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Experimental study on smart tracking and geo-event data warehousing system for person trip surveying

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Abstract

Use of wireless communication technology and location-enabled devices such as smart phones or tablet computers makes real-time geo-event data collection possible. The understanding of human mobility from a spatial perspective is important for transportation planners, human geographers and social scientists to understand travel behavior or pattern changes over time. In this paper, we report our experimental study of Smart Tracking and Geo-event Data Warehousing system to collect person trip with event information by using smart phone in order to enhance current person trip survey and Origin-Destination Route Identification process.

Key words: field experiment, geo-event data warehousing, GIS, GPS, smart tracking

1. Introduction

Over the last decades, the collection of human mobility information was a big challenge for spatial information users due to lack of mobile communication devices and ancillary GIS datasets, especially road network data, and computational resources (Greger and Murayama, 2014). Recent technological developments in mobile communication devices and wireless networking indicate that the movement of an individual can be tracked or monitored using their mobile log data, Wi-Fi Internet access and usage of location-based services. Several studies have calculated movement and travel times using cellular network (Bolla and Davoli, 2000) and mobile log data (Asakura and Hato, 2004; Bar-Gera, 2007). Person flow monitoring by mobile phone, also known as "mobile sensing" has been used in urban and landscape analysis, urban data collection and analysis of human mobility patterns (Ratti *et al.,* 2006; Reades *et al.,* 2007; González *et al.,* 2008; Koo and Cha, 2011).

Although these mobile sensing data is useful for real-time person flow in disaster management (Brachman and Dragicevic, 2014), additional information such as trip purpose and mode of transportation are required for transportation planners, social scientists and human geographers. Until now volunteered Person Trip Survey (PTS) data was the best way to understand human mobility in terms of travel behaviours and social characteristics. Collection of real-time person trips information by specific time intervals is possible in near future due to emergence of location-enable mobile devices and user friendly GIS applications on those devices under the scope of Public Participation Geographical Information Systems (PPGIS).

In general, Event Data records any transaction or changes in business applications, security system, IT infrastructure, social media and so on. In our proposed studies, Geo-event Data Warehousing System enables to record the trips/tracks and events (i.e. locations with trip purpose and mode of transportation) which allocate the points, store on a database and visualize the tracks. We have developed a Real-Time Geospatial Data Collection and Visualization with Smartphone, as a part of university campus management system (Lwin *et al.,* 2014). This system allows any spatial information users to collect, store and visualize real-time basis. We modify this system to use person trip with geo-event information. Therefore, the primary purpose of this experiment is to examine the possible use of smart phone to person trip survey by providing user friendly Web-GIS and Geo-event Data Warehousing System.

2. Smart tracking and geo-event data warehousing system

Until now, person trip surveys are based on paper work and require extensive labor resources for data entry tasks. Sophisticated Origin-Destination Route Identification process in order to convert non-spatial data into spatial data, *CSIS PFlow*, was developed by Center for Spatial Information Science (CSIS) at the University of Tokyo (Sekimoto *et al.,* 2011). It can collect only specific day or period due to cost and labor issues. By utilizing car navigation system or other IPS (Indoor Positioning Systems) with user friendly Web-GIS, it is possible to collect person trip with geo-event information. Moreover, the construction of Geo-event Data Warehousing System enables to collect, store and retrieve these person trip/track and geo-event information automatically (Fig. 1). This figure shows the comparison of current person trip survey and origin-destination route identification process with proposed Smart Tracking and Geo-event Data Warehousing System.

