TOWARDS A WEB-BASED URBAN STREET SIMULATOR FOR PEDESTRIAN BEHAVIORS STUDY WITH AGENT-BASED INTERFACES

CHIUNG-HUI CHEN
Department of Information and Design
Asia University, Taichung, Taiwan
chchen@asia.edu.tw

AND

MAO-LIN CHIU
Department of Architecture
National Cheng Kung University, Tainan, Taiwan
mc2p@mail.ncku.edu.tw

Abstract. The urban planning has largely placed the street users at the centre of infrastructural design, with significant implications for the perceived attractiveness of user environments. The urban designers faced with the task of designing such spaces and needs a tool that will allow different designs to be compared in terms of their attractiveness as well as their effectiveness. Therefore, this paper depicts an agent interface approach for creating a street simulator of user behaviors in urban street environments. We implemented the agent interface as individual-based simulation in the proposed project called "SCALE" (A Street Case Library for Environmental design). The project is demonstrated to find out differences between the simulation and the existed environment. The methodology and findings are reported.

1. Introduction

Computers have been used for years in the built environment for various applications such as visualization, simulation, and evaluation. However, it is difficult to simulate social interaction in the dynamic design processes by conventional simulation. Social interaction is a subtle mechanism for creating a sense of engagement. In artificial intelligence, there is a strong view of agents; they have desires, intentions and can learn, adapt and communicate.

Agents are autonomous, active computer processes that possess some ability to communicate with people and other agents and to adapt their behaviours. Much of this work is concerned with activities such as scheduling and controlling computer networks. Indeed, Broadbent (1958) proposed his attention filter theory which specified that we could only attend to one input at a time. The theory suggested that stimuli can be filtered based upon physical attributes, prior to full processing by the perceptual system. The Filter theory proposed that attention was a limited capacity channel that determined the serial processing of the perceptual system. The Filter theory did not allow for the influence of long-term memory or meaning of the stimulus. However, studies showed that semantic characteristics of the stimulus did affect attention. In other words, attention filter is applied to catch routine and not-routine behaviors which react upon the environmental stimulus.

Furthermore, urban planning has largely placed the street user at the centre of infra-structural design, with significant implications for the perceived attractiveness of user environments. The urban designers faced with the task of designing such spaces, needs a tool that will allow different designs to be compared in terms of their attractiveness as well as their effectiveness. Therefore, this paper depicts an agent interface approach for creating a street simulator of user behaviors in urban street environments. We implement the agent interface as individual-based simulation based upon the previous research project called "SCALE" (A Street Case Library for Environmental design) (Chen and Chiu, 2004). The project is demonstrated to find out differences between the simulation and the existed environment, and the methodology is specified. The research methodology undertaken include: observation, analysis, prototype system, and evaluation.

2. Define the user behaviors and the street simulator

2.1. DATA ACQUISITION

Past studies on the relationship between people's activities and spatial information given by the environment suggest that such studies can provide general guidance for urban design. However, it is not at all easy to collect enough data for such studies; observing people's behavior in a physical environment requires time and also difficult to identify the factors that influence user behavior. By the research method using agent technology, we investigated the characteristics of activity in the Taichung city. One is the characteristic from time-integral and the other is from pedestrians' speed. By limiting the subject of the study to observing the relationship between visual stimuli and the behavior of people in the study area, we started to test the applicability of the developed system as a tool for observing people's behavior in window shopping and strolling activities, conducted an

experiment.The procedure and findings of the studies will be described in the subsequent sections.

2.2. PROCEDURE OF OBSERVING USER BEHAVIORS

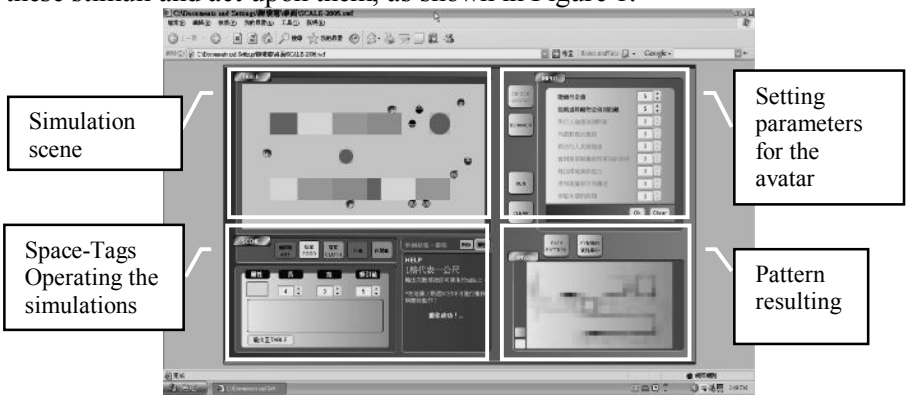
The methods of pedestrian behaviours research used to be classified broadly into 2 categories. One is the so-called "tracking observation", the other is "fixed-point observation". Tracking observation, which tracks pedestrians who pass through the given place. On the other hand, fixed-point observation enables us to count the data of pedestrians passing through a specific place in a given time interval. Tracking observation is effective in obtaining each data of each pedestrian's migration routes, and fixed-point observation is effective in obtaining data at each place.

