TRAFFIC INFORMATION SERVICE IN ROAD NETWORK USING MOBILE LOCATION DATA

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SUMMARY

The purposes of this study were to observe mobile location data for a road network continuously, and to apply the data to a system providing a dynamic traffic information service. A method of collecting location data using mobile communication devices is described. The proposed method is examined using experimental data. A field test in an actual network was used to examine the validity and practical limitations of the proposed method, and confirmed that mobile location data can be applied to a road traffic information service. The proposed method can overcome problems of existing road traffic information systems that depend on traffic conditions determined at fixed observation sites. Mobile location data will make it possible to provide more dynamic and precise traffic information without a large investment in road facilities.

INTRODUCTION

In recent years, location positioning technologies using mobile communication devices have developed rapidly. Several different types of mobile location services have been developed. It is expected that advanced traffic information systems that use real time location data on mobile users can be developed [1-3]. A traffic information system based on mobile devices has the potential to provide more dynamic and accurate traffic information than existing traffic information systems, which determine traffic conditions at fixed observation points. A mobile system can be completed without large infrastructure investment in road facilities. The rapid spread of mobile communication devices, such as cellular phones, will accelerate expectations for a traffic information system supported by mobile communication systems that collect data and provide information.

The goals of this study are as follows:

1) To summarize the trends in and current status of mobile location services, and to identify problems in applying mobile technologies to traffic information systems.
2) To collect and analyze location data.
3) To develop a method of transforming the location data into traffic information for a road network.
4) To verify the proposed method in an actual road network.
5) To develop an application program to provide traffic information, and to discuss the tasks to realize this goal.

The remainder of this paper describes 2) to 5) in detail.

DATA COLLECTION AND TRANSFORMATION

Data Collection Methods using Mobile Devices

There are two types of technology for collecting location data using mobile devices. One is based on GPS (Global Positioning System) and the other is based on a cellular phone system like PHS (Personal Handy-phone System). The location accuracy of GPS is improving and data communication is becoming possible by connecting GPS with cellular phones. It is well known that GPS is not available in underground areas and that its accuracy decreases near high-rise buildings. A PHS-based location system specifies location positions using the signal strength at multiple base stations [4)]. Both GPS- and PHS-based systems require communication with a center, where the location data is transformed into traffic information. A GPS-based system can be used with cellular phones [5)], while the PHS-based system has its own communication capacity.

Transformation of Location Data into Network Information

Temporal and spatial location data are converted into link information, and then into road network traffic information.

<u>Temporal continuity</u>
An object, such as a vehicle or a passenger, moves in time and space continuously. Locations are discrete in time, since the object is observed at a given time. When several vehicles are moving on the same street, they are observed independently and may be observed at slightly different times. Consequently, the location data for those vehicles may be scattered in time and space. In order to derive smooth traffic conditions, the position data for individuals within a time interval must be aggregated.

<u>Transformation to network information</u>
The continuous location data obtained are plotted on a road network. Then, they are transformed to link and network information. The transformation process is shown in steps 0-3.

Figure 1 outlines each step.

<step0> Input data
There are two kinds of input data. One is a series of location data and the other is the route data calculated using a route specification algorithm [6]. The notation for the network, location, and route data are shown below.

- *Network data*
  Ln{Nr, Nr'}: the number of links connecting node r and node r'.
  Nr{Xr, Yr}: the position of node r.
  Xr, Yr: X and Y co-ordinates of node r.

- *Location data*
  Pi{Ti, Xi, Yi}
  Ti: time at which i is observed.
  Xi: X co-ordinate of point i.
  Yi: Y co-ordinate of point i.

- *Specify route data for 1 trip*
  R{O-P, N1, N2, ... Nr, ...D-P}
  O-P : origin position of the trip
  D-P : destination position of the trip
  Nr : node r along the route.

<step1> Set the passage time at each node along the route.
Search the position data within a radius R of each node along the route. The radius R is determined by the accuracy of the mobile location device. The node passage time depends on the number of points within this circle.