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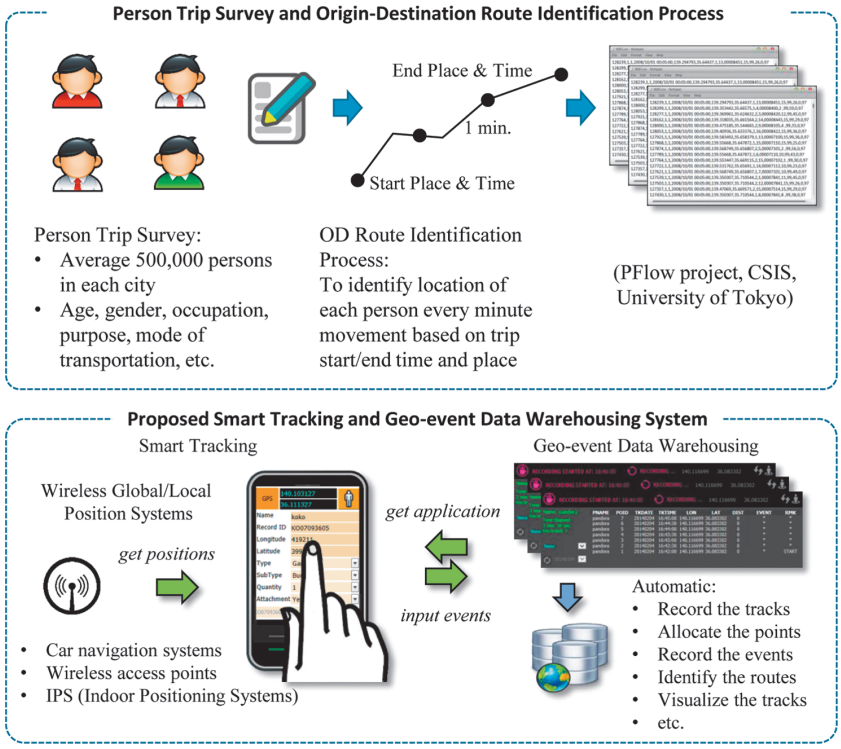

Fig. 1 Comparison of current person trip survey and Origin-Destination Route Identification process with proposed Smart Tracking and Geo-event Data Warehousing System

3. Field experiment

3.1. Experiment area

The University of Tsukuba and the surrounding were selected as the experiment area. We divided into 11 sub units/blocks and each unit/block was assigned to individual student. Wireless Internet access is also available for the whole area. Generally the landscape has low-rise buildings and patches with paddy fields and forests.

3.2. How it works

In our experiment, participants are required to create user account individually. After that they can Log-In and record their trips. The system enables to record the person locations by every 30 second and users can select their event along the trip whenever they make change. Users can also visualize their track and event along their trips. The Geo-event Data Warehousing System automatically stored the individual movement and event information. Users can retrieve their previous trip data by specific day and time. In this experiment, the system enables to export individual data into ESRI Shape file format in order to analyze and integrate with other GIS dataset for further decision making such as positioning errors assessment (Fig. 2).

3.3. Results and discussion

We got favorable results from the participants. Fig. 3 shows the individual movement points in different colors. Although there are some errors in allocating the points, majority of points fit into the actual walking track. These tracks can be visualized along with other ancillary GIS dataset. We used Web Map Service to streaming a base map from Microsoft Bing Maps. Users can select specific date and time to review their trips with common cartographic functions such as labeling, show/hide the track and adjust the animation speed (Fig. 4). The result can be seen at following URL: http://land.geo.tsukuba.ac.jp/fieldgis2014/visualizer.aspx.

4. Concluding remarks

Recently many spatial information users and researchers have been interested in human mobility studies from a space-time perspective. Current person trip survey and geospatial data conversion are time and cost consuming. We expect that the use of mobile communication devices with built-in GPS, such as smart phones or tablet personal computers will make online collection of data for the human mobility survey using the Public Participation Geographical Information Systems (PPGIS) possible in near future. This would dramatically reduce the time and cost with traditional paper-based surveys. The development of Web-GIS enables to provide location information, streaming base map or aerial image and visualize the result. Moreover, the collected data can be stored as GIS ready dataset for addi-

tional spatio-temporal analysis by providing export function in ESRI Shape file format. We hope that this experimental study will help to develop future person trip and associated geo-event data collection by utilizing wireless communication and location-enabled devices.

