Case Study of Mobility Trends in Daily Life in a Motorized City Using Spatiotemporal Information

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***Abstract*—The arrival of a super-aging society due to demographic changes is a growing concern in many parts of Japan. Ohnishi et al. (2015), through their approach to the problem of shopping refugees using large-scale telephone directory data, selected Maebashi City in Gunma Prefecture (2017-) as the subject of this study and actually conducted a field survey. The city has been selected from the perspective of conducting an actual field survey and conducting an analysis linked to movement trends. In this analysis, an overview of the movement patterns of this data both domestically and internationally was conducted in consideration of anonymity, as well as trends around stations, universities, and other institutions, and a discussion of movement patterns in relation to the effects of weather which is expected to show the trend of human flow in normal period because it is the data before the COVID-19 disaster after 2020.**

Keywords—GPS, Human Flow, Weather Information, Spatiotemporal information, Conjoint

I. INTRODUCTION

In this study, we focused on Maebashi City, Gunma Prefecture (2017-), where we actually conducted a field survey. We selected this city from the perspective of conducting actual field surveys and conducting analysis linked to trends in movement. Maebashi City in Gunma Prefecture is characterized by the fact that it has the highest rate of car ownership in Japan, and it is presumed that people travel by bus or car rather than by train, or by bicycle or walking in Maebashi City, making it easier to analyze speed by location as movement log data. We also paid attention to the tendency of the movement characteristics of the users who passed through Maebashi City in Gunma Prefecture during this period. Through this research, we are trying to find out whether it is possible to infer generalized behavioral patterns of people from anonymized movement log data, and whether it is possible to obtain readable insights from anonymized movement logs (human flow data) of large-scale cell phone users by examining the tendency of changes in movement patterns in relation to external environments such as weather. We analyzed the data as a basic research to see if readable insights can be obtained from anonymous movement logs (Human flow data) of large-scale mobile phone users.

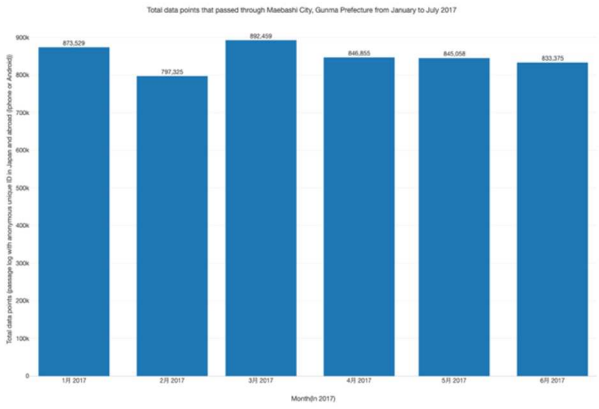

Fig.1. Total data points (passage log with anonymous unique ID in Japan and abroad (Iphone or Android)), passed through Maebashi City, Gunma Prefecture from January to July 2017.

As can be seen from Fig. 1, this data shows that there are many points that passed through Maebashi City during the holidays such as spring break (late February to March). Various cases such as travel from home and abroad, moving, etc. are assumed. The average is 848,100 cases per month, and since there is no big difference except in March, we thought that it would be good to try analysis and inference from daily anonymized human flow data. This data is the data that passed through Maebashi City, Gunma Prefecture in the anonymized data (2017 /01-2017 /06) provided by Softbank Agoop. This data uses the data of users who have been anonymized with permission to use the data for research use and analysis use. By using the data set based on the above conditions, the ethical and legal issues in this analysis were cleared, and basic research estimated from basic human flow data was reached. In addition, preprocessing is also performed to reset the ID every 24 hours so that the home, privacy, etc. of each ID in this data cannot be specified. In addition, in this paper, from the viewpoint of privacy, we will post the data analyzed as summary data only in places where people are most likely to be crowded (stations, supermarkets, etc.). First, as an introduction to this paper, we will touch on the outline of the data set logs used in this analysis and Fig. 1-7, which is a comparison of movement patterns in Japan and overseas.