[case1] Only one point inside the circle
The passage time of the node is the same as the observed time of the point.

[case2] Two or more points inside the circle
These points are assumed to represent waiting at a stop signal. The passage time of the node is set as the observed time of the last point.

[case3] No points inside the circle
A straight line is drawn from the last point to the next point of the node. A perpendicular line from the node is then dropped to the line connecting the two points. Then, the passage time is calculated due to the ratio of the distance to the point of intersection. If the case 3 persists, corresponding nodes are calculated at once.

<step2> Make link information from the passage time for each node.
Using the passage time for all the nodes on one trip, derive information on the interval between nodes, namely the link. The link information consists of the time required to travel between nodes and the average velocity.

<step3> Derive road traffic information from the link information.
Collect the link information for each user and filter it for all links. Store the trip data in a database for data-mining.

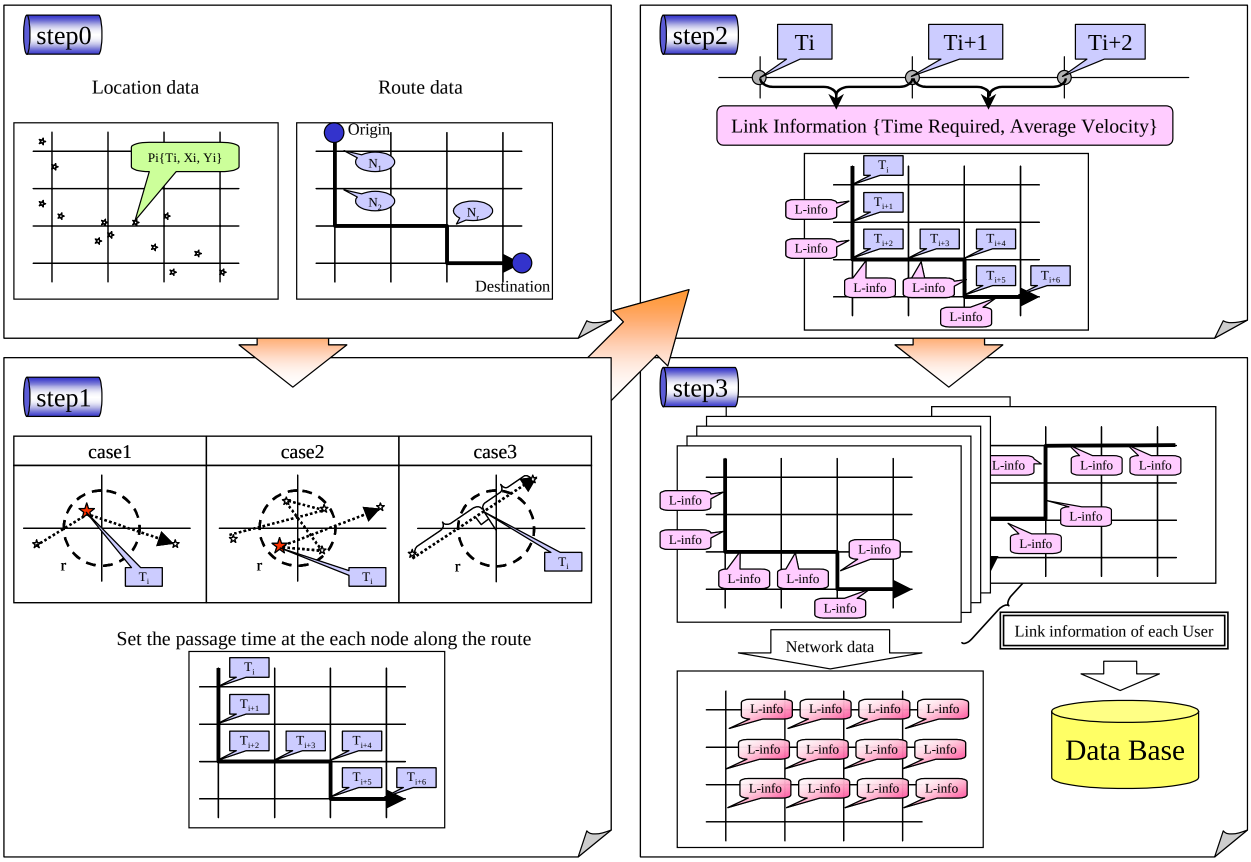


Figure 1 Location Data for Traffic Information in a Network

EXPERIMENT AND VERIFICATION

Data Collection

The proposed transformation algorithm is independent of the data collection device. Any mobile communication device, such as PHS or GPS, can be used as a data collection device if it has a location positioning function. The algorithm is also independent of the type of road network, including factors such as the network configuration, density, and so on.

In order to test the proposed algorithm, we collected location data under the following conditions. A simple GPS device was chosen for data collection, as this is suitable in both cities and rural areas. Downtown Osaka was selected as the test site, since the network is dense and traffic congestion could be observed.

- Data collection device: GPS (Garmin GPS2 Plus)
- Date and time of investigation: Monday 12 June 2000, 10:30-12:00

- Test site, route, and distance: Downtown Osaka, from Midousuji (Osaka City Hall) to Chuo-odouri (The Chuo Ward Office), route distance 2.4 km.

The location data were collected at 15-second intervals. A VTR recording with a time function was made along the route in order to calculate the true travel time between intersections. The VTR data were used as a reference for verification.

