Space Tags and User Behavior Modeling

Applying agents to detect navigational patterns in urban streets

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Urban pedestrian studies on navigation have been conducted for developing applications to ease the task of exploring in a virtual environment. As navigation in virtual environments is evidently difficult and as many virtual worlds have been designed to be used by untrained visitors that explore the environment, navigational supports are critically needed. This study is aimed to collect information about the user needs in order to build a model of user preference and produce simulative scenarios that can reveal the navigational patterns related to street design. The study is based on the attention theory for studying people who are socially interacting with street activities and furniture within designated areas. Furthermore, the study attempts to apply agent interface develop a prototype system with space tags. Finally, the system and its applications, and major findings of these applications are reported.

Keywords: *space tags; navigational patterns; street; agent interface; user behavior.*

Introduction

spatial cognition is important for inhabitants to organize memory and provide useful clues to functional tasks. Particularly in architectural and urban design, user behaviors are unknown to the designers. The gap between the assumption and the actual behavior is wide. Therefore, this paper attempts to explore the navigational patterns in streets for urban design purposes. Meanwhile, "what-if" conditions become a typical approach for environmental designers to better understand the user needs and actual behaviors. At present, we have developed a prototype model of the navigational system with Space tags. The model was derived from the point of view of attention theory and agent technology.

Agents are autonomous objects created by software for specific tasks. In artificial intelligence, there is a strong view of agents; they have desires, intentions and can learn, adapt and communicate. According to Neisser's theory, both properties of the stimuli as well as semantic factors play a role in attention (Treisman and Gelade, 1980). Neisser (1976) argues for a constructive view of cognition in which perception is shaped by existing knowledge and hence attention is influenced by experience. Indeed, theories proposed by Deutsch & Deutsch (1963) and Norman (1968) suggested that all inputs are analyzed but only pertinent stimuli were attended to. Eysenck (1982) examines the relationship between attention and arousal. He con-

cludes that there are two types of arousal: a passive and general system that can raise or lower the overall level of attention, and a specific, compensatory system that allows attention to be focused on certain task or environmental stimuli. In other words, attention filter is applied to catch routine and not-routine behaviors which react upon the environmental stimulus. Therefore, the research methodologies undertaken include: observation, analysis, prototype, and simulation. This paper first introduces the space tags for remarking the hints or memory in the study of street design. Secondly, it creates a prototype system to simulate the navigational patterns from observation. Third, agent interface is invented for identifying the navigational patterns. Fourth, issues are examined. The preliminary findings, demonstration, and testing results are presented.

Related Work

Urban pedestrian studies are an important research paradigm. The researches include social behavioral studies, the creation of programs for behavioral simulation, and the interpretation of the simulative results. For instance, Ishida (2002) developed the web-based FreeWalk system that is applied to a digital city project (Virtual Kyoto). It simulates the social interactions with the script language (Q) in order to make interactive scenarios between users and social agents. The characteristics of the system include:

- to recognize the users' positions all the time based on the coordinates values input in the system.
- to interact with the agents which are automatically created by the program using a given scenario, and with other users' avatars by means of 3D Chat.
- to provide input and scenario simulation service using the script language.
- to enable multiple users to create their own avatars on the internet and participate in the evacuation simulation.

We had considered the above functions in building a navigational system, while users can navigate easily with the assistance of agents to detect navigational patterns in urban streets.

The scope of this study

In urban places, people pay attention to attractive objects visually or acoustically. Paying attention to something makes us to see these objects more clearly, more accurately, and remember better. There are different ways to pay attention such as we can turn head, or eyes, or even make a step toward an interesting object in an environment. Using the analogy to the real space, people can visit plenty of scenes and sightseeing when situated in a digital city. Therefore, a prototype model of the street navigation system is developed. The study proposes that a digital city should provide a universal location identifying system using Space tags and other location-aware information system. The street navigation system with Space tags is a web-based platform to support digital data and is a media suitable for city guide information and social interaction, Figure 1. This paper particularly focuses on the agent-based interface.

