DATA FUSION OF VICS AND PROBE TO REDUCE UNCERTAINTY OF TRAVEL TIME INFORMATION

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ABSTRACT

This research aims to present the effect of data fusion of probe and VICS travel time information. VICS, which is so-called Advanced Travel Information System in Japan, collects link travel time based on loop or ultra-sonic detector speed, and updates travel time information every 5 minutes via on-board navigation system. However, it provides travel time information only for highways and major arterial roads on which detectors are installed, and assumes constant travel times for other miscellaneous links. When the major roads are jammed by heavy traffic, it can be happen that VICS navigation system will mislead a driver to the route consisting of minor roads of which the traffic conditions are uncertain and can be severe as well as the major roads. On the other hand, probe or floating car data collection system attracts considerable attention to survey the travel times of links widely over a city. At this moment, even though the frequency of data updating for link travel times with probe system would not be so high, we can utilize the probe data to spatially complement VICS data, in order to reduce the uncertainty of travel time information. In this paper, the methodology of data fusion proposed here will be explained at first. In the second part, the practice using real VICS and probe data collected in Nagoya-city will be presented to demonstrate the effect of data fusion.

INTRODUCTION

This research aims to present the effect of data fusion of probe and VICS travel time information. VICS, which came into operation from 1996, is so-called Advanced Travel Information System in Japan. VICS collects link travel time based on loop or ultra-sonic detector speed, and updates travel time information every 5 minutes via on-board navigation system.

However, a couple of shortcomings are pointed out to VICS. At first, it covers only highways and major arterial roads (VICS links) on which detectors are installed. As shown in Figure 1, VICS links sparsely cover the network, comparing with full links in Nagoya-city area. If someone starts his/her trip to destination, he/she will use not only major roads but also minor roads for access and egress, which sometimes may be in severe traffic conditions. A demand for the informative service including those minor roads seems to be large.

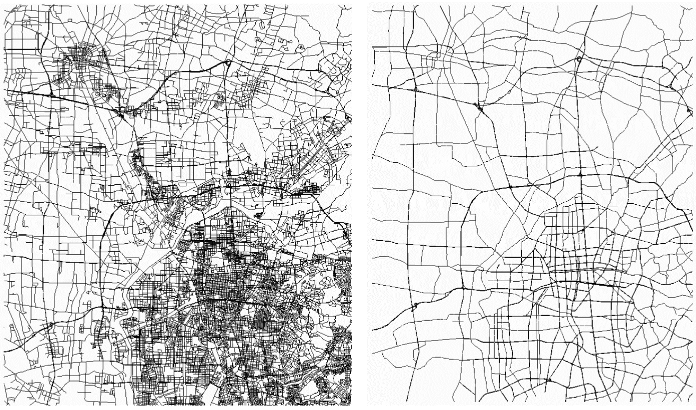

Figure 1. Full links (left) and the VICS links (right) in Nagoya-city area.

At second, it has to estimate link section travel time from detector speed at one point. Some models, such as simple queuing model, will be required for the estimation, but it is difficult and costly to calibrate those models well in long term. Moreover, detector speed can not distinguish vehicles' turning movements. Therefore, VICS only provides link travel time by assuming straight through direction.

Considering these shortcomings, we may regard even a driver using VICS is facing uncertainty of travel time information. It can be happen that VICS misleads a driver to worse situation than the driver without VICS information when the minor roads out of VICS links are severely congested, because most of on-board navigation system assume constant and moderate travel speed for those minor roads.

In order to provide much reliable travel time information, it is expect to merge prove information into VICS. Against to VICS, probe data can be collected on every roads that vehicles may run. It directly measures section travel time along the path of a probe vehicle by including the delay at left/right turn. Still we can not expect high frequency of updating travel time with probe at present, we may utilize stored probe data and extract statistical information among them.

In the following chapter, we will report the practical study for the data fusion of VICS and probe travel times. The concept and the methodology of data fusion will be explained at first. In the second part, the practice using real VICS and probe data collected in Nagoya-city will be presented to demonstrate the effect of data fusion.

CONCEPT OF DATA FUSION OF VICS AND PROBE DATA

The methodologies of data fusion proposed here take two ways, correction of VICS link travel times and spatial complement to VICS links with stored probe data. The concepts of these two methodologies are described in the subsequent sections.

Correction of VICS Link Travel Times with Probe Data

The popular way to estimate the travel time of a VICS link is so-called 'sandglass' method, which counts the number of vehicles at the upstream of the link as the traffic demand. By assuming the parameter of a reasonable flow rate at the downstream section of the link, the method calculates the average travel time with simple queuing theory.