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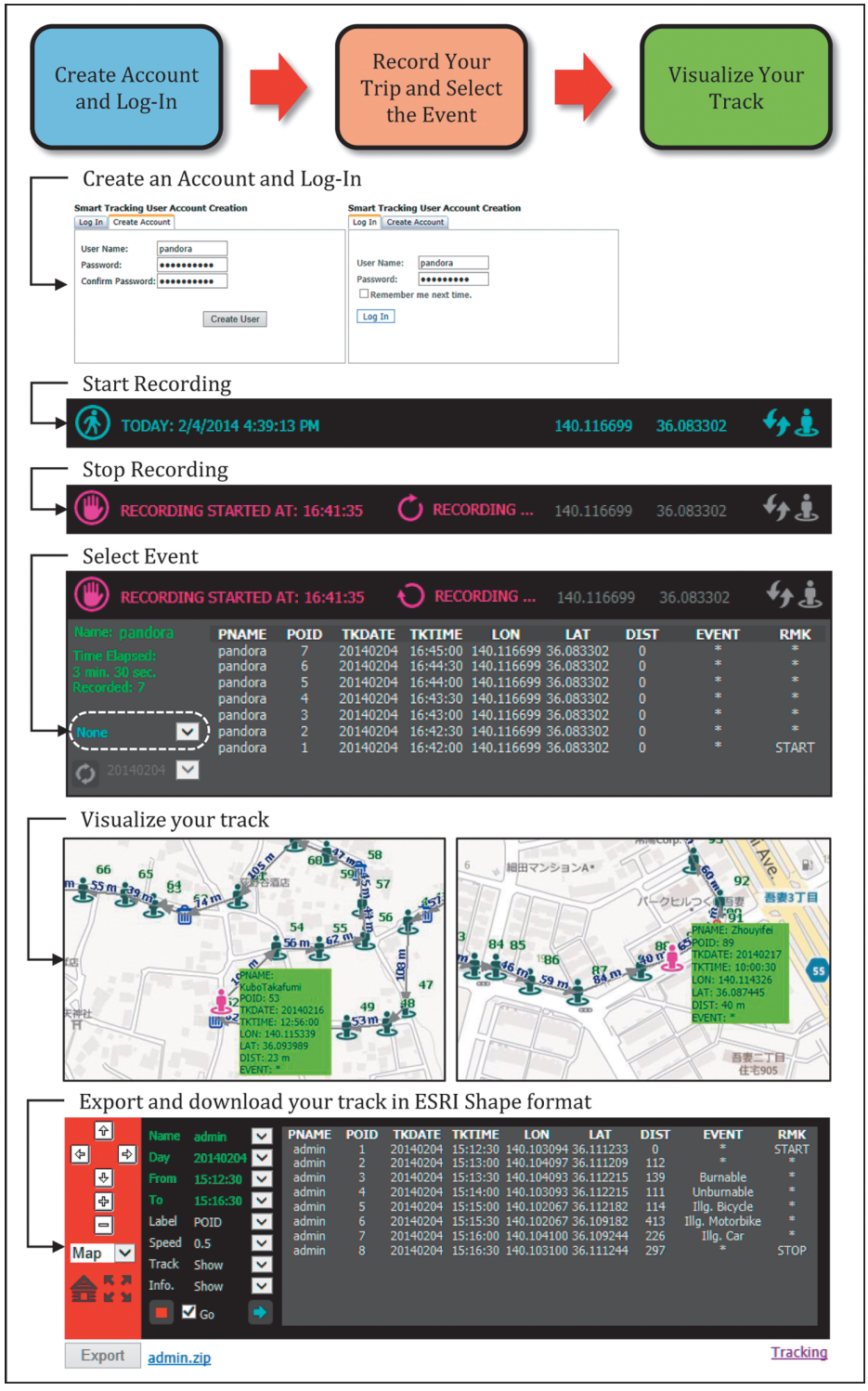