Space tags

Signs and signals are often visually accessed by people for ease of direction, orientation, and guidance. This study proposes the concept of "Space Tag" for marking the attractive space and activities by users. Related literatures about Space tags are listed as below:

- Space tag is an interface operated with other

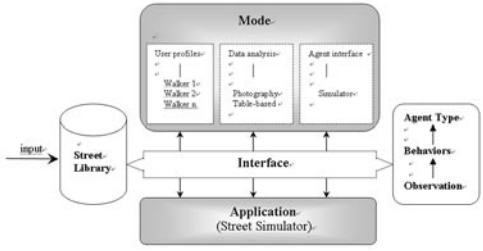


Figure 1
The Prototype System and Agent Interface

media allows data to be tagged to its objects, which is central to development of a 3D GIS (Batty, 2005).

- Space tag is an electronic tour guide to provide a variety of information for tourists by mobile devices (Brown, 2005).
- Space tag is a digital object that has at least the following attributes: ID, data type, effective zone, effective time period, access rights, channel, sounds, colors, etc (Ishida, 2000).

In brief, Space tags are virtual or physical objects that can be accessed only within limited area and limited time period for specific purposes. Location-aware digital objects can be stored in a database on a server which is required to manage Space tags objects.

The User Behavioral Model

Ethnologists such as Lorenz (1973) and Tinbergen (1951) viewed behaviors as being complex, temporally extended patterns of activity that address a specific biological need. As such, each behavior is viewed as a self-interested goal-directed entity that competes against other behaviors for control of the creature. They compete for expression based on a measure of relevance to the current internal and external situation. Each behavior determines its own degree of relevance by taking into account the creature's internal motivational state and its perceived environment.

The purpose of this study is to develop a street navigation system by storing the changing positions of users and objects in the database which is analyzed to make a prediction model. After users enroll the system, avatars will represent users to interact with the virtual street environment. According to user behaviors and purposes, we can classify users and develop a user model containing user information. Based on the classification of users and space, we developed a user behavioral model which can respond to virtual street environment intelligently. The current set of behavioral rules is based on "common sense" assumptions about how people behave in certain situations, such as users walking along a shopping street. The functional rules for avatars in the system can be expressed as:

Action-Direction: {Straight, Left, Right, Choice, Avoid}

- Straight: the avatar moves forward in the straight cell
- Left: the avatar moves diagonally forward into the left cell
- Right: the avatar moves diagonally forward into the right cell
- Choice: the avatar makes a decision based upon the value of the attractor
- Avoid: the avatar avoids moving forward, but moves into either the left or right cell

As shown in Figure 2, a working range is a sector where the avatar's location is in the centre. The process which determines local movements of avatar uses their viewing fields in order to avoid collision against obstacles such as other avatars. As each avatar has their own walking speed and direction, radius of body, and current location (x, y). When collisions are expected, the next step will be modified so that they can always keep a certain distance between other avatars.

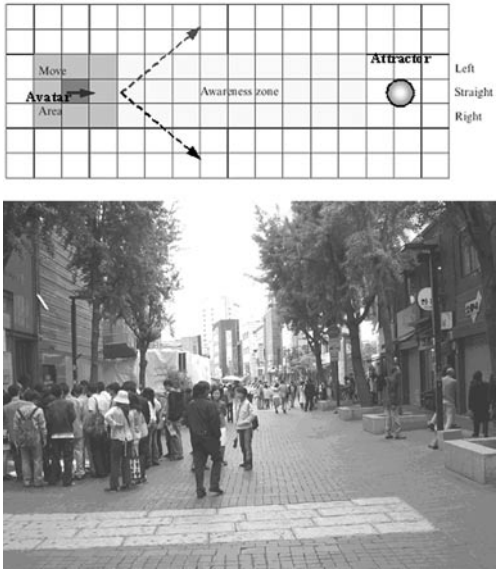


Figure 2
The scope of the avatar's movement

Street Activities and Attractions in the Street

As an example of a commercial street, Jing-Ming Street in Taichung City is chosen for the research. The attraction of the street is strongly related to the people movement and street activities as observed. There are various kinds' activities namely, walking, people-watching, eating, relaxing, chatting, gathering, and performing along the street. These noticeable features in the Jing-Ming Street are classified into two major categories as follows:

- Physical features: These are referred to all tangible features in the street, especially architectural features, which include landmarks, open spaces, and shops. Landmarks are referred to physical forms that are monumental or symbolic meanings to the people.
- Non-physical features: These are referred to all the intangible, non-permanent and mobile features which can be classified as (1) general ambience: General ambience represents the nuances of the street, scenery, and also people's activities which can be perceived during experiencing the street. The best way to perceive ambience is by walking through the street and experiencing the nuances of the street space; and (2) specific ambience: Specific ambience represents all features mentioned by the perceiver, such as street performance, vendors, foods, culture, etc. (Figure 3).

