Searching for Links with Fluctuating Travel Time in Sapporo City

Hokkaido University　○Student Member　Kam Cheong Choy
Hokkaido University　Regular Member　Takashi Nakatsuji

1. INTRODUCTION

In transportation field, travel time becomes one of the most important factors for road users. Since drivers can realize the road situation from travel time, clear pictures can be figured out for their trips. Based on the travel time information, road users can predict their trip time.

In Sapporo city, the taxis probe data system has been deployed in June, 2008(1). Now, there are total 1700 taxis probe which are under running in this city (1). Theses taxis can provide probe data and these taxis keep collecting the data and the accumulated data send to the traffic center per 5 minutes.

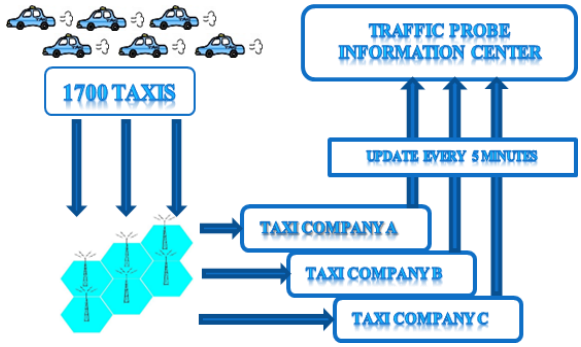

Fig.1 Transition process of probe data

This data is providing us the link travel time which is defined as the used time from one upstream intersection to next downstream one. Therefore, it cannot avoid the influence due to traffic signals in urban road network. Hence, this kind of travel time data is quite fluctuated due to the influence of intersection delay. Besides, the longitude and latitude of that upstream intersection as well as that of that downstream intersection are also provided to us so that the begin node and end node of any specific link can be known. Moreover, based on these longitudes and latitudes, the length of any links can also be calculated.

However, in general, since it is impossible to provide a huge amount of taxis probe for obtaining abundant data, these taxis probe cannot provide full set of data for every individual link in each time period. Hence, it cannot be avoid that missing data occurs in the data set. In this study, the influence of missing data is ignored and the existing data is used only.

2. OBJECTIVE

The objective of this study is to:

a) Search for the links with fluctuating travel time

3 STUDY AREA

Since the main objective of this study is to look for the links with fluctuating travel time, some main roads in Sapporo city are chosen for searching uncertain travel time.

The selected roads in this study can be basically classified as general, urban and national roads. The name type, direction and length of each selected road are listed in the following figure and table.

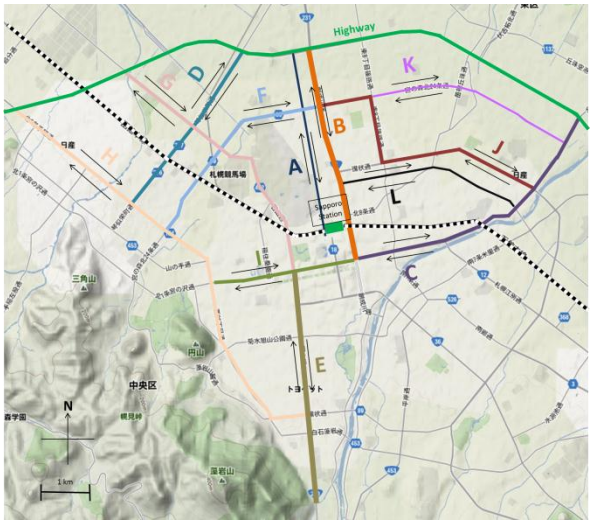

Fig 2 Notation of selected road in Sapporo city

Table 1 Name and type of the selected roads

Name	Type of Road	Bound for	Length (km)	No. of Links
A-s	General	South	2.98	48
A-n	General	North	2.89	47
B-s	National	South	3.59	45
B-n	National	North	3.48	52
C-e	National	East	6.93	46
C-w	National	West	6.93	46
D-s	Urban	South	3.95	59
D-n	Urban	North	3.95	59
E-s	National	South	3.78	64
E-n	National	North	3.78	64
F-e	Urban	East	5.01	55
F-w	Urban	West	5.30	60
G-s	Urban	South	6.12	73
G-n	Urban	North	6.12	73
H-s	Urban	South	10.25	90
H-n	Urban	North	10.26	144

I-e	Urban National	East	5.64	52
I-w	Urban National	West	5.64	52
J-e	Urban	East	5.01	51
J-w	Urban	West	4.87	51
K-e	General	East	4.082	29
K-w	General	West	4.085	29
L-e	General	East	6.92	76
L-w	General	West	6.97	77

The reason of choosing these roads is that they are passing through or closed to the downtown area in Sapporo city. It can be believed that fluctuation travel time is probably happened for these roads.

