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“Technical Research and Development for Road Policy Quality Improvement”
Study Summary

No.	Title	Principal Researcher
No.28－2	Development of hierarchical database for efficient use of historical vehicle trajectory data	Takamasa Iryo (Professor, Kobe University)

Although the potential value of vehicle trajectory data, which has been accumulated in recent years, is large, the size of such data can be very huge and, sometimes, with poor quality. Hence, it is clear that dealing with these data in a naive manner leads to premature failure. In this research, we construct a hierarchical vehicle-trajectory database for large-scale trajectory data, which can also manage quality of data. We then show its case-studies of its application.

1. Backgrounds and Objects

The purpose of this research is to construct a hierarchical vehicle-trajectory database for large-scale trajectory data, which also can manage quality of data, and shows case-studies of its application. In recent years, continuous acquisition of movement trajectories of individual vehicles has become technically easy, and such data has been continuously accumulated by e.g. ETC 2.0. However, the amount of such data is enormous, and the quality is not always what can be expected, so it is clear that dealing with these data in a naive manner leads to premature failure.

In order to solve quality problems, it is necessary to verify the degree of quality of trajectory data and develop methods to complement or manage deterioration of quality. Meanwhile, although the aggregation operation is effective to solve the volume problem, the aggregation is also an operation that impairs the high resolution of both time and space, which is the most distinctive feature of the vehicle-trajectory data. Hence, it requires careful attention in its implementation. However, no research has been found under the present circumstances to discuss how to aggregate vehicle travel paths based on such awareness of problems.

2. Activities in Research Period

We conducted research on the following three themes:

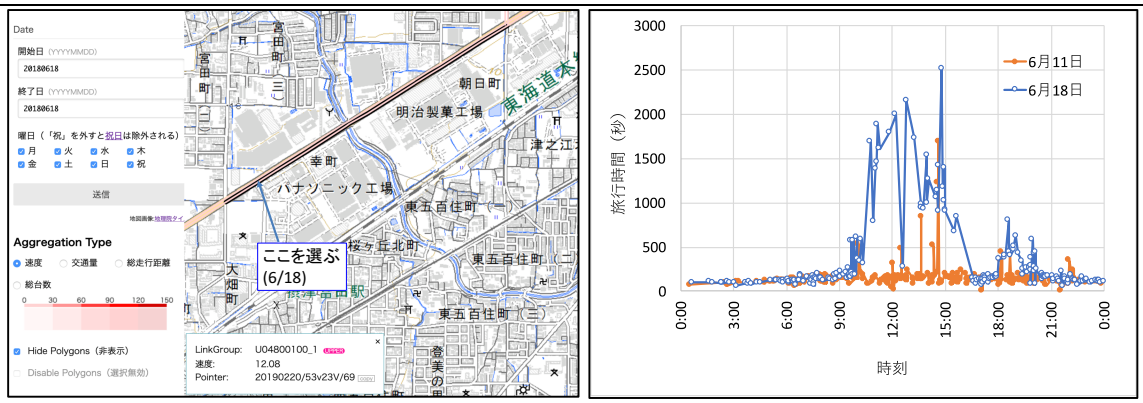
[Theme 1: Quality verification and improvement] We quantitatively verified how much the actual quality of the vehicle trajectory data has deteriorated from the ideal level and evaluate how it affects data analysis. At the same time, we developed a methodology to improve or control the quality.

[Theme 2: Aggregation] We first analyzed statistical characteristics of actual vehicle-trajectory data. Based on that, we developed a methodology of appropriate aggregations.

[Theme 3: Implementation of hierarchical DB and case study] We implemented hierarchical database using the results of themes 1 and 2, and performed case study using it.

3. Study Results

In theme 1, various statistics are compared with the data of road traffic census for ETC 2.0 probe data etc. to evaluate the quality. We especially pointed out problems with bias of sample rate. There are two main causes of sampling rate bias: different penetrate rate of in-vehicle devices in different regions in the country, and loss of data on vehicles that do not pass ITS spots. In theme 1, in order to examine the quality of the vehicle trajectory data and to examine the improvement method, an on-road survey of vehicles equipped with ETC 2.0 and GPS terminals is also conducted in Matsuyama City. Using this result, accuracy of map-matching was evaluated and improved, and it was also confirmed that there are vehicles for which ETC 2.0 probe data can be easily obtained and for vehicles that cannot be easily obtained. In theme 2, first, existence of strong heterogeneity of road network and vehicle trajectory data was confirmed. We utilized it to propose a method of hierarchizing networks into upper and lower networks. For the upper network, we developed an effective reduction method of its structure. Lower networks are aggregated in area units. Using ETC 2.0 data, it was shown that the proposed method can reduce the amount of data by 70% or more.



Screenshot of GUI for operating the hierarchical database (left). Example of analysis of traffic congestion at the time of June 18, 2018 northern Osaka Prefecture earthquake. Selecting the upper network link on the screen, it is possible to immediately obtain vehicle data. The right is a graph of travel time of that link.

In theme 3, we constructed hierarchical databases and conducted case studies using the hierarchical database. The hierarchical database implemented in this study dramatically improves the efficiency of vehicle trajectory data extraction. In the past, it took much effort just to get the necessary data from the primary data, which took a lot of time to decompress the compressed file. In the hierarchical database implemented this time, the analysis target links can be easily selected using a graphical user interface (GUI), and the data to be analyzed can be extracted quickly from there (see Figure). Furthermore, it is possible to easily access primary data because the database does not aggregate trajectories of different vehicles.

By performing the case studies, we also showed that the network aggregation technic in the hierarchical database is also useful to analyze data in a macroscopic manner. By simplifying and aggregating complex networks by area, it becomes possible to analyze global characteristics. Although area aggregation has been known in the form of macroscopic fundamental diagrams, it has been found that contraction of upper networks is also effective for a macroscopic analysis of a network.

4. Conference Presentations

- Yasuda, S., Iryo, T., Sakai, K., and Fukushima, K., Data-oriented network aggregation for large-scale network analysis using probe-vehicle trajectories, 2019 22nd Intelligent Transportation Systems Conference (ITSC), 2019, 10. (accepted)
- Sakai, K., Koyama, Y., Yasuda, S., and Iryo, T., Investigations of electronic toll collection (ETC) 2.0 system for validation of map matching algorithm and analysis of spatial deviation in observed data, ISTS and IWTDCS 2018, Matsuyama, Japan, 2018, 6.
- Yasuda, S., Iryo, T., Koyama, Y., and Sakai, K., Characteristics of ETC2.0 probe data compared to road traffic census data, ISTS and IWTDCS 2018, Matsuyama, Japan, 2018, 6.

5. Study Development and Future Issues

If the hierarchical database developed in this research can be implemented as a general application so that it can be used easily by many users, which leads to accumulations of experiences, it will be possible to extract the unknown issues of the database. It can be expected that this will enable the construction of more convenient databases. In addition, the result of quality verification of ETC2.0 probe data in this research will be an important reference material when updating it.

6. Contribution to Road Policy Quality Improvement

Utilizing the knowledge of the quality problem of ETC2.0 probe data clarified in this research, it becomes possible to utilize ETC2.0 probe data in planning and evaluation of road policy in a more accurate form. In addition, it can be expected that the hierarchical database developed in this research will promote the use of ETC 2.0 probe data.

7. Public relations activities

The results report meeting was held jointly with other researchers on February 22, 2019, and the research results were disseminated to the public. There were approximately 250 participants.