK information, which has already been stated in the reference[1]. UPLINK information consists of vehicle identification numbers, present passing beacon numbers, previous-passing beacon numbers, previous-passing prefecture numbers, origin-beacon numbers, car types, travel time, and others.

MODIFYING UPLINK INFORMATION

First of all, UPLINK information is stated here about the outline of simple modification method, which isn't based on digital maps.

Types Of Errors

Before checking UPLINK information, data were divided into each vehicle. The divided data was called an ID data. When all ID data were checked their sequences using beacon numbers, some of them weren't continuity. In these cases, their communication between the beacon and the vehicle couldn't be completed, or their communication between the computer in traffic management center (TMC) and the beacon couldn't be finished. Such types of errors were shown as follows;

Uplink Error

When an UPLINK error happened, it could be thought that communication 2 in the figure 1 was broken or lost.

Downlink Error

If a DOWNLINK error occur, it could be considered that transmission 4 in the figure 1 was broken or missed.

Both Directions Error

When both directions error occurred, it could be thought that transmissions 1 and 4 in the figure 1 ware broken or lost.

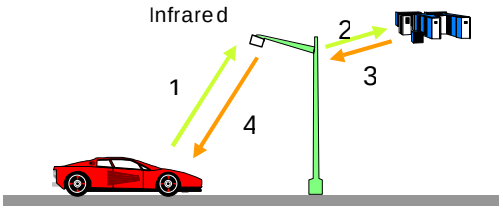

Figure 1; Communication between Beacon and Vehicle

A Modifying Method

So UPLINK information has both a passage beacon and a previous passage beacon, errors as mentioned before can be modified to some extent. Typical modifying methods are as follows;

Modifying Uplink Information

A typical UPLINK eror is shown in following table;

Table 1; UPLINK List within Errors

Passage Beacon Number	Previous Passage Beacon Number	Passage Time	Travel Time
100	N.A.	9:00:00	N.A.
300	200	9:05:00	00:02:30

Table 2; Modifyed UPLINK List

Passage Beacon Number	Previous Passage Beacon Number	Passage Time(hh:mm:ss)	Travel Time(hh:mm:ss)
100	N.A.	9:00:00	N.A.
200	*100*	*9:02:30*	*00:02:30*
300	200	9:05:00	00:02:30

In such cases as shown in Table 1 before, modifying list could be added between first information and third one as shown in Table 2.

Modifying Uplink Information Using Road Network

Secondy UPLINK information is stated here about the outline of modification method, which is based on road networks. The method of the modification is explained by using the following figure example. First, passed beacons location are setted on a map, then connect them using shortest path algorithm on a road network and make a trajectory. When located beacons without passing information are on the trajectory, they are redarded as modifying data.

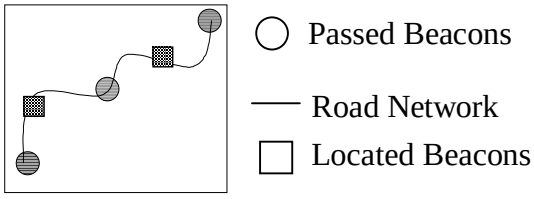

Figure 2; Beacons on a Road Network

OD ESTIMATING

OD estimaitng method is mentioned in the reference [2].

ANALYZING

Using Data

Conditions of using data are as follows.

Date; 6th December 1998

Place; All infrared vehicle beacons (about 2,000 beacons in March 1999) installed in Kanagawa Pref., Japan

Data; Uplink information and traffic volume

Road Network; is shown in figure 3, there are 13 intersections.

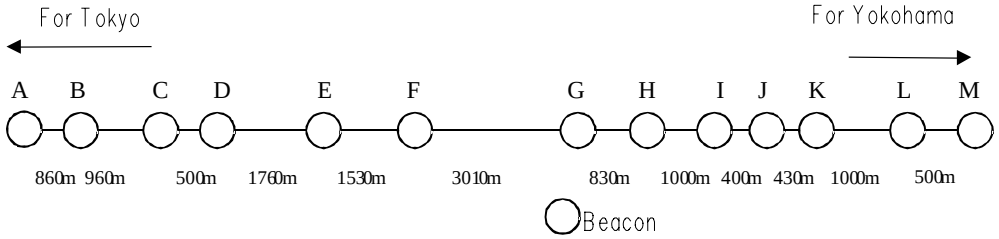

Figure 3; Beacons on a Road Network

Uplink Information

Uplink information consists of vehicle identification numbers(random), present passing beacon numbers, previous-passing beacon numbers, previous-passing prefecture numbers, origin-beacon numbers, vehicle types, travel time, and others.

