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RECONSTRUCTION OF SPATIO-TEMPORAL DISTRIBUTION OF EVENT VISITORS BY FUSING MULTI-SOURCE DATA

Hiroyuki TANAKA, Yoshihide SEKIMOTO, Ryosuke SHIBASAKI
Shibasaki Laboratory Institute of Industrial Science University of Tokyo
Address : 4-6-1 Komaba, Meguro-ku, Tokyo 153-8505 Japan
Tel & Fax : +81-3-5452-6417
E-mail : tanayang@iis.u-tokyo.ac.jp

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ABSTRUCT

Recently, information on spatio-temporal distribution (temporal changes of spatial distribution) of human flow is required in many fields. For example, with more detail OD-flow data, transportation planning can be more practical. And the distribution data can also be useful in disaster mitigation planning or marketing.

So far, we can only acquire the limited part of the whole information, for example counting people from the video image at several specific sites. But with the development of sensor and information technology such as positioning systems, mobile phones, it will be possible to acquire much more variety of data on the spatio-temporal distribution of people, though the data are still fragmentary in terms of spatial and temporal coverage.

In this research, we try to reconstruct the whole spatio-temporal distribution by fusing the fragmentary data from multi-sources. The experiment is conducted to measure the human flow at an event hall, and by integrating these observational data with the human behavior model (same patterns or restrictions of human behavior), we reconstructed the spatio-temporal distribution of the event visitors.

1. INTRODUCTION

Information on spatio-temporal distribution of human flow is utilized in many fields. Examples of such fields are given to below.

- Transportation infrastructure projects such as road, railway or airline development
- ITS (Intelligent Transport System), where information of traffic situation are collected and distributed to drivers as the guidance information
- Evacuation planning or emergency decision support in case of an earthquake
- Prediction of consumer behaviors in marketing or the location-decision of shops

With the advancement of future needs more detail spatio-temporal (more detail temporally and spatially) distribution of human flow is required.

So far, we can only acquire the information of limited aspects of the whole phenomena, for example counting people from the video image at several specific sites, or questionnaire to people about their travel behavior. If a target-object of observation becomes larger, such as a specific zone of a city, it becomes still more difficult to grasp the whole images.

But with the development of sensor and information technology such as positioning systems, mobile phones, it will be possible to acquire much more variety of data on the spatio-temporal distribution of people, though the data are still fragmentary in terms of spatial and temporal coverage.

People's behaviors are tracked in usual, by such newly developed sensor, automatic ticket checker, surveillance camera, and so on. And if we can combine such fragmentary information, we can identify whole image of human flow.

In this research, we try to reconstruct a whole spatio-temporal distribution by fusing the fragmentary data from multi-sources. An experiment is conducted to measure the human flow at a large event hall, and by integrating these observational data with human behavior models (same patterns or restrictions of human behavior), we reconstructed the spatio-temporal distribution of the event visitors.

2. DATA INTEGRATION

Spatio-temporal data of human flow is needed to identify spatio-temporal distribution of human flow. There are various kinds of spatio-temporal data, and they are roughly divided into aggregative data and disaggregative data (Tabale1). The spatial and temporal density, the accuracy that depends on measurement sources, or the ease of use of data also change with each data.

Table1: various source on human flow data

Disaggregative data	Aggregative data
Trajectory data with GPS, PHS	Traffic counter
Purchase record of credit card	Automatic ticket checker
Log of mobile phone	Surveillance camera
…	…

We show an easy example below how can such different data is integrated. Suppose that three people (person1-3) were in observation area, and there are two observation data of their behavior, PHS data (for tracking person2 from t3 to t5, disaggregative data) and traffic counter data (counting number of people at t1, at position of x1-x5, aggregative data). The data structure of human flow represents position of each person at every time interval (individual state expression type). First we extract the data matched with fragmentary observation data (PHS and counter data) from prospected solution. Then we evaluate whether the solution fits to observation data, and finally re-presumed solution. Repeat this process until solution is converged (Figure1).

