A STUDY ON MODELING OF HUMAN SPATIAL BEHAVIOR USING AGENT

Hiroyuki TANAKA*

Kay KITAZAWA*

Ryosuke SHIBASAKI*

*Shibasaki Laboratory, Institute of Industrial Science, University of Tokyo

Address: 4-6-1 Komaba, Meguro-ku, Tokyo, 153-8505, Japan

Tel: +81-3-5452-6417, Fax: +81-3-5452-6417

E-mail: tanayang@iis.u-tokyo.ac.jp

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ABSTRACT

If we can understand what kind of information is acquired when people behave in urban spaces and how the acquired information affects the behavior, this kind of knowledge can be applied for planning and designing of urban spaces where people can move safely or comfortably. Recently, needs for a detailed human spatial behavior model are increasing. It is partly because urban spaces have been highly and complicatedly developed and partly because people can acquire various information due to the development of information technology. These changes imply that various information can be easily offered to people who behave in urban spaces. So a model which can describe human behavior in detail will be helpful to realize context-aware services based on individual locations, purposes, preference etc.

In existing studies while there are a lot of macro models targeting wide urban areas, there are few examples in which human micro behavior models were built by detailed observations. In this research, we built a human spatial behavior model targeting a commercial space. As the first step for modeling, we conducted an observation experiment together with questionnaire surveys to build a hypothetical model. We identified some major factors that affect human behavior from the experiment, and built the hypothetical model on the basis of these factors under some preconditions

1. INTRODUCTION

Recently, needs for a detailed human spatial behavior model are increasing. One of the reasons is that urban spaces have been highly and complicatedly developed. In the big cities in Japan, more advanced and complex commercial spaces, station spaces and underground spaces are being built with a concept of urban redevelopment. It is important to consider how people can move comfortably or evacuate quickly in case of disaster during the plan and the design stage of such urban spaces. When we considered such kind of problems, it is necessary to understand basic ideas of human spatial behavior in detail.

Other reason is that people can acquire various information due to the development of information technology. For example, drivers can acquire information about the traffic jam or the location of the nearest gas station from Intelligent Transportation System (ITS), and they may change their traffic behavior referring to these information. Due to the wide-spread use of mobile devices such as a cellular phone, passengers can also acquire information and schedule their behavior plan referring to information. Thus, if such situation emerges, context-aware services based on individual locations, purposes, and preference are highly required. In order to realize such kind of services, it is important to know what kind of information is acquired when people behave in urban spaces and how the acquired information affects the behavior. However, while there are needs to understand human behavior, it is very difficult to actually observe this or build models in urban spaces where various factors are intricately intertwined with each other.

It is helpful to measure actual behavior trajectories and environment situations that affect human behavior to understand human spatial behavior. Such measurement technologies are being developed in recent years. And some researches are also conducted in our laboratory. For example, tracking passengers with laser scanner (ISHIHARA, 2001), the positioning system with RFID-tag (KITAZAWA, 2001), the automatic construction of 3D city model using TLS data (NAKAGAWA, 2001), etc.

In the existing studies, although there are a lot of macro models, for example, "Huff model" often used for consumer's destination selection probability in urban areas, or "Disaggregate Logit model" often used for traveling route selection based on utility maximization, there are few examples in which a human micro behavior model was built by detail observation.

In this research we will build a human spatial behavior model targeting a commercial space.

2. EXPERIMENT TO EXTRACT HUMAN BEHAVIOR RULES

A preliminary experiment and surveys were conducted in order to build a hypothetical model. In this experiment, subjects migrated in a commercial space for two hours with a positioning system (Figure1), and their migration routes were specified to some extent. After the experiment, we asked the subjects why they chose their routes, or what had them chosen their routes. We used six subjects who were all young women in order to omit the influence of age and gender. A commercial space called "The Venus Fort" in Tokyo was chosen for the experiment site. This is a suitable place where people can spend long time doing different tasks. Additionally, questionnaire surveys were conducted at some commercial spaces to ask what ideas would be actually considered during migration.

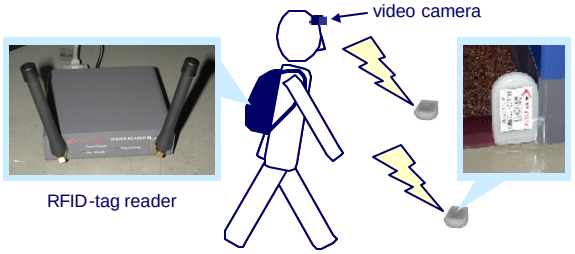

Fig1: Positioning system with RFID-tag and video

From these experiment and surveys, some major factors that affect human behavior were extracted.

- Whether cognitive map can be drawn clearly (Whether there are sufficient on-site knowledge)
- Whether there are clear purposes to come to a commercial space
- Whether there is a limit of time
- Whether there is a limit of money

3. MODEL PRECONDITIONS

On the basis of factors extracted by the experiment and the surveys, a hypothetical model was built. However, since some factors are very difficult to observe or evaluate objectively, some preconditions were prepared as a first step.