Besides, during searching for the links with uncertain travel time, a whole month data in November, 2009 totally has 30 days data which is including weekdays, weekends and holidays in this month.

4. SEARCH LINKS WITH FLUCTUATING TRAVEL TIME

4.1 Definition of "links with fluctuating travel time"

The definition of fluctuation can be quite abstract and diverse depending on different people. Therefore, a concrete definition is clarified numerically in this part.

In this study, travel time is assumed to be normal distribution. The mean and standard deviation of travel time are calculated based on the whole month data and the missing data is ignored during calculation. Therefore, if the travel time falls into the stable region in **Fig 3**, i.e., $Z_1 < Z < Z_2$, the travel time is treated as stable travel time.

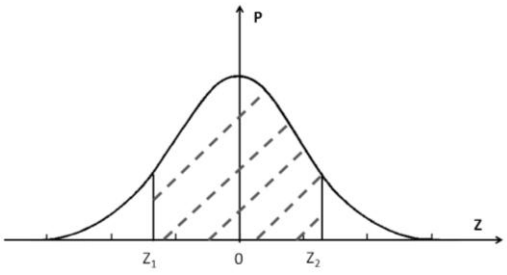

Fig 3 Probability of stable range

However, it cannot say that the link is uncertain and has fluctuation travel time if less amount of the travel time being out of the stable range. Therefore, another assumption is made. If percentage, let say fluctuation percentage, $\mathbf{P_{flu}}$, of the probe travel time data is out of the stable range, it is classified as "link with fluctuating travel time".

4.2 Set up

Two case studies are going to be done in this study.

(1) For Case 1, by fixing P_{flu} = 0.1, assuming the probability that the travel time falls into a stable range to be 0.6, 0.7, 0.8 and 0.9, the percentage of number of links with fluctuating travel time can be found and the variation of that percentage can be understood. By referring to the following table, the stable range for the corresponding probability can be obtained.

Table 2 Different stable range corresponding to various probabilities

Probability, P	Stable Range
0.6	-0.84 < z < 0.84
0.7	-1.035 < z < 1.035
0.8	-1.28 < z < 1.28
0.9	-1.645 < z < 1.645

(2) For Case 2, by fixing P = 0.8, changing P_{flu} to be 0.06, 0.08, 0.10, and 0.12. The variation of percentage of links with fluctuating travel time can be observed.

4.3 Result

(1) Case 1

The percentage of number of links with fluctuating travel time is plotted for change the probability in the following.

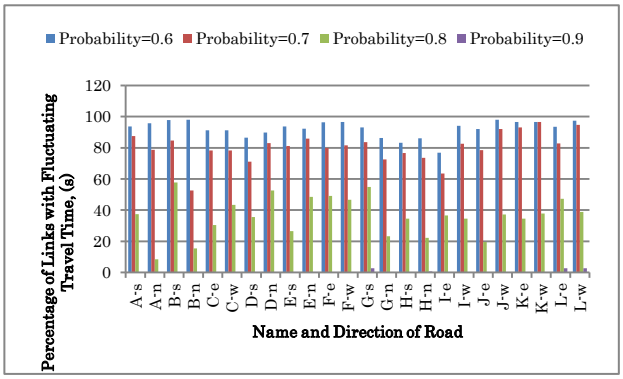

Fig 4 Number of Fluctuating and total links vs. name and direction of roads

By looking at **Fig 2** and **Fig 4**, some interesting issue can be noticed. For all the cases, as the road direction is pointing to downtown area such as Road A-s, B-s and C-w etc., the percentage of number of links with fluctuating travel time is higher than the same road but pointing to the opposite direction. It can be stated that this situation is induced by the higher amount of vehicles passing through the downtown area in Sapporo city. Besides, when the probability equals to 0.9, almost all the travel time falls in the stable range. While the probability equals to 0.6, almost all of the roads have more than 80% of links with fluctuating travel time. Besides, it can be noticed that when P is changed from 0.7 to 0.9, the variation of percentage of links with fluctuating travel time is varied dramatically.