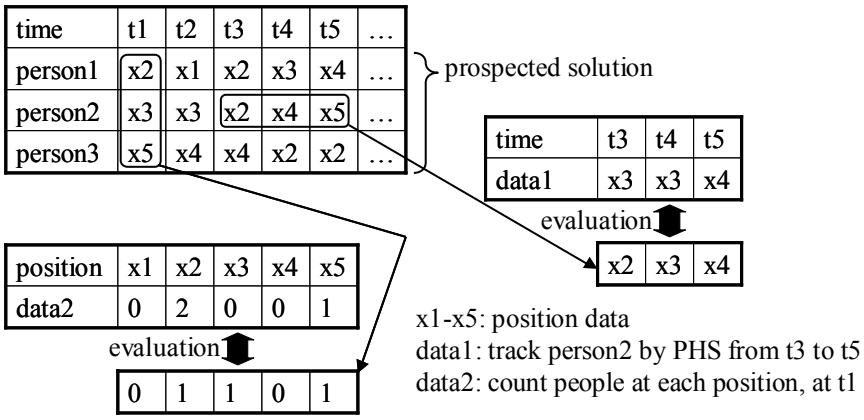

Fig1: Example of data integration

3. EXPERIMENT OUTLINE

In order to verify the proposed integration model, we conducted the measurement experiment of a human flow at the event hall. The reason we chose a large event hall is that although it is small scale, it is suitable as a place where a collected number of people flow. The measurement time is 3 hours. In this experiment, in order to verify that what data can be used more effectively to reconstruct human flow, we prepared various sources of data.

- PEAMON (Personal Activity MONitor)
  PEAMON is an off-line type terminal and can store information. From the power antennas (there are two kinds of power antenna, normal antenna and attenuator), which have been set beforehand, it can receive the ID and electric intensity of these antennas. By having experimental subjects carry PEAMON, we can track their behavior in the event hall. We got 30 sampling data from this source.

- Traffic counter
  We counted total passage number (pass direction, left and right differently) at 10 points, at 5 minutes intervals in the event hall.

- Digital camera
  We took pictures in the event hall by a digital camera, and from these pictures we counted the numbers of people. In the focused area, we took at 10 points, at 30 minutes interval, and in the other area, at 18 points, at 90 minutes intervals.

- Questionnaire to companies
  We conducted questionnaire to company, which joined this event, about how many people visited their company in these 3 hours and what kind of exhibition they did (did any demonstration?). A demonstration usually attracted many people and might be one factor that affects human flow. It is due to verify whether a demonstration affects human flow. We got 90 responses among 95 companies.

- Questionnaire to event visitors
  We conducted questionnaire to event visitors about how long they stayed in event hall and which company they dropped in. We handed out about 1200 questionnaires and got 189 responses.

- Laser scanner
  We set up two laser scanners at the exit of the event hall and tracked visitors (number of visitor who passed the exit) for 30 minutes.

- Infrared video camera
  We set up the infrared video camera in the focused area and tracked visitors for 3 hours.

Counting people by laser scanner or an infrared video camera is not yet established technology. However, they possibly became important source in the future, and were used experimentally this time. The details of those technologies and their results are reported separately in the same conference.