Fig. 2 Working steps

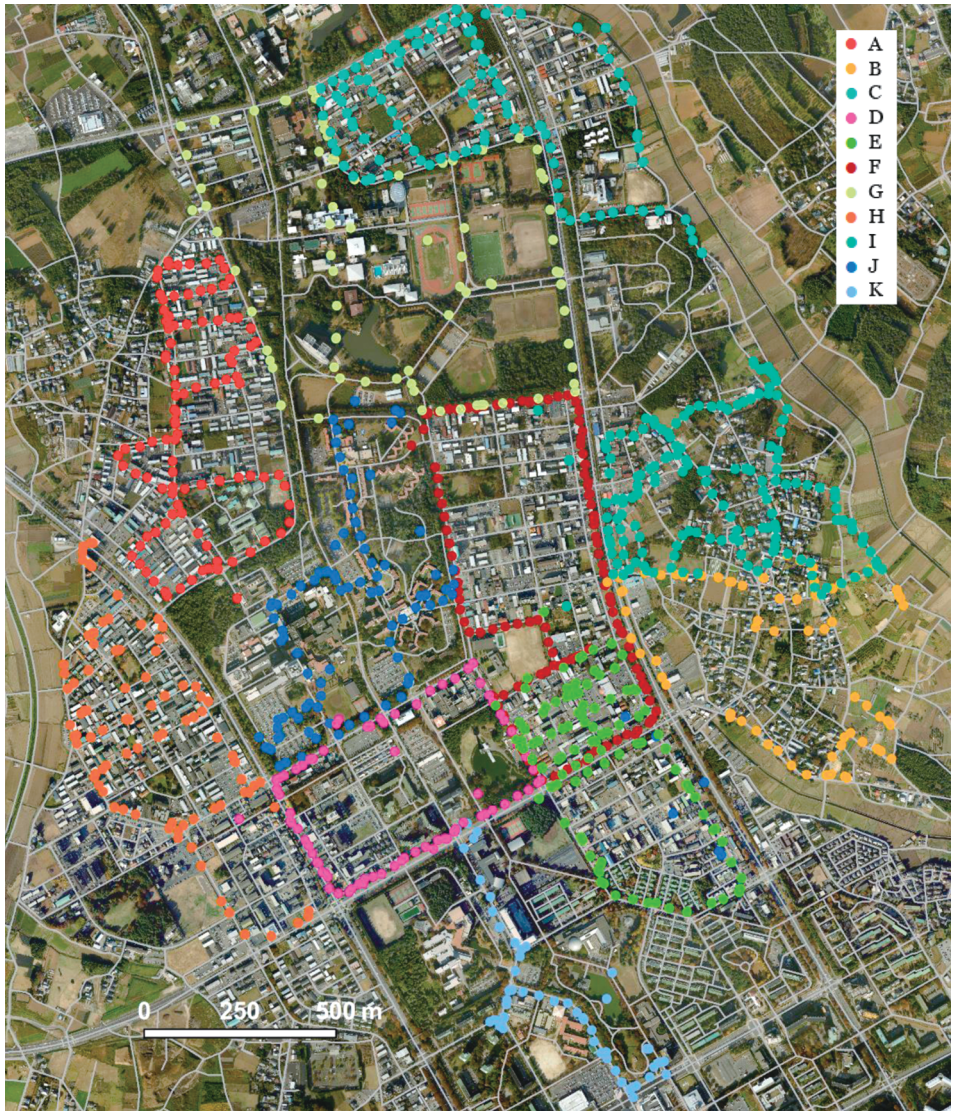

Fig. 3 Tracking points grouped by individual student movement recorded by every 30 second