3.1. Agents

Three agents are supposed in this model, people, passages, and shops. Passages and shops are connected in a network expressed with links and nodes, and people are supposed to migrate on this network (Figure2). So, human migration behavior can be divided into three cases, "walk along a passage", "drop into a shop", and "come out of a shop". An attribute is given to each shop, which contains content of goods and a scale of the shop. The degree of charm and whether it is a destination are also given as the attribute based on people's preference and purposes (Figure3). These attribute of factors used to judge whether people drop into shops.

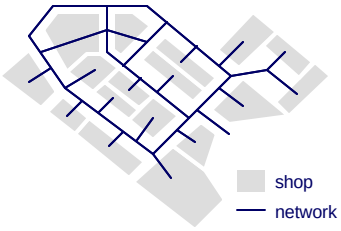

Fig2: Network of commercial

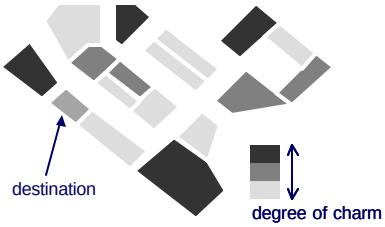

Fig3: Distribution of degree of charm

3.2. Cognition to commercial space

We have considered that cognition to a commercial space is divided into cognition to a shop, cognition to the location of a shop, and cognition to the network of a commercial space.

- Cognition to a shop

  It means whether people have knowledge about a shop name and content of goods.

- Cognition to the location of a shop

  It means whether people have knowledge about where a shop is located in a commercial space. It is thought that people who know the location of the shop is also know the shop name and the content of goods. So this cognition includes "cognition to shops".

- Cognition to the network of a commercial space

  It means whether people have knowledge about the network of a commercial space. Since a

commercial space usually contains a lot of shops, all of them may not be memorized. Therefore, people usually memorize only some stores suitable for their preferences. However, the network is a common infrastructure, so it may be memorized easily.

In this model, we have supposed that the above-mentioned three cognitions are not distinguished. So, "cognitive" means that people have all three cognitions sufficiently. Usually, the degree of cognition changes gradually and cannot be divided into only two groups, 0 (not at all) and 1 (completely). However, for simplification we have expressed the degree of cognition as 0 and 1. Here, state 0 (cannot draw cognitive map) means that people do not have any knowledge about a commercial space, and state 1 (can draw cognitive map) means that people have all knowledge about the commercial space (Table1).

Table1: Degree of cognition to commercial space

state	meaning
0: cannot draw cognitive map	do not have any knowledge
1: can draw cognitive map	have all knowledge

3.3. Purpose to migrate in commercial space

When coming to a commercial space, some people prepare clear purposes to buy something, but like window shopping, some people come to enjoy shopping itself and in such case people often do not have clear purposes. And usually the importance of purposes is also changed gradually. However, for simplification it is supposed that there are only two patterns people migrating in a commercial space, 0 (do not have clear purposes) and 1 (have clear purposes). Here, state 0 means that people migrate on the basis of their preference. State 1 means that people migrate to achieve their purposes (Table2).

A purpose is divided into two, "location specific purpose" and "goods specific purpose". Location specific purposes are achieved by going to a certain locations. Goods specific purposes are achieved by buying a certain goods, so people may turn around two or more shops that sell the same kind of goods for purpose achievement.

Table2: Purpose to migrate in commercial space

0: don't have clear purpose	migrate on basis of preference
1: have clear purpose	migrate to achieve purpose

3.4. Reference to on-site information

One of the big features of migration behavior is that behavior schedule is sometimes changed by information acquired during the migration and by the change of environment situation. People usually refer to on-site information, but how much information is made reference is dependent on individual character, amount of knowledge, etc. However, for simplification it is supposed that there are only two patterns people, 0 (do not refer to on-site information) and 1 (refer to on-site information). Here, state 0 is the case that people never refer to information not suitable to their behavior schedule. State 1 is the case that people refer to various information and if it

Table3: Whether refer to on-site information

state	meaning
0: don't refer to information	schedule is never changed
1: refer to information	schedule may be changed

is suitable for their preference or purposes, their schedule may change (Table3).

3.5. Difficult factors for modeling

In this model, following factors are not considered. These factors are so human specific that it is very difficult to observe, or to quantify.

- Migration with two or more people

It is difficult to know decision-making process in case of migration with friends.

- Physiological phenomenon

It is difficult to know what is the trigger of physiological phenomenon such as wanting to go toilet, feeling bad.

- Limit of money

Although it is possible to observe whether people bought goods, it is difficult to know what made people buy this goods in detail.

- Limit of physical strength

Although behaviors such as "resting on a bench since it got tired" is considered, it is difficult to know when people feel tired and want to take a rest.