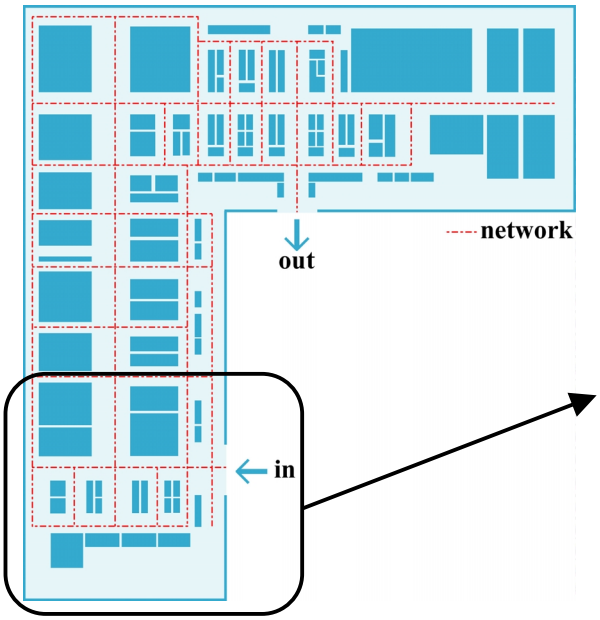

Fig2: Layout of event hall and its network

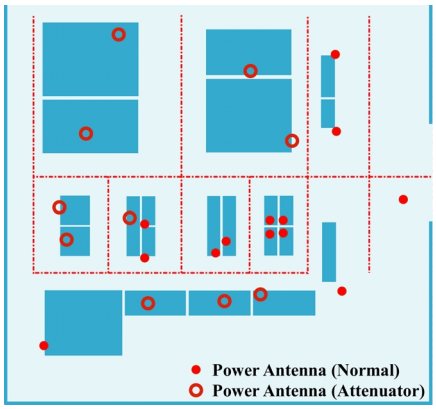

Fig3: Position of PA at focused area

4. CONCLUSIONS

The final result are not obtained at present. The following figure shows change of rough human flow from the data of digital camera, traffic counter and questionnaire to companies. The integration results of reconstructing more detail human flow spatially and temporally integrating the other data will be presented at the conference.

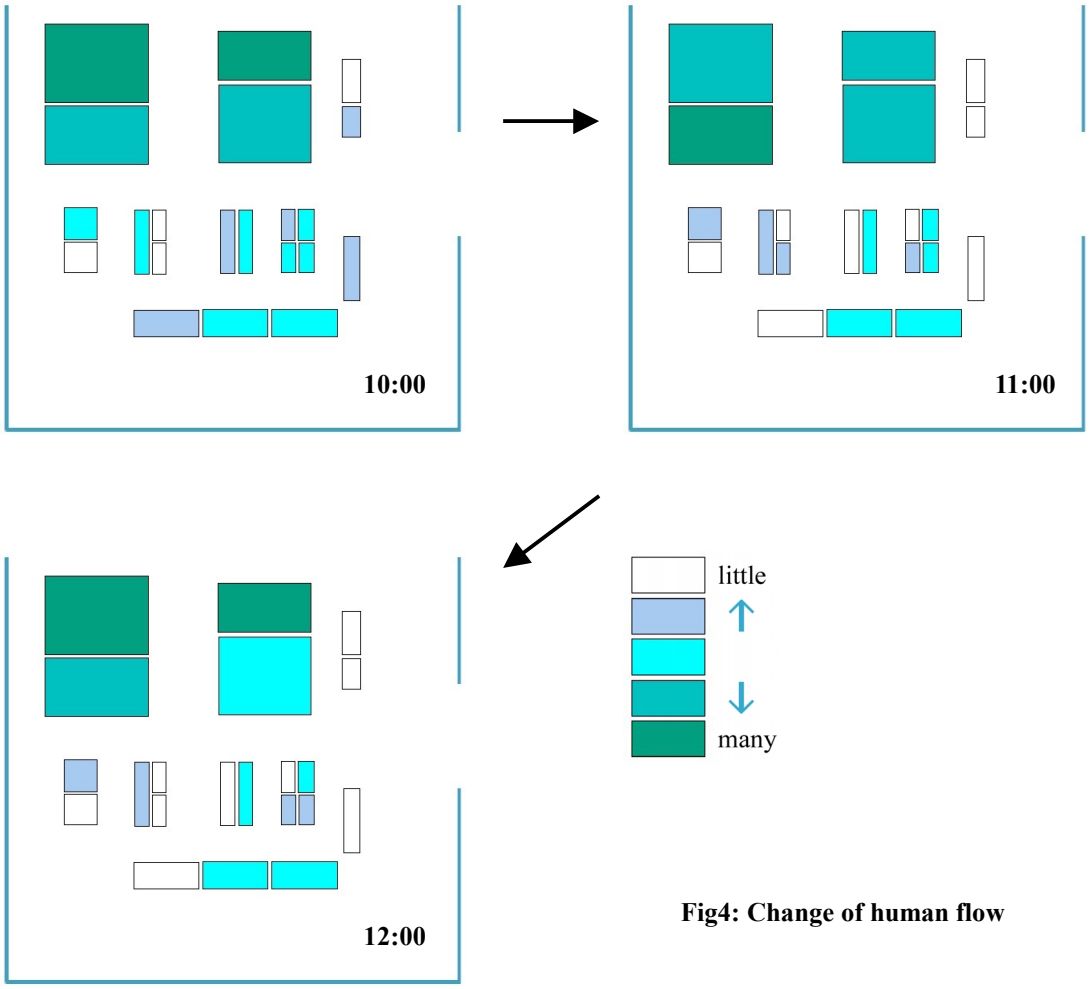

Fig4: Change of human flow

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