Time-series Monitoring of Area Characteristics Using Mass Person Flow Data by Mobile Phone GPS Data ~ Case study in Greater Tokyo Region ~

Yuki Akiyama[1] and Ryosuke Shibasaki[2]

Abstract

This paper introduces a monitoring method of time-series changes of area characteristics in Greater Tokyo Region using mobile phone GPS data. Stay areas of each mobile phone user can be estimated with aim of stay, namely at home, work place, sightseeing spots and so on, to calculate GPS data spatio-temporally. This study realized to monitor time-series changes of area characteristics: residential area, business district, commercial/sightseeing area, transport hub, and mixed area to accumulate them by grid areas. It is expected that the method of this study can be widely used for urban monitoring in not only Japanese but also Asian megacities because same kinds of GPS data are accumulated everyday by mobile phone careers throughout the world. ZENRIN DataCom Co.LTD provided us comprehensive and analytical processing of the GPS data.

1. Introduction

Monitoring of hourly changing distribution of population in urban area is a very important problem for planning of urban development, traffic, disaster and epidemic prevention, etc. Residential populations can be monitored to use existing census in developed countries. On the other hand, monitoring of detailed population distribution throughout urban area is difficult in developing countries because census data are not developed adequately in such countries (Takashima and Hayashi (2001)). In addition, monitoring of hourly changing population is also difficult even in developed countries.

In recent years, monitoring methods of hourly person flow and stay using mobile phone GPS data obtained from phone users who permit to be used their information collected by mobile phone carriers ("GPS data" in this paper) attract attention for this problem. Sekimoto et al. (2011) stated that it is becoming possible to monitor mass person flow and stay in broad area continuously using mass GPS data. Monitoring methods of hourly changing populations and area characteristics are very useful in many mega cities in not only Japan but also all over the world because same kind of mass GPS data with permission from users are being accumulated by carriers around the world.

[1] Earth Observation Data Integration and Fusion Research Institute, The University of Tokyo
[2] Center for Spatial Information Science, The University of Tokyo

* This is an abstract peer-reviewed by the International Affairs Committee of the City Planning Institute of Japan for ISCP2014.

This paper therefore introduces the monitoring method of hourly changing distributions of population and area characteristics using GPS data in Greater Tokyo Region. There are few studies to monitor daily time-series changes of area characteristics in broad area even though there are many studies to monitor static area characteristics. It is expected to be able to monitor it using GPS data. It is considered that these data are fruitful information for solution of the aforementioned problems in urban area.

2. Data development

This study first developed stay area data of each phone user with attributes. Second, magnification factors of each user were calculated for estimation of actual population. Finally, we monitor hourly populations and area characteristics of each 500m square grid which covers throughout Greater Tokyo Region to accumulate this result into grid areas. Comprehensive processing of the GPS data in this section were performed by not authors but ZENRIN DataCom Co.LTD.

2.1 Processing of GPS data

This study developed monitoring methods of hourly changing distributions of population and area characteristics using GPS data in 2012, 365days. This data contains GPS data of about 1.5 million users constructed by about 9 billion-records text data.

First, stay area of each person were calculated and classified into home location, work location, or others, i.e. stay for shopping, eating, or sightseeing. Methods by Horanont (2010) and Akiyama et al. (2013) are used for these calculations. Second, stay areas near train stations and bus stops were classified into use of public transportations. Figure 1 shows these classifications. Third, magnification factors of each user were calculated for estimation of actual population to compare estimated home areas with existing population census as in Figure 2. Finally, daily mean time-series populations in Tokyo metropolitan area can be monitored to accumulate stay areas in 365 days into 500m square grids in every 24 hours shown as Figure 3. All grids have estimated populations to stay home, work place, use public transportation, and others.

2.2 Definition of are characteristics

This study defined area characteristics of all grids using these 4 values. Figure 4

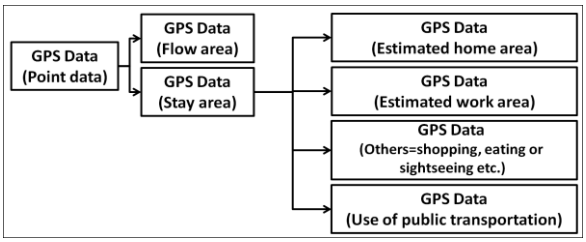

Figure 1. Classification of GPS data of each user [1]

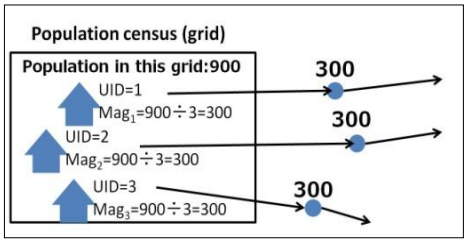

Figure 2. Calculation of magnification factor [1]

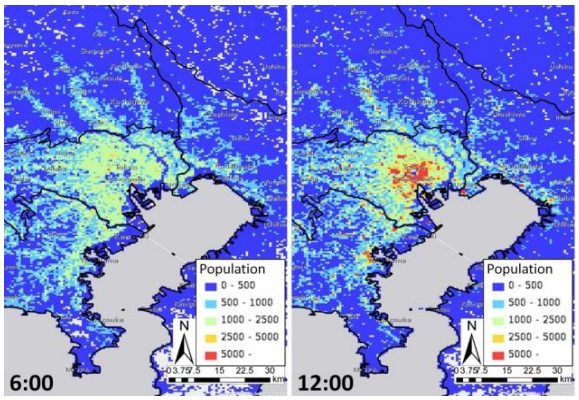

Figure 3. Time-series changes of estimated Populations in Greater Tokyo Region [1]