- Psychological aspect

Some people buy something after careful selection, but some people buy impulsively. Some people can put into an interested shop rapidly, but some people hesitate and cannot put into easily. But it is difficult to express such kind of behavior deeply concerned with individual character.

- Satisfaction by migration itself

  Some people enjoy migration itself and feel satisfaction. But it is difficult to quantify such kind of satisfaction.

4. HYPOTHETICAL MODEL

Table4: All cases of human behavior

		can not draw		draw cognitive map	
		not refer	refer info	not refer	refer info
have clear purpose	location specific	A1	A3	C1	C3
	goods specific	A2	A4	C2	C4
not clear			B3	D1	D3

On the basis of the preconditions prepared in the previous chapter, we divided human spatial behavior into some cases as shown in Table4. Then we built hypothetical behavior models for each case. Detail explanations of some cases are given below.

As a fundamental framework of the model, a concept of "people take the optimal behavior based on given resource and cost for their purpose achievement" was adopted. Under this framework, people achieve multi-purpose, and sometimes change their purposes by referring to on-site information.

Figure4 shows the flowchart for case C3. In this case, people have all knowledge about a commercial space, and try to achieve their purposes, referring to on-site information. Since people know all about the commercial space, they can consider the optimal route that can make them drop into all destinations within a time limit. The technique adapting Traveling Salesman Problem (TSP) is used to calculate the optimal course. TSP is the typical technique of an optimization problem of searching for "The route through which travel distance becomes the shortest when a salesman visits every cities only once and returns to the starting city". If the calculated route does not satisfy the time limit, destinations are narrowed down according to their priority, and then calculate the optimal route again. People may drop in to interested shops other than the destinations, if there is enough time. This process is repeated until people return to exit.

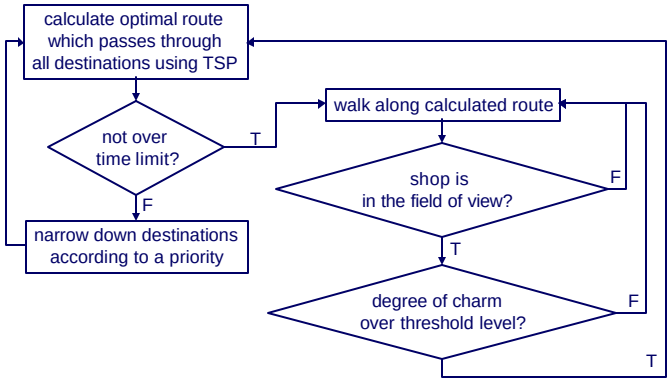

Fig4: Flowchart of case of C3

Figure5 shows the flowchart for case B3. In this case, people have no knowledge about a commercial space at all, and have no clearly purposes. So people migrate on the basis of their preference, referring to on-site information. Since people do not know any situation about the commercial space, first people select their route arbitrarily. When migrating a passage, people tend to select an unknown node. When a shop is in the field of view, people judge whether the degree of charm is over the threshold level, and if it is over, people drop into this shop. This process is repeated until people return to exit (when a time limit approaches, people return to exit through the shortest path).

5. CONCLUSUIONS & FUTURE WORKS

In this research, we built a human spatial behavior model targeting a commercial space. As the first step for modeling, we conducted the measurement experiment and the questionnaire surveys. From these results, some major factors that affect human behavior were extracted. Then, on the basis of these factors, we built the hypothetical models under some preconditions.

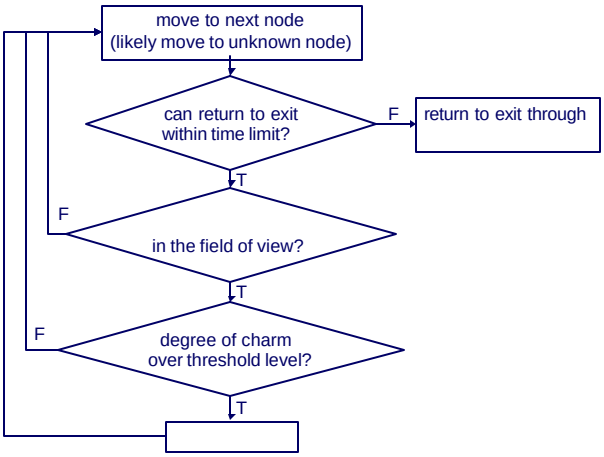

Fig5: Flowchart of case of B3

As future works, in order to verify the

validity of this hypothetical model, more detailed observation data for verification is needed. Since the positioning system used this time is inadequate, we have to improve the system to acquire the data. Moreover we also have to consider verification methods of the model. At this time, the hypothetical behavior models are built for some divided cases. But considering actual human behavior, each case does not occur independently but some cases may occur simultaneously. So we also have to consider a structure that expresses transition between each behavior model.

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