It is obvious that the accuracy of the traffic counts and the flow rate will strongly affect on the reliability of the estimated travel times. In practice, however, it is the case that the assumed flow rate is different from the actual value or that the measured traffic counts include errors by some reasons from maintenance works. Since it will be very costly to seek the perfection to maintain the sensors and the parameter values, we may permit some errors in VICS travel time information whatever the magnitude of errors are not acceptable.

In order to correct the errors in VICS link travel time, VICS data is to be compared with stored probe data that is reasonably cleansed to measure link travel times (Sarvi, *et. al*, 2002), as shown in Figure 2. Each plot in the figure represents VICS link travel time at the same time when a probe vehicle passes through the subject VICS link.

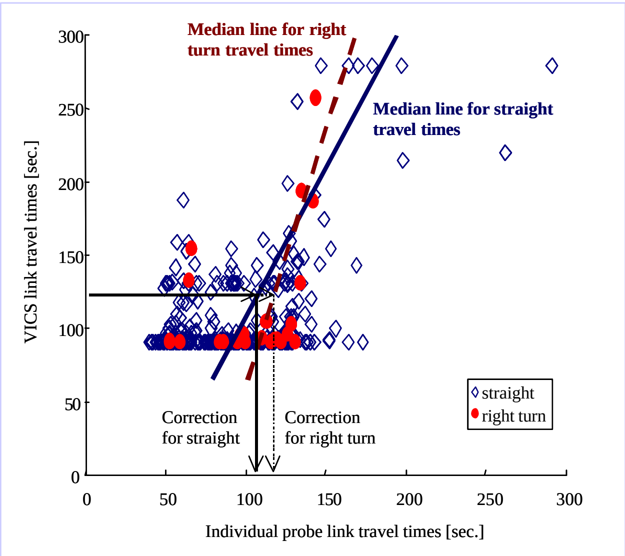

Figure 2. Correction of VICS link travel times with stored individual probe data.

Even though the variation of 'individual' probe travel times is larger than VICS travel times, we may derive some relationships from the comparison to be used for the correction of VICS data. In Figure 2, we derived two liner regression lines to the 'median' plots which provide median values of prove travel times for every 30 second range of VICS travel times. Since the turning movement at the downstream intersection is given to each probe travel time, we may obtain the correction line not only for straight but also right or left turn. When a certain value of link travel time is provided by VICS, different travel times will be provided according to the turning movement at the intersection by using this method.

Spatial Complement to VICS Links with Probe Data

As shown in the right picture of Figure 1, most of the minor roads are not designated as VICS links. However, considerable number of VICS links are not given travel time information because of the reason that they have no traffic detector on themselves and so on. Table 1 shows the total length of links in terms of information provision types in Nagoya-city. It is found that only 4% out of whole links are provided travel time information, and we have to estimate the travel times for the rest of 76% links by not using VICS.

Table 1. Total length of links for each information provision type (Nagoya-city).

Type	Description	Total length	%
1	VICS link with travel time information	400 km	4%
2	VICS link without travel time information	2,150 km	22%
3	Non-VICS link	7,000 km	74%

In this research, timetables of expected travel times are derived from the historical probe data for the links without VICS information. Figure 3 illustrates an example that contains the expected link travel times of certain non-VICS link for every 15 minutes. Even though the derived timetable is static and cannot consider the daily traffic condition, it still reveals that the profile of the travel time has two peaks in the morning and the evening. This timetable helps to make the travel time information be reliable, rather than by assuming constant speed.

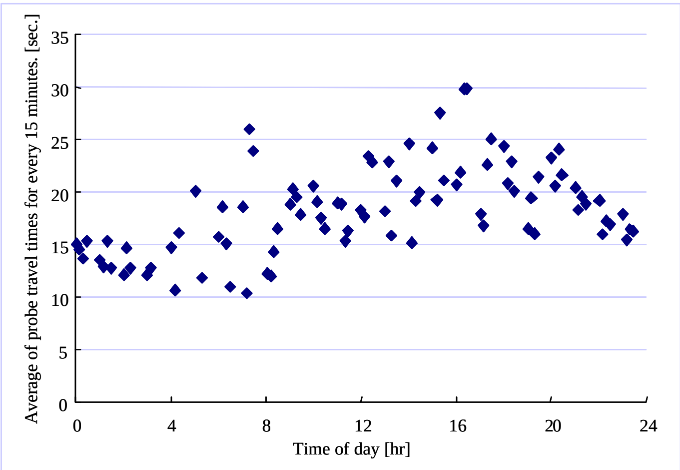

Figure 3. Timetable of expected travel times for a non-VICS link.