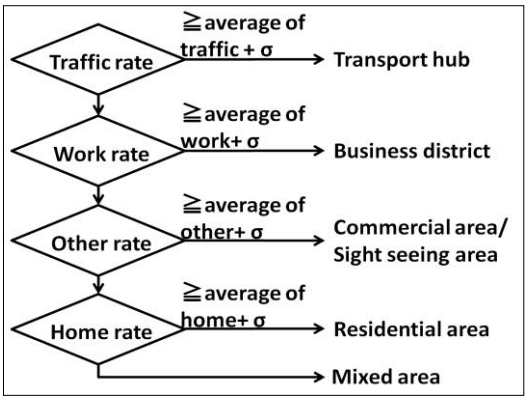

Figure 4. Method of area classification [1]

shows the classification method of regional characteristics of each grid. Average values and standard deviations of each value were calculated based on values in all grids in 24 hours. 5 characteristics in Figure 4 were defined.

3. Result

Figure 5 shows time-series changes of area characteristics in Greater Tokyo Region. There are drastic changes in commuting time: between 6:00 and 8:00. This is because many residential areas in suburban area changed mixed area because of people movement from suburban areas to the city center of Tokyo in daytime and business areas and commercial/sightseeing areas increased in the city center of Tokyo due to this movement. In addition, converse phenomenon of it can be monitored in clock-out time: between 17:00 and 20:00. However, this change is more moderate than commuting time. There are a few increase and decrease in the transport hub throughout the day. In addition, areas where main train terminals or loads are located are the transport hub. Commercial/sightseeing areas are located in not only the city center of Tokyo but also suburban areas of Tokyo, mountainous areas and waterfronts. It is considered that these areas are constructed mainly of sightseeing areas. On the other hand, they are mainly commercial areas in the city center of Tokyo. Using this method, it is realized to monitor spatio-temporal changes of area characteristics based on dynamic change of population by mass GPS data.

4. Conclusion

This study realized methods to monitor time-series changes of populations and area characteristics using mass GPS data in urban area. This is the first study to monitor time-series change of area characteristics with homogeneous spatial resolution and quality throughout the Asian megacity of Tokyo. This is a germinating study to try utilization of geo big data: Micro Geo Data of mass GPS data for the field of city planning.

There are many research challenges. First is to improve the classification method

of area characteristics to cross-check with other census data and field surveys. Second is to enrich classification categories of stay areas of GPS data. Third is to verify difference of result by a day of the week, weather and season. Finally, we will plan to apply this method and data to concrete issues of city planning.

Keywords: time-series analysis, mobile phone GPS data, clustering, area characteristics

Note:
1) Raw GPS data processing in all figures were provided by ZENRIN DataCom Co.LTD.

Acknowledgement:
The authors were given the "Konzatsu-Tokei Data®" from ZENRIN DataCom Co.LTD. The data is the person flow data developed by comprehensive and analytical processing of the GPS data with permission from phone users. The authors would like to thank CSIS and EDITORIA for their contribution.

Reference:
1) Takashina, M. and Hayashi, H., 2001. Measurement model of city light distribution for the estimation of earthquake damage potential using DMSP/OLS night-time imagery: application for population estimation. Journal of Social Safety Science, 3, pp. (In Japanese) 101-108.
2) Sekimoto, Y., Horanont T. and Shibasaki, R., 2011. Trend of People Flow Analysis Technology Using Mobile Phone. IPSJ Magazine,. 52(12): 1522-1530. (In Japanese)
3) Horanont, T., 2010. A Study on Urban Mobility and Dynamic Population Estimation by Using Aggregate Mobile Phone Sources. Department of civil engineering, The University of Tokyo., PhD. Thesis.
4) Akiyama, Y., Ueyama, S., Horanont, T., Sengoku, H., and Shibasaki, R., 2013. Spatio-temporal Analyses of Visitors in Commercial Accumulations Using Mass People Flow Data in Kanto Region. IGU2013 Kyoto Regional Conference., JS104-3-1.

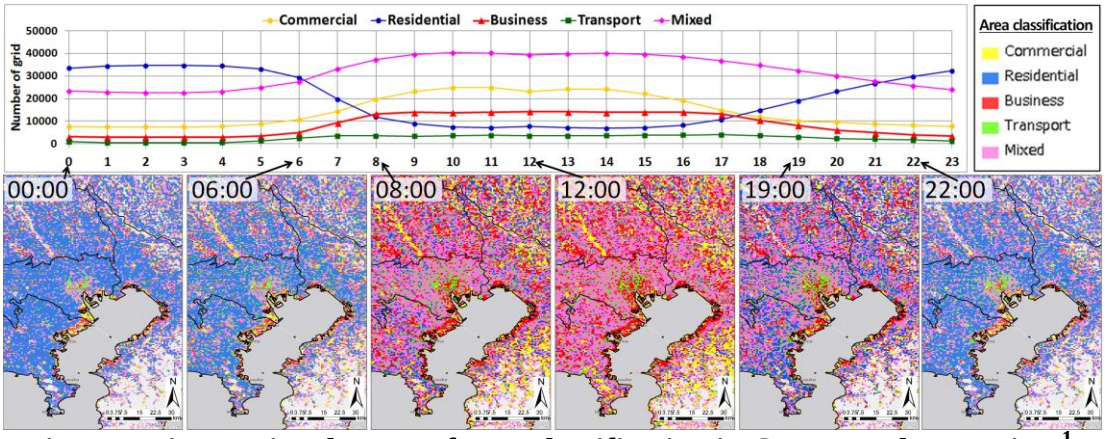

Figure5. Time-series changes of area classification in Greater Tokyo Region [1]