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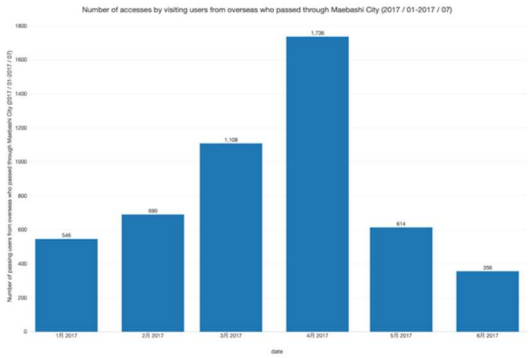

Fig.2. Number of accesses by visiting users from overseas who passed through Maebashi City (2017 / 01-2017 / 07)

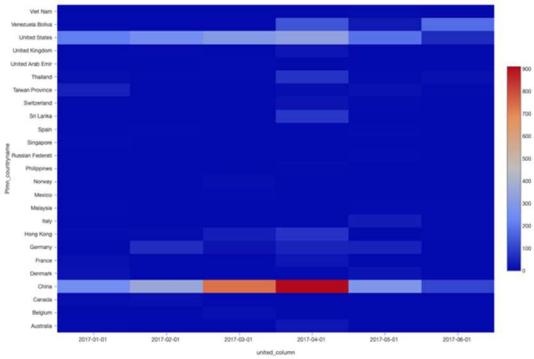

Fig.3. Number of accesses by visiting users from overseas who passed through Maebashi City (2017 / 01-2017 / 07), Heat map by country

Fig. 2 and 3 show the number of accesses by licensed users of data utilization who visited Maebashi City from overseas during the period, but the access from the People's Republic of China was particularly conspicuous in April, and the People's Republic of China as a whole. Next, it is characteristic that there are many accesses from the United States and Southeast Asia.

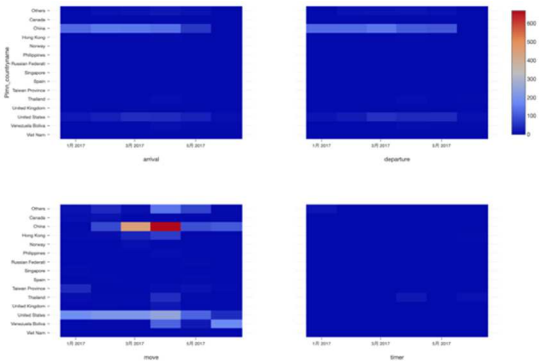

Fig.4. Number of accesses by visiting users from overseas who passed through Maebashi City (2017 / 01-2017 / 07), Heat map by country, Classified by movement pattern

In Fig.4, the ones divided by the movement pattern are presented. Here, it can be confirmed that the process of arriving in Maebashi City, Gunma Prefecture as a whole, and passing through the process of movement is more remarkable in April 2017 than the tendency of staying.

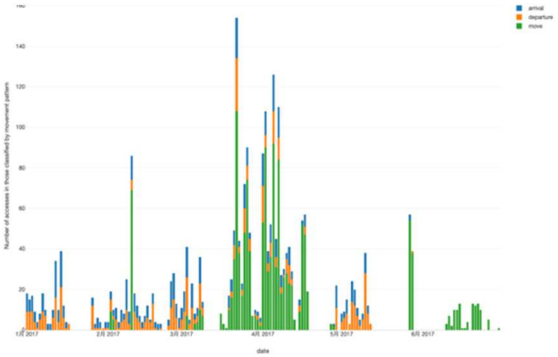

Fig.5. Number of accesses in the ones classified by movement pattern (the tendency of visitors from the People's Republic of China, which was particularly frequently accessed)

Fig.6. Number of accesses in the ones classified by movement pattern (the tendency of visitors from the United States of America, which was particularly frequently accessed)

Fig.7. Number of accesses in the ones classified by movement pattern (the tendency of visitors from other countries, which was particularly frequently accessed)