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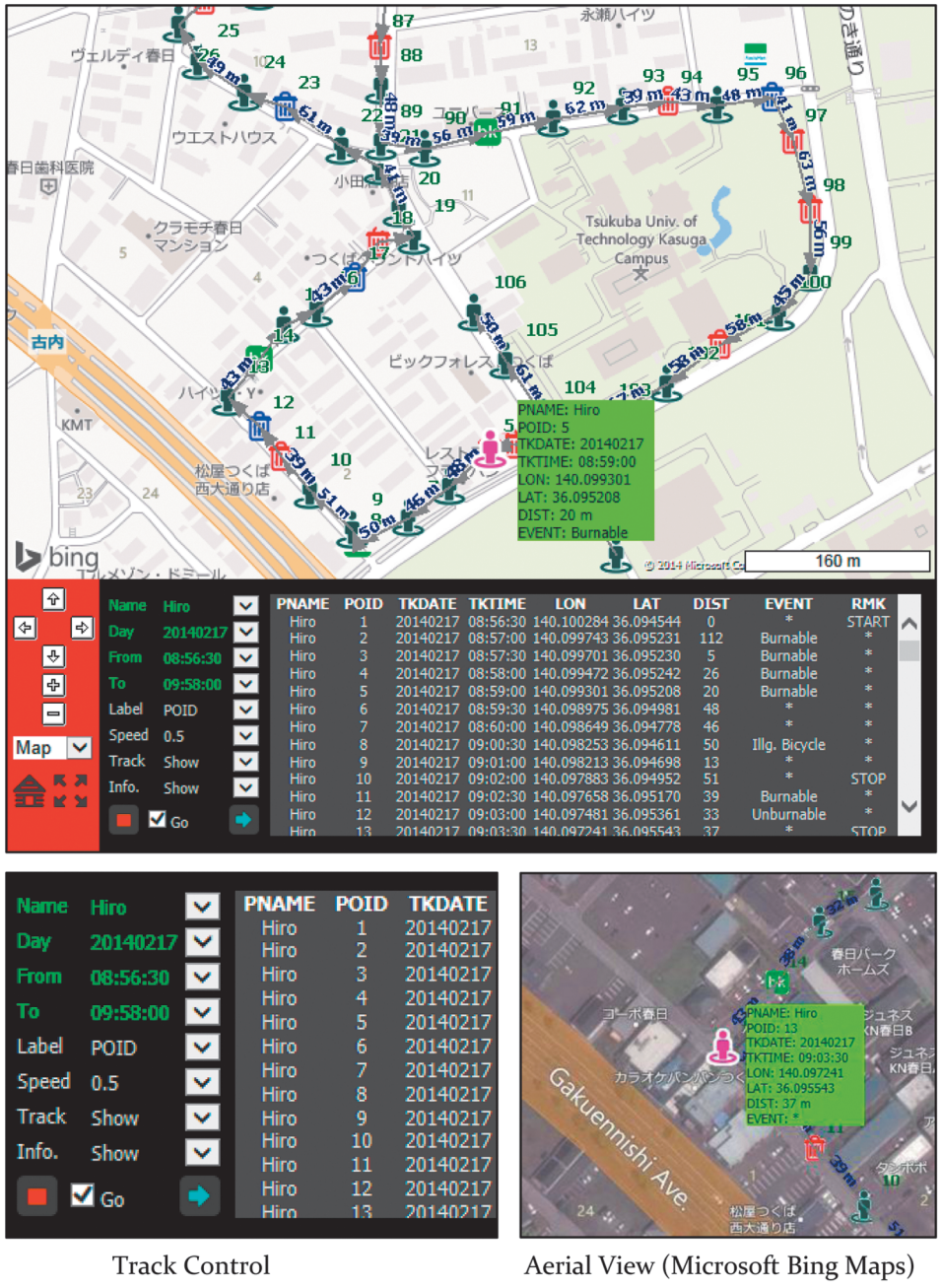

Track Control　　Aerial View (Microsoft Bing Maps)

Fig. 4 Person trip data visualization with Microsoft Bing Maps using WMS Web Map Service

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