PRACTICE OF DATA FUSION USING REAL VICS AND PROBE DATA

In order to demonstrate the effect of data fusion, two sample path as shown in Figure 4, which start from Nagoya-city and goal to Ichinomiya-IC, is selected. The distance from start to goal is approximately 13 km. VICS link travel time is provided to the section of 2.4 km along Path-1, while no VICS link travel time is provided to Path-2.

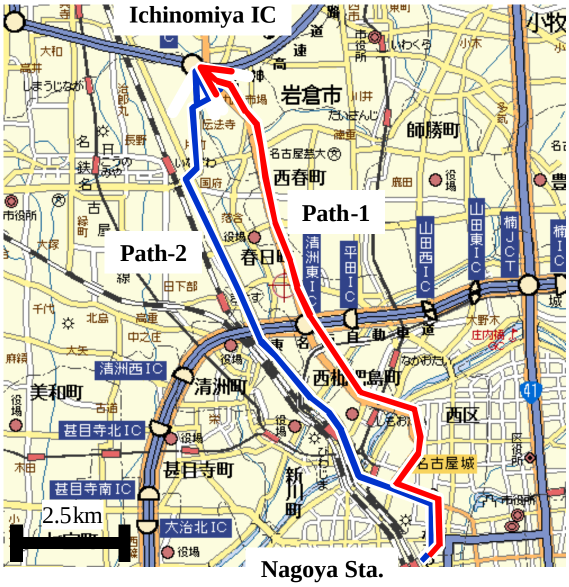

Figure 4. Sample path to demonstrate the effect of data fusion.

Figure 5 compares the travel times of the two paths for every 15 minutes on a certain day. The left picture shows the travel times using only VICS information. As we assume constant travel times for non-VICS links and VICS links without information, the travel times of Path-2 are always the same. Although the change in the travel time of Path-1 is moderate, the graph says Path-1 always faster than Path-2.

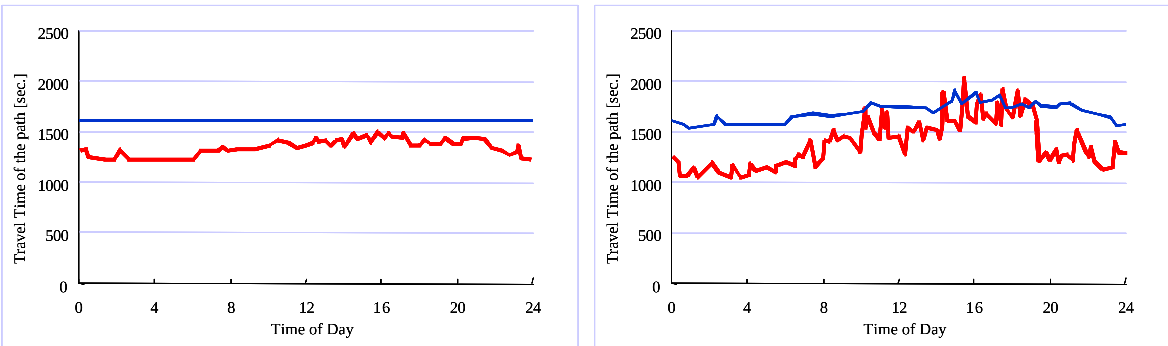

Figure 5. Comparison of path travel times (left: only VICS data, right: data fusion)

On the other hand, the right picture shows the travel times calculated by the data fusion method proposed in this paper. The changes in the travel times now become more conspicuous than the left picture. The difference of travel times between Path-1 and Path-2 gets larger during the off-peak, and are almost equal to each other at the peak period. The result of data fusion seems to be more realistic than the result with only VICS data.

CONCLUSION

In this paper, we described the concepts and the processes of data fusion with VICS and probe link travel time data. Imagine a driver who provided the path travel times based on the left graph in Figure 5 at peak period, he/she will tend to choose Path-1 that looks faster than Path-2. However, provided the data fusion travel times in the peak period, he/she may aware both Path-1 and Path-2 are congested as much as each other, and the result of path choice behavior will never be the same as the previous case. Indeed, let us conclude that the data fusion can reduce the uncertainty of travel times and increase the reliability of the network.

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