Analyzing Data

For the uplink information from all infrared vehicle beacons, more than 90,000 to 120,000 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 beacons, abnormal previous-passing beacons, 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 modifying methods which were mentioned before.

Result Of Uplink Information

Result Of Between Uplink Information And Traffic Volume

Measured traffic volume and measured UPLINK information are shown in following figure;

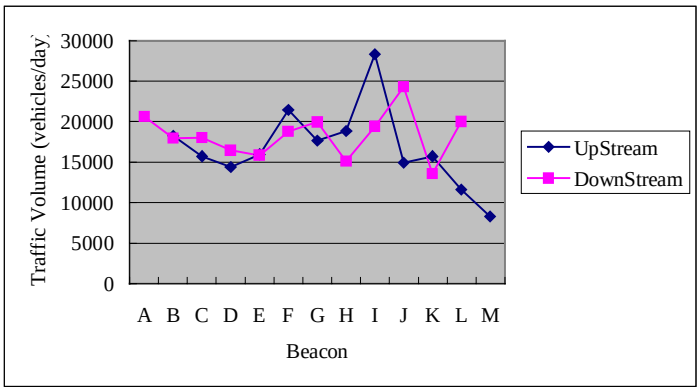

Figure 4; Measured Traffic Volume

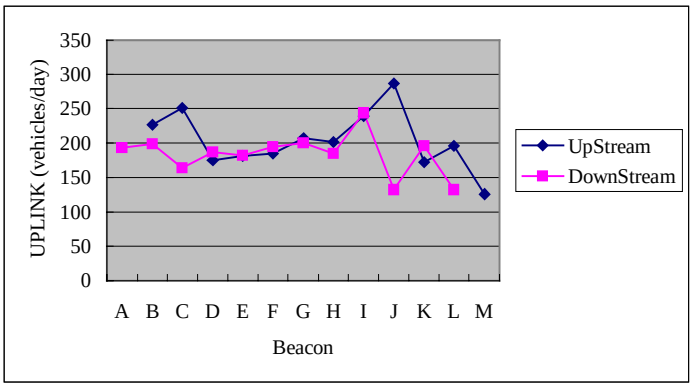

Figure 5; Measured UPLINK Information

One hand, when the result of measured traffic volume in fugure 4 is compared with the result of measured UPLINK inormation in fugure 5, the rate of measured UPLINK information is around 1.0%. On the other hand, the total amount of registered vehicles is 70 million in Japan and the total number of vehicles with car navigation systems is 1.02 million in the end of March, 1999. The diffusion of car navigation is about 1.45%. Therefore we can define that the relation between the rate of measured UPLINK information and the diffusion of car navigation systems is almost the same.

Result Of Uplink Od Matrix

Table 3; Measured UPLINK OD Matrix

ALL	A	B	C	D	E	F	G	H	I	J	K	L	M
A	7	3	2	0	0	0	0	0	0	0	0	0	0
B	0	16	6	1	1	0	0	0	0	0	0	0	0
C	84	0	44	7	3	0	0	0	0	0	0	0	0
D	26	53	0	66	12	0	0	1	0	0	0	0	0
E	7	19	56	0	48	6	1	2	1	1	0	0	0
E	5	14	35	72	0	31	15	3	1	1	0	0	0
G	1	7	17	44	76	0	68	39	7	3	0	0	0
H	1	4	9	19	35	95	0	97	23	10	0	0	0
I	0	0	0	4	10	40	98	0	56	19	2	3	0
J	0	0	0	0	5	14	70	29	0	52	6	12	0
K	0	0	0	0	3	5	12	23	59	0	31	44	0
L	0	0	0	0	1	2	6	7	19	31	0	0	0
M	0	0	0	0	0	0	1	1	2	3	9	0	0

From measured UPLINK OD in table 3, almost each trips are between 2 intersections or among 3 intersections.