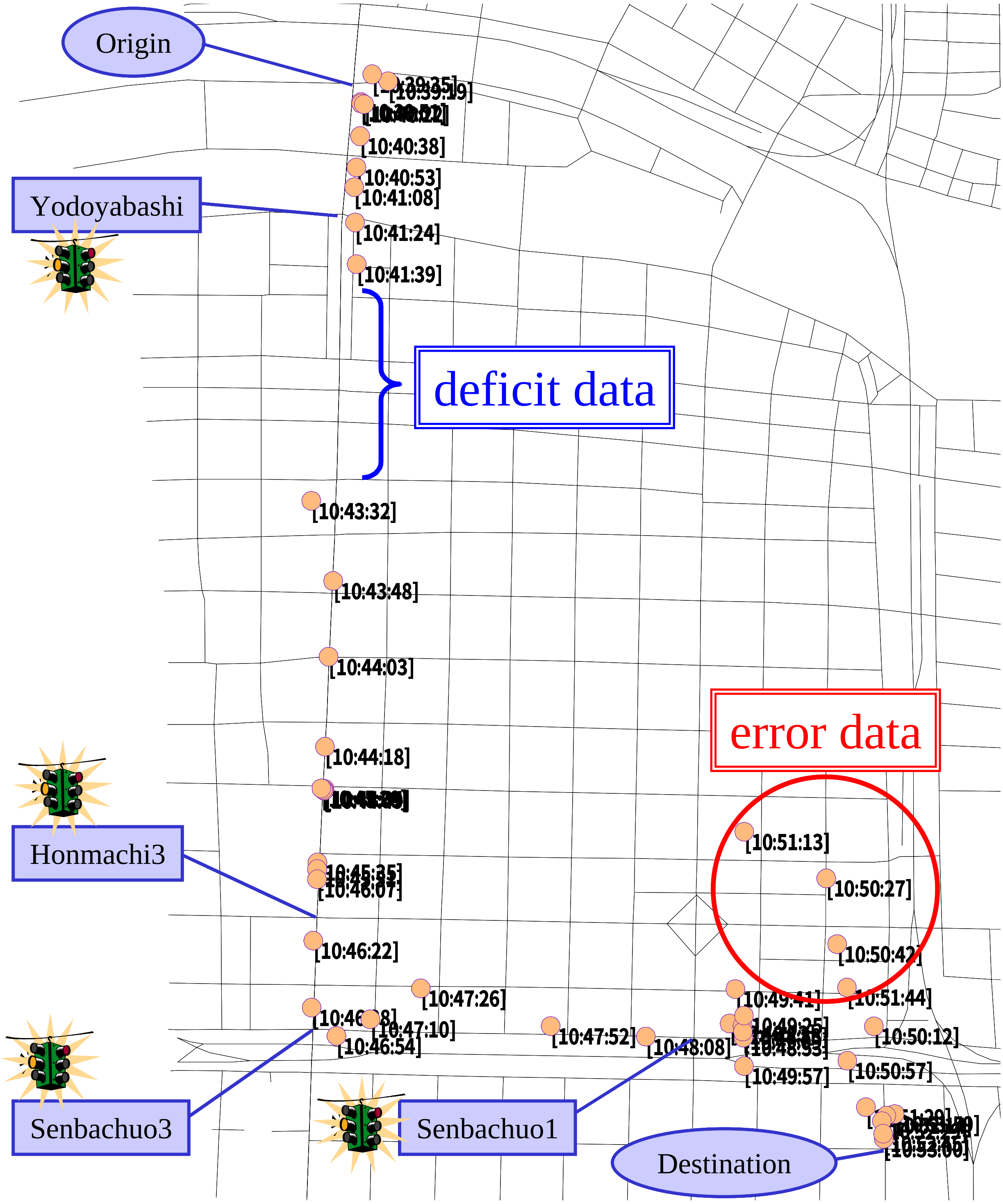


Figure 2. Aspects of Location Data

Characteristics of the Location Data

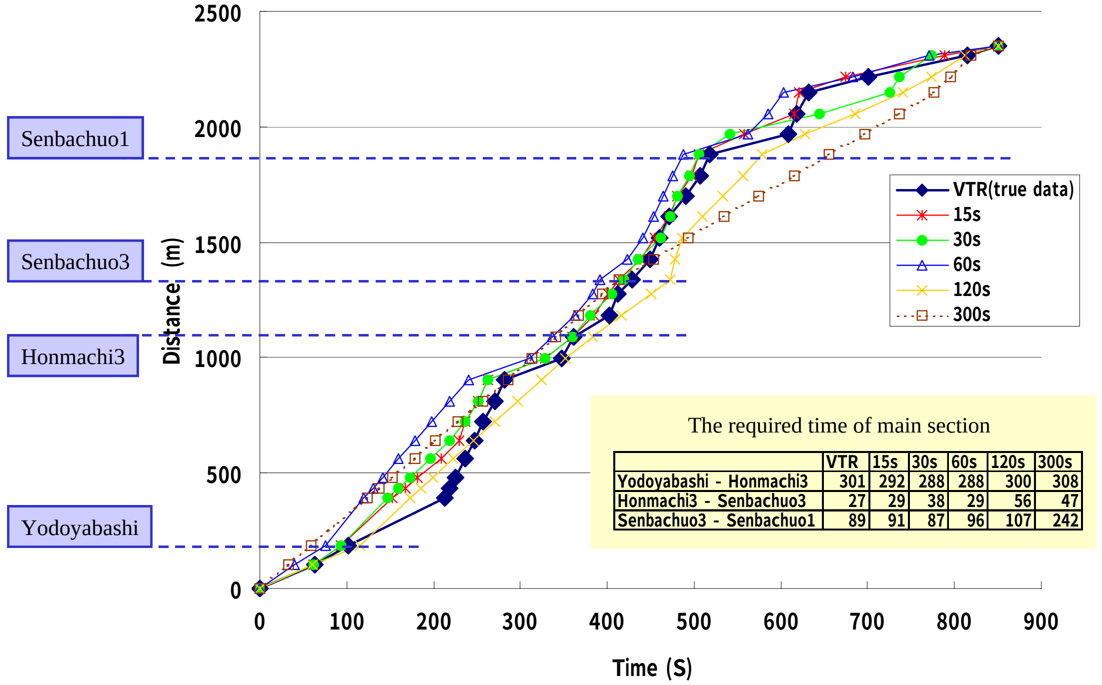
Figure 2 shows the GIS plot of the collected location data in the network. During the experiment, traffic was moving smoothly and it took 13.4 minutes to drive the selected 2.4-km route by car. Since there are several intersections with stop signals along the route, the average speed was 10.6 km/h. The collected location data showed some spatial disturbance. For example, location data could not be collected for about 2 minutes from 10:41:39 to 10:43:32, and there were some hidden points near the destination, since roadside buildings or dense high trees can disturb the GPS signal. However, it was possible to specify the journey route. The actual route was identified exactly using the route specification algorithm developed by our research group [6].