3. The SCALE and the interface

The simulations are carried out in two-dimensional virtual environments. The interface is designed so that users can create their own environments and conduct these experiments. Before presenting the experiments, we briefly introduce the interface.

3.1. CREATING SIMULATION SCENE

The virtual environment is defined by a plane(x, y) of a street space, limited by a grid frame. In the area defined by this frame different tags can be created. In urban street environment, stimuli can range from more physical elements. These tags represent the following external stimuli, we characterize stimuli into six groups: (1) seats, (2) trees, greenery space, (3) signs, (4) shop, (5) parking, (6) public services (telephone, toilets, etc). The avatar agent perceive these stimuli and act upon them, as shown in Figure 1.



http://140.116.37.7/PUD-Agent/SCALE-2006.swf

Figure 1. The main functions of the SCALE system

The simulator as a set of the following individual elements: user behaviors, objects and environments. We have identified three underlying properties which are described by the quadruplet: (1) where user behaviors are properties of avatar agent, for example, a pedestrian walks, stops, seats and talks; (2) objects are the set of all represented passive entities that do not react to stimulus (e.g., street furniture in urban spaces); (3) environments are the urban street where agents and objects are located, where they can move and act, and (4) where signals propagate, such as sounds, smell, etc. These properties were derived from empirical studies of observing pedestrians walking in a shopping street.

3.2. PARAMETER OF THE BEHAVIOR

In order to create different categories of behaviour more easily we have identified two underlying parameters that contribute to the decision making process of the user. These parameters were determined both by video observation and by direct observation of a shopping street. The first is called static awareness and is a measure of how far in front the pedestrian perceives changes in the environment. The second factor is the desired walking speed of the pedestrian. Thus by changing these values we can easily alter the behaviour of each pedestrian in the simulation.

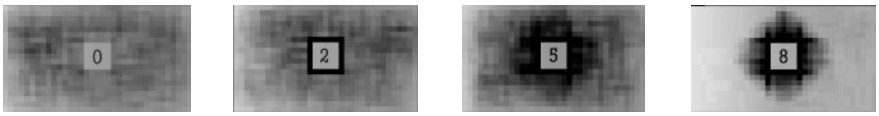
3.3. SIMULATIVE EVALUATION OF THE PEDESTRIAN PATTERNS

This section reports on a series of simulations – experiments – showing how behavior and environment influence each other, from local interactions between individuals and other elements of the environment to the emergence of global movement patterns.

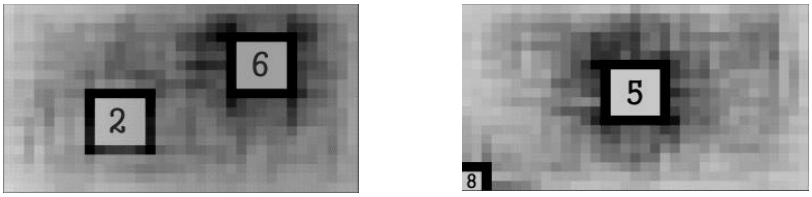
3.3.1. Experiment : Simulation Scene

The experiment presents a series of simple simulation runs to convey the idea that the change of street environment can have different effects on movement patterns and the use of space. We create three simulation scenarios, differentiated by the space-tags and varying the character of the composed elements. In this series we mix three types of pedestrians together in one scene. Each scene has a same number of pedestrians and the same proportion. In addition, in each simulation the run period is ten minutes. The movement pattern traced from simulation scene is displayed in Figure2. The simulation scene is described as follows：

Scenario-1 : Only one types space-tag infill, male=10, female=10, elder=10, random walking=0, detect distance=10, run time=10minutes.



Scenario-2 : Two types space-tags infill, male=10，female=10, elder=10, random walking=0, detect distance=10, run time=10minutes.



Scenario-3 : Four types space-tags infill, male=10, female=10, elder=10, random walking=0, detect distance=10, run time=10minutes.

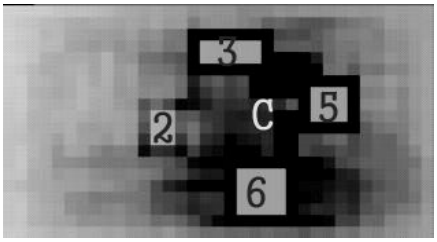


Figure 2. The simulation of various patterns

Comparing these three patterns, we see clearly that the differences of space tags and the location of the attractions in space affect the distribution of spatial movement patterns. All the differing effects are based on the interaction between each individual and the elements it perceives. The patterns generated from this experiment, and the trace of movement pattern is a useful technique for graphically recording the dynamic quality of behavior and environment relationships. In brief, the above simulation suggests that quality of visual information observed has an important influence in guiding pedestrians each street. A visual indication that shops were located further, such as continuous street surface design, integrated design of street signs or street furniture, was an important factor for guiding visitors. Reviewing these results, it is possible to assert these patterns of recorded paths in the real walk that the system can be used to observe people's behavior during window shopping and strolling activities.