In Fig. 5-7, the classification was made by the People's Republic of China, the United States of America, and other countries, which had the highest number of accesses. Then, it was found that there are many users who moved / passed through in April 2017, especially in the People's Republic of China, and there are many users who enter and leave Maebashi City at other times such as departure or arrival. In the case of the United States, there are basically many users who pass through Maebashi City, and the same tendency was seen in other countries. Also, the United States and other countries were dotted with users who would be staying, and there was no

tendency to go in and out like the People's Republic of China. As for Maebashi City, Gunma Prefecture, the airport is far away and it is also a land route area, so it is likely that you are already staying in Maebashi City, Gunma Prefecture for the purpose of studying abroad and training with passengers heading to areas after Gunma Prefecture. It was inferred from this data that users presumed to be students would have been observed.

date(%)	arrival	departure	move	timer
2017-01-01	13.01	12.71	58.82	15.46
2017-02-01	13.25	13.00	59.96	13.78
2017-03-01	13.32	13.04	60.20	13.44
2017-04-01	13.19	12.97	60.66	13.19
2017-05-01	12.97	12.89	60.55	13.59
2017-06-01	13.25	13.24	60.06	13.45

Table.1. Number of accesses in the ones classified by movement pattern (the tendency of visitors from other countries, which was particularly frequently accessed)

Here, we will touch on the movement pattern when Japanese users are limited. Since the total number was a very large value, the contents were as shown in Table.1. When summarized as a table in percentage (%) notation. As a whole, it can be seen that there are many users who are passing (Move), but it can be seen that there are also many users who have arrived at schools, companies, etc. when there is a high tendency to commute to work or school. In addition, it was speculated that the weather, such as cold weather, might have affected the number of users who would be timers (staying) only in January, although they were weaker than in other times.

II. Examination of Joint Analysis for Estimation of Weather Preference Behavior

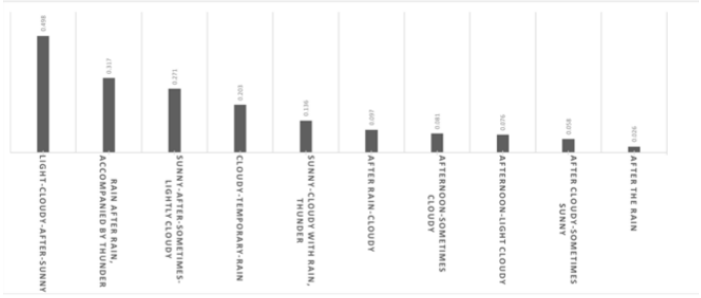

Fig. 8. Conjoint analysis in a trial using the data of the hourly weather conditions up to January-July 2017 and the average speed of the whole hourly average

In this study, we conducted a conjoint analysis in a trial using the data of the hourly weather conditions up to January-July 2017 and the average speed of the whole hourly average[6-7]. Conjoint analysis to understand the structure of preferential behavior (eg, Using a car to go out quickly) under certain conditions such as weather conditions and changes in the means of movement of people per point The approach using was performed. Although this method is a model used for understanding the structure of purchasing behavior such as marketing, we presume that preferential behavior can be seen with regard to transportation means and speed under conditions that require judgment in transportation means such as rainy weather. As a result, as can be seen from Fig. 8, lightning or rain falls within the top 10 in the weather conditions that contributed to the speed (Weather Overview Noon 06: 00 to 18: 00 /47 types of weather conditions). These were inferred that the condition had a big factor.

III. Summary and Future Prospects

In this study, we tried to capture the trends of people's behavior and distribution in Maebashi City by decomposing location data by time and place, using anonymized human flow data (domestic and international users) transmitted by cell phones and licensed for data analysis and utilization. By inferring speed trends in zones where people tend to congregate, such as stations and university institutions, we were able to gain insight into the relationship between weather and speed. In other words, by decomposing the relevant location data, we expect to be able to understand the temporal and spatial characteristics of people's behavior around Maebashi's facilities. In the future, we would like to investigate the trends of time trends for each industry in conjunction with field surveys using telephone directory data. In addition, in our trial using conjoint analysis, we would like to incorporate more detailed conditions than in previous studies. We will investigate conjoint analysis not only in time units, but also in simulations in seconds. In future research, we hope to use these methods to gain quantitative knowledge about the movements and causes of various human activities, such as human mobility, weather, and events.

Acknowledgment

We would like to also thank you for the support from the 2019 Scholarly Scholars Research Grant Program(Leading Initiative for Excellent Young Researchers (LEADER)), which provided support for this research in general.

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