Link Travel Time

Using the continuous location data, we estimated node passage and link travel time for a test vehicle in a network. Five different time intervals (15, 30, 60, 120, and 300 seconds) were examined in order to find the best interval for estimating travel time. Location data were observed every 15 seconds, and the other four cases were generated from this data.

Figure 3 compares the time-distance diagrams for the test vehicle. The estimated time-distance diagrams are consistent with the observed route when the measurement interval is less than 60 seconds. This implies that it is necessary to collect location data at least every 60 seconds. It is then possible to reproduce the link travel time in a high-density downtown road network.

The estimated travel times between adjacent major intersections were also consistent with the observed times when the measurement interval was less than 60 seconds. The differences in travel time are less than 1 minute. This implies that link travel time information can be estimated from mobile location data using the proposed transformation algorithm.



	VTR	15s	30s	60s	120s	300s
Yodoyabashi - Honmachi3	301	292	288	288	300	308
Honmachi3 - Senbachuo3	27	29	38	29	56	47
Senbachuo3 - Senbachuo1	89	91	87	96	107	242

Figure 3. Comparison of the Time-Distance Diagrams for a Test Vehicle

PROSPECT OF PROVIDING TRAFFIC INFORMATION

Usefulness of Mobile Location Data

This paper demonstrates the possibility of using mobile location data to obtain road traffic information. This road traffic information is superior to present road traffic information obtained using fixed-point observations. The advantages of the new system based on mobile location data are as follows:

- It is possible to provide road traffic information using point-to-point travel data, which are not available in present systems.
- It becomes possible to provide more dynamic and optimal route information.
- A large investment in roadside facilities is not necessary.
- Application service connected with the mobile service is expected.

Application to a Traffic Information Service System

The ultimate goal of this research is to provide dynamic road traffic information. To realize such an application, we plan to use the strategy shown in Figure 4.

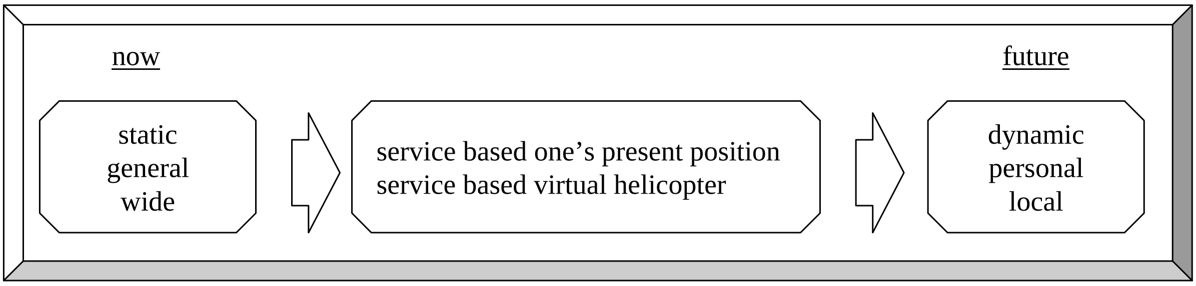


Figure 4. Strategy for obtaining Road Traffic Information based on Mobile Location Data

Future Topics

The following topics need to be examined to realize the information service just described.

<u>Technical topics</u>

- Generalization of the methodology through experiments.
- Development of a method to screen invalid data.
- Sampling problem in comparison with the population of network users.

<u>Other topics</u>

- Project evaluation including communication costs.
- Integration with the other value-added municipal services.

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