Result Of Estimated Uplink Od Matrix And Variance

Table 4; Estimated OD Matrix

EstimatedOD	A	B	C	D	E	F	G	H	I	J	K	L	M
A		563	188	165	0	0	0	0	0	0	0	0	0
B	7358	-	1002	494	88	116	0	0	0	0	0	0	0
C	2666	6397	-	3129	528	348	0	0	0	0	0	0	0
D	1066	1982	4720	-	5282	1390	0	0	118	0	0	0	0
E	213	541	1646	4214	-	4750	511	93.2	236	52	91.6	0	0
E	213	360	1098	2458	5137	-	2385	1212	354	52	91.6	0	0
G	0	90.1	549	1141	3134	6162	-	5595	4132	312	275	0	0
H	0	90.1	329	527	1393	2985	8165	-	10271	1093	916	0	0
I	0	0	0	0	348	963	3585	6938	-	2705	1739	119	198
J	0	0	0	0	0	481	1394	4734	2304	-	4303	356	727
K	0	0	0	0	0	289	498	898	1589	8817	-	1543	2379
L	0	0	0	0	0	96.3	199	490	556	3490	2078	-	0
M	0	0	0	0	0	0	0	81.6	79.4	367	208	1364	-

Table 5; Variance of Estimated OD Matrix

Variance	A	B	C	D	E	F	G	H	I	J	K	L	M
A	-	0.38	0.58	0.71	-	-	-	-	-	-	-	-	-
B	0.1	-	0.25	0.41	1.01	1	-	-	-	-	-	-	-
C	0.19	0.1	-	0.15	0.41	0.58	-	-	-	-	-	-	-
D	0.31	0.21	0.14	-	0.11	0.29	-	-	1	-	-	-	-
E	0.71	0.41	0.25	0.13	-	0.14	0.41	1	0.71	1.01	1.01	-	-
E	0.71	0.5	0.31	0.18	0.11	-	0.18	0.28	0.58	1.01	1.01	-	-
G	-	1	0.45	0.28	0.16	0.11	-	0.12	0.16	0.41	0.58	-	-
H	-	1	0.58	0.41	0.25	0.17	0.09	-	0.09	0.22	0.31	-	-
I	-	-	-	-	0.5	0.32	0.16	0.09	-	0.13	0.22	0.71	0.58
J	-	-	-	-	-	0.45	0.26	0.12	0.18	-	0.13	0.41	0.3
K	-	-	-	-	-	0.58	0.45	0.3	0.22	0.12	-	0.19	0.15
L	-	-	-	-	-	1	0.71	0.41	0.38	0.22	0.18	-	-
M	-	-	-	-	-	-	-	1.01	1.01	0.71	0.58	0.33	-

When we focused on table 4 and 5, we think to be able to judge that estimated OD matrix could be calculated and predicted using traffic volumes and equations, which were mentioned before. However, long trips, which are among 4 intersections or more, couldn't be estimated and their variance couldn't be calculated on account of lack of data.

CONCLUSIONS

In the past, when we measure an OD matrix, OD matrix was counted using video tape recorder or audio tape in advance. Otherwise vehicle numbers were measured by using expensive AVI (Automated Vehicle Identification) system. In this paper, we can introduce modifying methods in practice and we can estimate an OD matrix easier and cheeper than before using UPLINK information , traffic volumes and estimating methods.

After this, we will have to develop following methods;

- Estimating OD matrix of each vehicles
- More accurate prediction of traffic arrival flows
- Estimating turning rate using UPLINK information

Furthermore we will apply these estimated traffic data to traffic signal control and merging control.

REFERENCES

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

[2] Mashiyama. Y, Kuwahara. M, Yoshii. T., Niikura S. and Oda T., "Estimating Traffic Demand using Uplink Information from Infrared Vehicle Detectors", ITS98, Seoul, Korea, 1998