Navigational Patterns in the street

The idea of "patterns" reflects the perceived regularities in an environment. For instance, Alexander's "Pattern Language" (1979) depicts common uses and activities in architectural and urban spaces. Alexander's patterns for architectural features are at different levels of abstraction. Each pattern expresses a relation between a certain context and system of factor which occurs repeatedly in that context and a solution which allows these factors to resolve themselves. Similarly, urban design situations can be summarized as a pattern language for describing the relationship between the residents and the space. Therefore, design scenarios can be derived from empirical studies, such as to have greenery space and decorated pavement surround a coffee shop in a street corner where people can sit outside because it creates a pleasant atmosphere. Empirical use patterns are "informal" design guidelines for urban design. Comparing with formal urban design guidance, the advantage of these patterns is to provide examples for simulation and evaluation. Thus, patterns are embodied as concrete "situations".

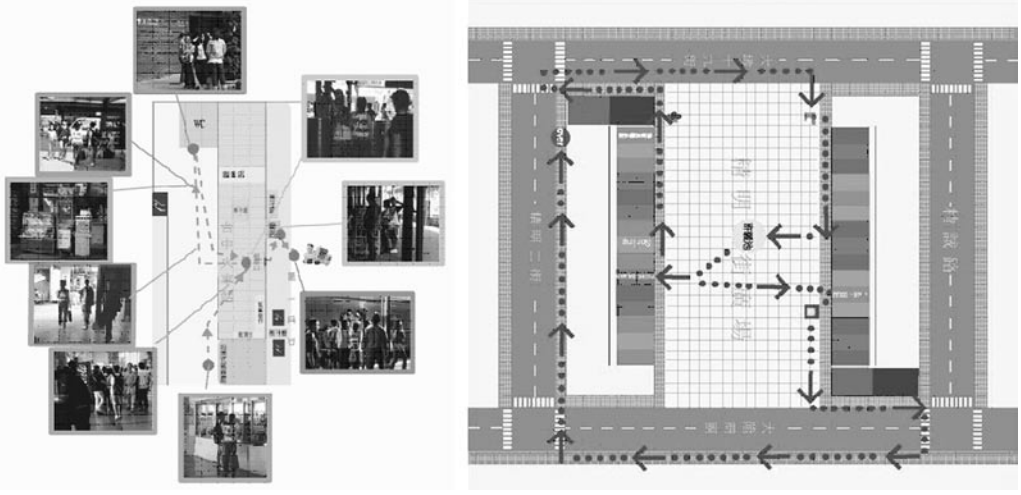


Figure 3
Sequence of images with position and location detection during the walking in a street

Environment	Behavior	Situation
In street sidewalks	wander	Aimless when an undesired stimulus appears
In street sidewalks	pass through	Success in achieving goal when an undesired stimulus(streetlamp) appears
A large tree is planted in middle of a street	avoid obstacle	Move away from streetlamps or parterres
Orientation signs for showing information in a street corner	avoid collision	Detect the distance and location when a sudden stimulus(streetlamp) and people appear
In a small greenery space that is connected with a street	seeing others	Green spaces, especially under trees are also used to do activities due to the tropical climatic conditions in the daytime
Public facilities are located in middle of a street	follow others	Fun to play with something and evoke attention when sitting in the arcade
The artists and musicians used the street space to gather and discuss their performances with each other	searching stimulus	Looking for a logo (a coffee shop) in a street
Food stalls for resting and chatting	seeking goal	Looking for a rest area or seats
At the crossroad, visitors try to way-finding	asking people	The diversity of activities and products sold by vendors along the arcade

Table 1
Scenarios implemented

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 Space-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 (toilets, etc) (Chen and Chiu, 206). The avatar agent perceives these stimuli and act upon them.

Navigation is an activity of search and exploration. Urban navigation is concerned with finding out about locations and moving through an environment. By using avatars, we can walk around and realize the virtual environment in 3D scenes. Space tags in the virtual environment are referred to the location and activities and an avatar can interpret the meaning for association and further instruction. Thus, avatars of the navigation system can access Space tags on the web or with mobile devices. People walking around in a street can not only find and add Space tags for reminding, but also sharing information with the others. They also can put Space tags at the location where he or she is, which can be found by other people nearby. This function also enables social interaction among the local community.