4. Discussion

By observing human behaviors, the interaction in the virtual environment can be enhanced through agent interface. Based on the results of this study, some issues are discussed.

4.1. HOW CAN THE BEHAVIORS IN A STREET ENVIRONMENTAL SETTING BE REPRESENTED AND SIMULATED?

The SCALE has the ability to deal with a number of factors including walking speed, pedestrian density, and levels of service at quantitative levels. At the subjective or perceptual level (qualitative) the model has the capability to represent and simulate subjective aspects of pedestrian behavior which influence both random walking behavior and static behavior.

In other hand, the microscopic modelling approach and emergent behaviour within the model allow not only the representation of walking speed but also the property of these variables by a number of attributes (for example, gender and age). This property is important because it increases our understanding of a number of factors that influence walking speed and density. Therefore, SCALE has an important contribution to make to the development of theory as it relates to pedestrian use of street space, architectural and design theory, and the further development of the computing application itself.

4.2. THE MEASUREMENT CRITERIA FOR THE BEHAVIORAL PATTERNS OF HUMANS

We have mentioned previously that the development of the behavior rules for the model will encompass subjective and objective elements. A measurement issue that still needs to be further investigated in SCALE is how to define the nature and attractiveness or unattractiveness of features of the built environment for pedestrians. Objective behavior of the pedestrian is that which is directly observable and measurable by visual means, for example, through the use of video cameras or time-lapse photography. Subjective aspects of behavior include perceptions, past experiences, and attitudes, that is, those factors which are unobservable and can help to determine and influence observable pedestrian behavior.

4.3. VISUALIZATION OF PEDESTRIANS' BEHAVIOR AND ACTIVITY USING AGENT-BASED SIMULATORS.

We implement some scenarios founded in the pilot studies as computer scripts in the agent-based simulators. In such attempts, the work contribute to the understanding of the effects of specific interventions and their potential to

achieve desired changes in pedestrian mobility, behavior and perception. Then by the visualization of hot-points, we succeeded in showing the places where pedestrian tend to stay, or pass and analyze the relation between urban space and pedestrians' activities. Thus, the urban designer can test the effects of any design changes through the SCALE simulators on pedestrian behaviors before their implementation, and allow us to explore how the layout of urban street space affect human behaviors within it, what kinds of factors afford them more enjoyable walking experience.

In summary, this study proposes an agent-based platform allows the urban designer within the model scalable environmental features to represent those that currently exist and those that are planned for the future. Presently, the range of behavior we model has not yet reached a higher cognition level.In the future, our intention to initiate behavioral studies to formulate rules that represents action execution, rising up to the motivation level representing action and comparison with other streets is necessary.

Acknowledgements

The author is grateful for the assistance by Chia-Hsueh Wu. This study is supported by the Taiwan National Science Council, grant-NSC 94-2211-E-468-001.

References

Arthur, P. and R. Passini. 1992. Way-finding. *People, Signs, and Architecture.* McGraw-Hill.

Alexander, C., Sara, I., & Murray, S. 1977. A Pattern Language. New York: Oxford University Press.

Berlyne, D. 1960. *Conflict, Arousal, and Curiosity*. New York: McGraw-Hill.

Chen, C.H. and M.L. Chiu, 2004, Learning from the old street experience with computer agent interfaces,*3rd Great Asian Street Symposium*, *GASS*, National University of Singapore, pp.40-41.

Chen, C.H., H.T. Lin and M.L. Chiu 2004, A scenario-based agent system for digital city interaction, *Proceedings of CAADRIA* 2004, Korea, pp. 693-705.

Benyon, D., P. Turner and S. Turner, 2005, *Designing Interactive Systems: People, Activities, Contexts, Technologies*. Addison-Wiley.

Deutsch, J. & Deutsch, D. 1963, Attention: Some theoretical considerations. *Psychological Review*, 70, 80-90.

Eysenck, M. 1982, *Attention and Arousal*. NY: Springer-Verlag.

Ishida, T., Nakanishi, H.,2003, Designing scenarios for social agents. in Zhong, N., Liu, J., Yao, Y. (Eds.), *Web Intelligence*. Springer, Berlin, pp.59–76.

Jiang, B.,1999,SimPed:Simulating Pedestrian Flows in a Virtual Urban Environment. *Journal of Geographic Information and Decision Analysis* (GIDA), 3 (1), pp.21-30. http://publish.uwo.ca/~jmalczew/gida_5/Jiang/Jiang.htm#Contents

Neisser, U. 1967, Cognitive Psychology. New York: Appleton-Century-Croft.

Reynolds, C. W. *Computational Models of Complex, Life-like Behavior*, http://www.red3d.com/cwr

Therakomen,P. 2001, *MouseHaus.class : The Experiments for Exploring Dynamic Behaviors in Urban Places*, Master Thesis. Department of Architecture, University of Washington, USA, URL at
http://depts.washington.edu/maushaus/newMH/mousehaus/mousehaus/ mousehaus.html