STUDY ON ESTIMATION OF TRAVEL SPEED USING PROBE VEHICLE SYSTEM AND V2V －VERIFICATION BASED ON TRAFFIC MICROSIMULATION MODEL－

Nihon University Student Member ○Tatsuya Aoyagi
Nihon University Regular Member Tetsuhiro Ishizaka
Nihon University Regular Member Atsushi Fukuda

1. INTRODUCTION

Recently, probe vehicle system, which accumulate positioning data using GPS has being expected as one of mobile traffic observation system. However probe vehicle system needs huge cost such as fixed cost to expand the number of probe vehicle and operation cost in order to estimate reliable travel speed. These costs depend on the number of probe vehicles. Therefore it is required to balance the reliability of estimated travel speed and costs (number of vehicles). The study proposed data collection system by not only probe vehicle system and V2V system.

V2V does not require central data server and transmission network because vehicle can send their positioning with time stamp to each other.V2V system can produce travel speed data estimated by V2V data transmission in each other.

If the data collected by V2V is sent to central data server by probe vehicle when probe vehicle pass though V2V vehicle, it has possibility to enhance number of data samples and improve reliability of estimated travel speed. The purpose of this study was to examine the possibility of travel speed estimation by integrating V2V in probe vehicle system. Travel speed estimation is verified by traffic simulation VISSIM.

2. Literature reviews

Kitazawa et.al. (2014) has shown the feasibility of travel speed estimation by using Bluetooth. They had conducted experimented study in urban expressway and loop road. Present conditions, Bluetooth can calculations representing value of travel time. Local road is count by ten minutes; urban expressway is count by fifteen minutes.

Wang et.al. (2006) studies that estimate travel time by probe data integrate in VICS data.

3. Proposal estimation method by PV and V2V

3.1 Estimation method

This study proposed advanced methodology to estimate average travel speed by integrating probe vehicles system and V2V system.

Fig 1 shows vehicle trajectory to explain methodology. There are two probe vehicles which are running to outbound, and one V2V vehicle running to inbound. Travel speed is estimated by the time difference and distance between two cross points where probe vehicle and V2V vehicle pass each other. At the cross points, V2V vehicle send its time stamp and position with vehicle ID. The PV send these data received from V2V vehicle to data center. The data center can calculate travel time using difference of passing time with vehicle ID.

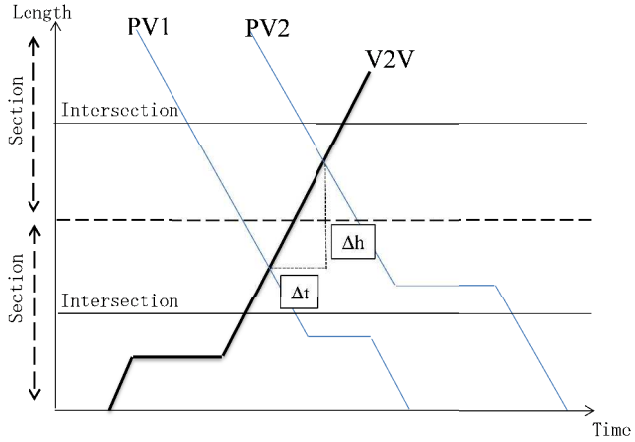

Fig. 1 Image of PV and V2V system

The average travel speed is estimated as a weighted average by using frequency table with 5km/h interval.

3.2 Micro simulation model

In this study, micro traffic simulation model is employed to verify new method. The road network which has one lane for each direction is shown in Fig.2.

Interval of intersection is 1km. Total length is 7km long road. Simulation time is 3600 seconds. The experiments are divided into 6 cases: Factor of variability is traffic volume and rate of probe vehicle and V2V vehicle.

The maximum transmission length between V2V and PV is 10m.

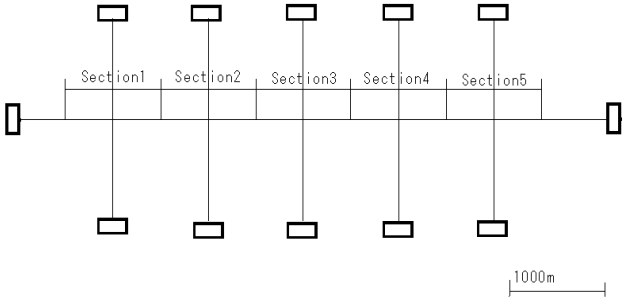

Fig.2 Micro simulation network

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Contact address: Dept. of Transportation Engineering and Socio-Technology, College of Science and Technology Nihon University739C,7-24-1,Narasinodai, Funabashi, Chiba 274-8501, Japan TEL/FAX 047-469-535