Avatars in street are a basic element and it is needed to analyze the relationship between characters based on these avatars'"action category". A qualitative analysis was performed on the Table 1. Each of these behaviors needs both signals from external perception and internal state to drive them to move around and react to their environment.

Agents as Navigational Aids

To identify potential problems, the scenes were modeled as close to the existing environment as possible as well as realistic human behaviors. Presently, these scenes often do not include motivated agents because human motion is difficult to create. The animation of the high-level behaviors of humans is particularly difficult and time consuming to produce. Thus, we adopt an empirical approach for generating reactive path based on the user's examples of the desired behavior. The examples are used to

Figure 4
The user interface of the system with Space tags

build a model of the desired reactive behavior. The model is combined with reactive control methods to produce 2D user movement simulation, Figure 4. Some scenarios are demonstrated for highlighting the relationship, Table 2.

Through the results of the simulation and observed data from the study of retail behavior in a shopping street, it is clear that velocities of people tend to be rapid at streets between each sight, and become slower near the goal or crossings. Furthermore, places where people tend to stay longer or walking slowly, and those where they are gathering,

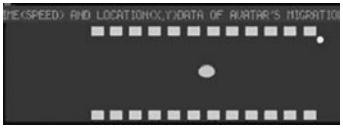
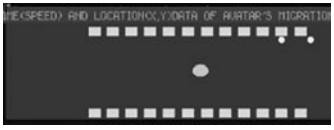
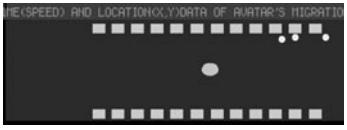
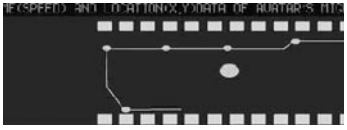
Time	Avatar's Behavior	Agent Interface	Current Position and Location
After 60 seconds			
After 120 seconds			
After 150 seconds			
After 300 seconds			
After 420 seconds			

Table 2
Sequence of simulation with position and location detection during the walking in a street environment and navigation with the agent interface

are found. Then we can find out places whose commercial potential is high or how much it is crowded at the streets.

Discussion and future studies

Cognition Map and Human Memory

The preliminary results of the study indicate people tend to think in activities, events and needs. Which general routes do users choose? What are the most interested places? How do people move and place themselves in urban street? In our study, the Space tags and agent provides navigation support for visitors of virtual street environment and helps designers with the organization and layout of street environment content and the tuning of interaction possibilities.

However, first-time visitors acquire information about the virtual environment that is then augmented and modified on return visits. The memory of places we have visited may guide us back to those locales. The classic model of spatial learning proposes that individuals first acquire route knowledge, then begin remember the existence of landmarks, trees and signs, although not their location. In addition, the navigational system can serve as a tool to research virtual environment and their evolving social impacts. With Space tags, we can implement attractions and entertainment scenes at events or activities, like festivals. If a city offers many attractions by Space tags, many people will visit there, explore only those they need, like sightseeing information and to enjoy them.

Scenarios and Navigational Agent Interface

There are important issues to be considered as to what people want to do (intention) and what information is kept on them. However, the exploration through our empirical studies of user behavior in the "real world" is undertaken; what are the measurement criteria for the behavioral patterns of users?; and how feasible are the behaviors be observed and simulated? We implemented scenarios founded in the pilot studies as computer scripts in the agent-based interfaces. In such attempts, the work will contribute to the further understanding of the effects of specific interventions and their potential to achieve desired changes in user mobility, behavior and perception.

In addition, "Guide Map" can be used to provide navigational information and supplemented with additional details about the tags in the environment. In other words, "maps are social tags", they are there to give information and help people explore, understand and find their interests through spaces. Even when we are not directly looking for information we use a wide range of cues, both from features of the environment and from the behaviors of other people to manage our activities. Thus, a virtual environment with multi-purpose space tags and navigational aids such as guide agents will be useful for interesting navigation.

Future Studies

An important further step of this research will concern the degree of changeability that is desirable or acceptable for users. As indicated, agents may become more "adaptive", the virtual environment itself tends to become more complex, and consequently multiple agents as needed may be present at same time. In the next step, we will incorporate spatial locators such as GPS to investigate human activities in an urban street, and examine the possibilities of application for the urban street design.

Acknowledgements

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