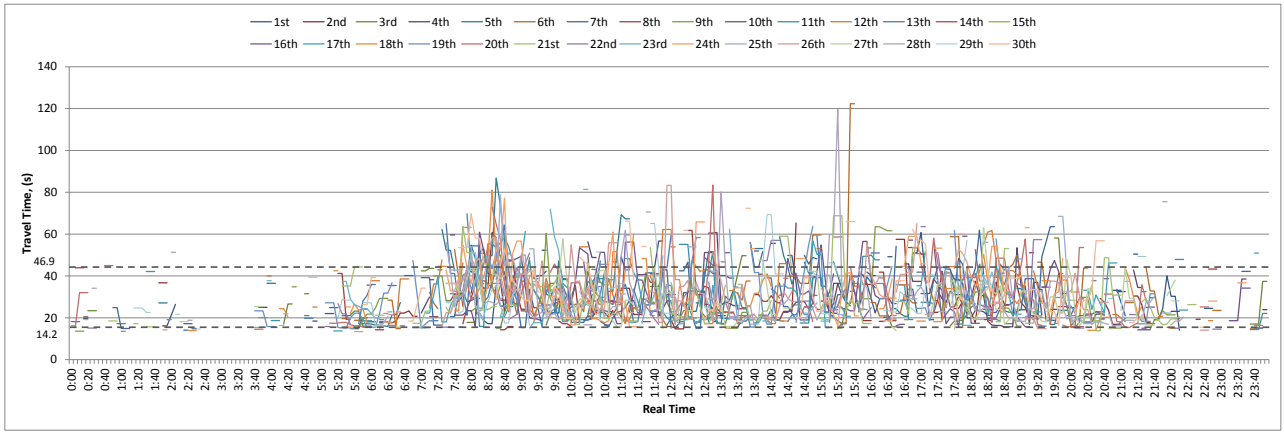

Fig 5 Travel time vs. real time for different date in November, 2009 of selected link

(2) Case 2

The percentage of number of links with fluctuating travel time is plotted for changing the P_{fluc} in the following.

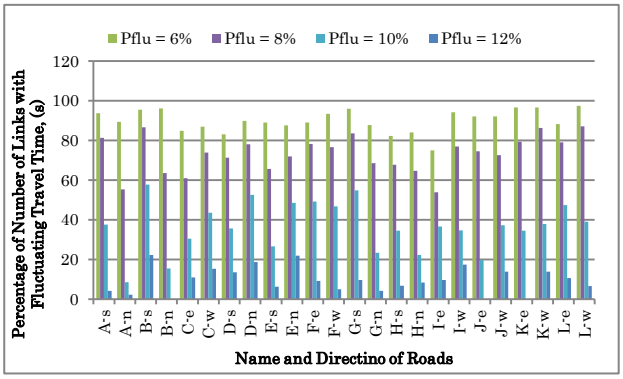

Fig 6 Number of Fluctuating and total Links vs. name and direction of roads

From **Fig 6**, it can be noticed that the dramatic change of percentage of number of links with fluctuating travel time is starting from P_{flu} = 8%. When P_{flu} = 12%, the percentage of number of links with fluctuating travel time for all of the roads is less than 20%. Therefore, for 8% < P_{flu} < 12%, the number of links with fluctuating travel time is varied a lot.

4.4 Profile of travel time fluctuation

From **Fig 4**, when P = 0.8 and P_{flu} = 10%, the highest percentage of number of links with fluctuating travel time over an entire road is Road B bound for south direction. Therefore, Road B-s is chosen as an example for interpretation.

One link along Road B-s is chosen for plotting travel time variation figure. The location of this link is shown in the following figure.

The length of this link is about 230 m which is long enough to reflect the fluctuation of travel time in urban road network. Besides, there is a traffic signal in the upstream and downstream of this link, respectively. Therefore, this link can be represented the fluctuation situation of travel time. In the following, the variation of travel time for whole month is plotted.

The mean and standard deviation of this link is equal to 30.55 and 12.74 second, respectively. In accordance with these two values, the stable range of travel time can be calculated. Hence, the stable minimum and maximum travel time are equal to 14.2 and 46.9 second, respectively. These two values are plotted in **Fig. 5** for knowing how serious the fluctuation of travel time is. From **Fig. 5**, it can be noticed that a lot of travel time is out of the stable range over different time period. When focusing in the stable range, it can also be noticed that the travel time is still fluctuating seriously. Besides, before 7:00 and after 21:00, the travel time data becomes missing. Therefore, the filling up of this missing data is necessary. The method is introduced in next section.

5. CONCLUSION

In this study, the probe vehicle data for providing link travel time in Sapporo city is introduced. Since intersection delay must be happening in urban road network, the travel time may be fluctuated a lot. By clarifying the definition of “fluctuation” numerically, searching for links with fluctuating travel time for some roads in Sapporo city is down. The reason for choosing these roads is that they are passing through or closed to the downtown area in Sapporo. From the searching result, as the direction of the roads pointing to downtown area, the number of links with fluctuating travel time is obviously greater than the same road but the direction being outgoing from downtown area.

6. REFERENCE

[1] *札幌圏商用車プローブ実用化検討会活動報告書.* Sapporo. (2011).