Proceedings of the 2017 Winter Simulation Conference
W. K. V. Chan, A. D'Ambrogio, G. Zacharewicz, N. Mustafee, G. Wainer, and E. Page, eds.

AUTOMATIC AND DYNAMIC GROUNDING METHOD BASED ON SENSOR DATA FOR AGENT-BASED SIMULATION

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ABSTRACT

Agent-based simulation(ABS) is a promising way to reproduce congestion situations in large-scale facilities and to evaluate the effectiveness of various types of policies for congestion avoidance based on individual behavioral model. Real-world grounding for determining model parameters plays important role to build valid ABS for a specific facility. However, to use ABS continuously for daily decision, parameters should be updated because user characteristics of the facility changes daily or longer term. This study provides a novel grounding method that can automatically and dynamically estimate the parameters of a human behavioral model based on sensor data at a certain interval. To evaluate the method, we conduct simulation experiments using an agent based model to analyze congestion situation in a building. The result with the method can perform congestion prediction with higher accuracy as compared with a conventional method.

1 INTRODUCTION

Managers of facilities in which users walk around choosing target such as shopping malls, theme parks and retail stores, need to deal with congestion situations in order to improve users satisfaction. Agent-based analysis can evaluate effectiveness of various types of policies for congestion avoidance such as layout design of checkout in a supermarket(Yamane 2012) and information boards in a theme park(Ohori 2013). Since the conventional studies intend to determine the layout fixed in long term, real-world grounding and analysis are performed once in the design phase. To use ABS continuously for daily decision such as human resource allocation, parameters should be updated in dynamic manner because user characteristics of the facility changes daily or longer term. One reasonable way is to collect human behavior data by human tracking systems and dynamically update parameters, that is also seen in a part of Dynamic Data Driven Application Systems(Darema 2004). However, there are two difficulties in applying the approach to ABS: 1) how to estimate internal parameters which are related to decision-making using behavior data, 2) how to calibrate parameters which change day by day. This study provides a novel grounding method that can automatically and dynamically estimate the model parameters.

2 SIMULATION MODEL AND PARAMETER ESTIMATION

Each agent is generated in a facility having an evoked set of one or more shops located in the facility. The agent walks in the facility, gets information such as congestion and distance for each shop, select a shop to visit and walk to the shop. The selection of shops are stochastically generated by a multivariate logit model. The utility value of each shop is calculated by weighted sum of attractiveness of the agent to the shop, congestion and distance. The agent repeats the process until it visits all shops in its evoked set. In the model, evoked set, parameters of utility function and time to enter the facility should be estimated. Evoked set and parameters of utility function are estimated based on classification and maximum likelihood estimation respectively. Since the estimation requires sufficient amount of data for each method, evoked set, parameters of utility function are estimated in advance. On the other hand, the distribution of time to enter the facility is determined in statistical manner in advance and dynamically modified using collected data at a time of the day, because the distribution changes day by day.

3 EXPERIMENT

We conducted simulation experiments to evaluate the method. The target of the simulation is lunch time congestion in a specific office building. There are restaurant and retail shop in the building. Employees in the building can take lunch in the restaurant, buy a lunch box in the shop or go outside of the building for taking lunch. They can visit the shop to buy something before/after the lunch. We used beacon receivers and beacons for human tracking. We also placed cameras to measure congestion in the restaurant and the shop. The number of employees who wear beacons is 200 which is 1/5 of all the employees in the building. In addition, we counted the number of employees queuing in front of the restaurant and the shop by human eyes for evaluation of the accuracy. The experiments are conducted seven days. First in a day, we estimated evoked set, parameters of utility function and distribution of time to enter, then predicted the congestion with dynamic modification method. The method acquires data from beacon receivers every five minutes, modifies the distribution based on the data, then runs simulation again.

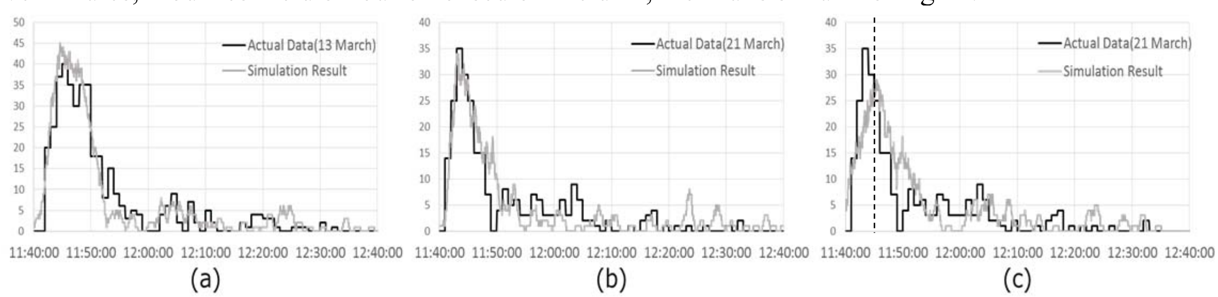

Figure 1: (a) Simulation result on 13 March, (b) Simulation result on 21 March, (c) Simulation result on 21 March run at 11:45 based on acquired data.

Comparison between the actual data and simulation results are shown in Figure 1. While the simulation can predict the congestion at 11:40 (start of the lunch time) on 13 March, the simulation at 11:40 on 21 March failed to predict the congestion. On the other hand, the simulation result at 11:45 on 21 March fit well to the actual data. This result shows that the modification method improved simulation accuracy using collected sensor data in first five minutes.

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