Table 1 Condition of each case

	Case1	Case2	Case3	Case4	Case5	Case6
Traffic value of main road	1000	750	500	1000	750	500
Traffic value of sub road	500	375	250	500	375	250
Traffic value of sub road	1000	750	500	1000	750	500
Rate of PV[%]	5	5	5	2	2	2
Rate of V2V[%]	25	25	25	10	10	10

4. Result

4.1 Numerical result

The travel speed data collected from all vehicles on VISSIM and estimated by the system of integrating PV and V2V are shown in Fig. 3. Both value is calculated as average and the former one means actual average speed to show actual traffic situation. In order to verify the accuracy of estimated travel speed, the error of estimated travel speed is calculated by subtracted the estimated travel speed from the actual average travel speed. And the relative error is calculated by dividing actual average travel speed by absolute of error. Table 2 shows number of sample on each cases, relative error, absolute value of error, average of coefficient variation. Fig.4 also shows coefficient variation of section. The coefficient variation is defined as following Eq. (1).

$$\text{C.V.} = \frac{\sigma}{\bar{x}} \qquad (1)$$

Here is

$\bar{x}$:average travel speed, σ : Standard deviation.

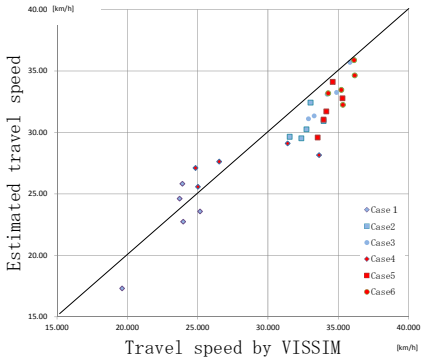

Fig.3 Result of estimation travel speed

Table 2 absolute of Error, relative error, coefficient variation

	Error[km/h]	Relative error[%]	Cofficient variation	Number of sample
Case1	1.60	7.03	0.44	2109
Case2	2.18	6.66	0.24	1654
Case3	1.33	3.93	0.20	858
Case4	2.33	7.79	0.30	440
Case5	2.47	7.24	0.17	329
Case6	1.55	4.39	0.16	97

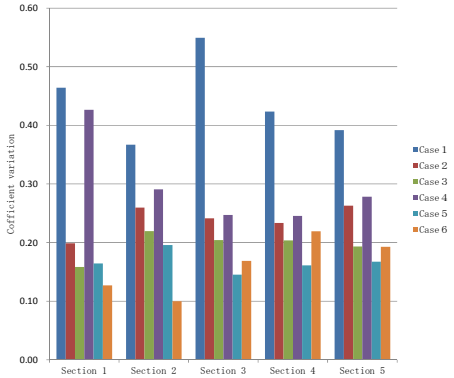

Fig.4 coefficient variation of each section

4.2 Considerations

The estimated travel speed has almost liner relationship with actual travel speed in Figure 3. As confirmed numerical results on table 3 and figure4, the accuracy is decreased as increase of relative error even in the case of high traffic volume compared with the case of low traffic volume. Accuracy is increased in the case of high rate of PV and V2V compared with case of low rate of PV and V2V. The reason why accuracy was dynamically changed is that the transition of traffic situation was changed between low and high through critical condition about speed and density. Especially in the case of low travel speed and low transmission rate, it was confirmed that these situation often occurred.

The C.V. in high rate of PV and V2V is lower than the low rate even if the traffic volume is increased and traffic situation is often changed. Therefore, if enough sampling rate is absolutely gained, the variation of traffic situation can be captured by PV and V2V system.

5. Conclusion

This paper proposed new method to estimate travel speed using integrating probe vehicles system and V2V system.

As the result of simulation, high correlation between actual travel speed and estimated travel speed, is achieved even in the case of low transmission rate relatively.

Number of transmission between PV and V2V vehicle is depending on traffic volume, rate of PV and V2V vehicles. However, it might be difficult to get enough sampling if traffic volume and rate of PV and V2V vehicles.

For the future study, the following items are planned to be studied to improve the proposed methodology.

- Effect of transmission characteristics.
- Adaptation to multi-lane road.
- Capability to collect other traffic information.
- Improvement to accuracy of estimated travel speed considering various traffic conditions.

Reference

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