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Current models to estimate human's spatial behavior

Needs for human's behavior model in Urban Planning

Design of urban area is to design supporting systems for activities of those who use the area. It is, thus, essential to understand what kinds of activity exist or to make an accurate estimate the number of people to come to the area for an efficient urban planning. Since activities in urban area vary in an immense range, we should focus on the spatial phase of people's behavior to develop a model for the estimate. Several models describing how people move, or how they choose their destination in urban areas have already been proposed. This report aims at introducing those current models by giving general idea of each and suggesting a new technology for collecting necessary data to improve them.

Good Urban planning won't be done without proper appreciation of human behavior. Planners should comprehend the actual state of their city to solve problems such as insufficient infrastructure or lack of service, or to do some investment for further development of the city. The state of the area can be represented by the combination of following items.

- What kind of activity is done?
- When and where does it occur?
- How many and what kind of people are involved in?
- Is the activity permanent or temporary?
- Is the activity worth to support?
- What kind of infrastructure or service does it need?
- Does current systems support it enough?
- If not, to what extent and what kind of support should be done?
- Future plan of the area
- Interest of all people concerned etc

Planning should also be rational and reasonable. Since most urban development plans are projects of large scale, which involve many people whose interests sometimes clash each other, planners have to be able to give an plain account of whole the plan in fine detail to coordinate such complicated interests. Numerical data is the best way to make an explanation plain because of its objectivity. Thus, we have to go far beyond an appreciation of human behavior by conversion of it into any patterns or numerical formulas, which can be applied to another situation or can be used for comparison with several cases with different parameters. Knowledge of how people move in the urban area should be developed into certain human behavior models.

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Current models of human spatial behavior

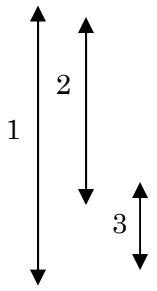
Current human behavior models falls under one of 3 headings:

1: Models for calculation of the number of potential visitors to the area or to the facility;

2: Models for visualization or representation of the actual flow movement of clouds;

3: Models used in the simulation of interaction among people in the same place

Level of Scale that each model covers is as follows.



Super-region (complex of megalopolises)
Megalopolis (City and surrounding suburban areas)
City
Area
Block
Building

■ Type 1

Models under this category are mathematical, not based on human actual movements but on collective numerical data such as statistics.

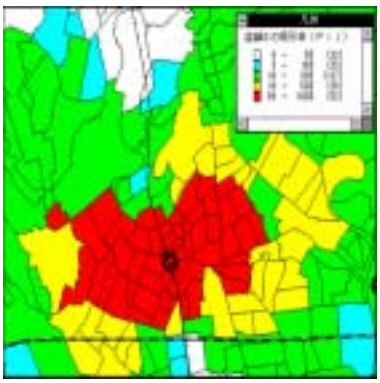
Aggregate models

Genetic Algorithm

This model is often used for estimate of population trends, making use of statistics. Behavioral patterns are to be caught as in/out flow.

Huff model

This model is used for location planning and market size analysis in the field of marketing as it shows the potential demand for the facility in that area. Planners and developers can easily see the best location where huge gains are expected.



Huff model

$$Pij = (\alpha j Kj / Dij\,\lambda) / \Sigma (Kj / Dij\,\lambda)$$

i= residence j= site of facility
Pij = probability of choice j
αj= attraction of j
Kj= capacity of j (size or sales)
Dij = distance between i and j
λ=characteristics of the area/product

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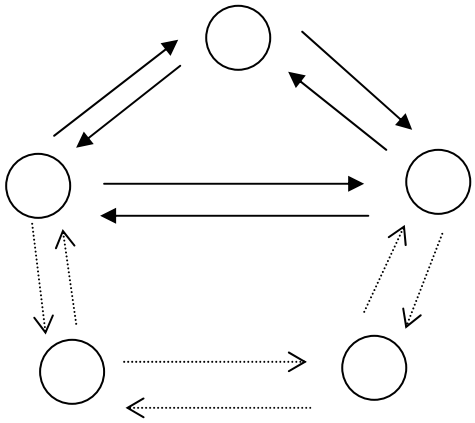
Disaggregate models

Markov chain model

This model is often used for representation of shop-around behavior (to go to a shop after another). It makes use of the idea that is " the probability of choose one option depends only to the last state (not whole past history)" .

When
time n N
any states $i_0, i_1, i_2, i_3 \ldots\ldots i_n, i_{n+1}$ S

$$P\{X_{n+1} = i_{n+1} \mid X_0 = i_0, X_1 = i_1 \ldots\ldots X_n = i_n\}$$
$$= P\{X_{n+1} = i_{n+1} \mid X_n = i_n\}$$



Markov chain model

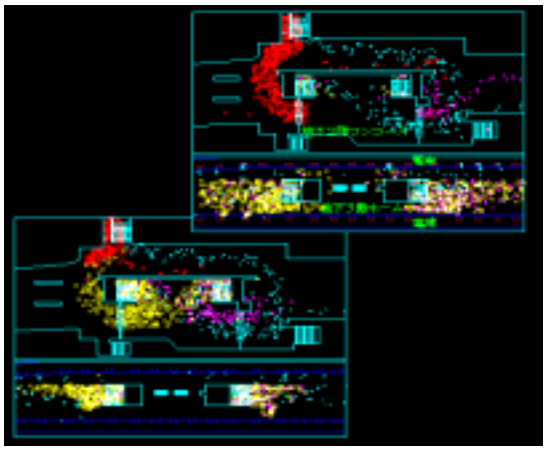
Poisson Regression Model

This model also makes use of probabilities and can be applied to forecast the distribution of frequency of travel either to central commercial area or suburban shopping districts.

■ Type 2

Representation of flow movement

In this model, people are regarded as mass, and the concept of system dynamics and fluid mechanics are used to explain the mechanism of flow movement of this mass. This model helps designers by visualization of observed human movements to understand how visitors use the space or the facilities in the actual situations. Sequential data may also give the hint of better floor plans to designers, clearly showing the bottlenecks of flow and obstacles in the space. So this model is often used in design process in the field of architecture or the science of disaster prevention.



Flow on the platform

The problem of this model is that we can't expect any accidents caused by people themselves because it doesn't take account of each person's movements, not to mention the interaction among them.

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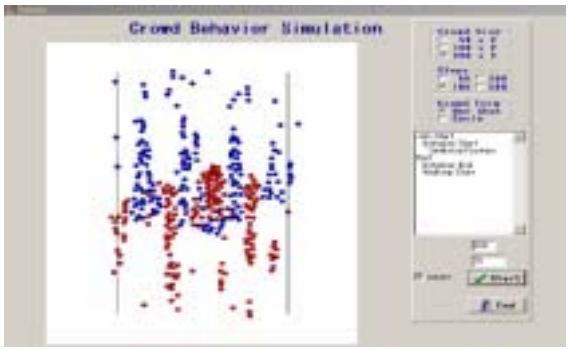
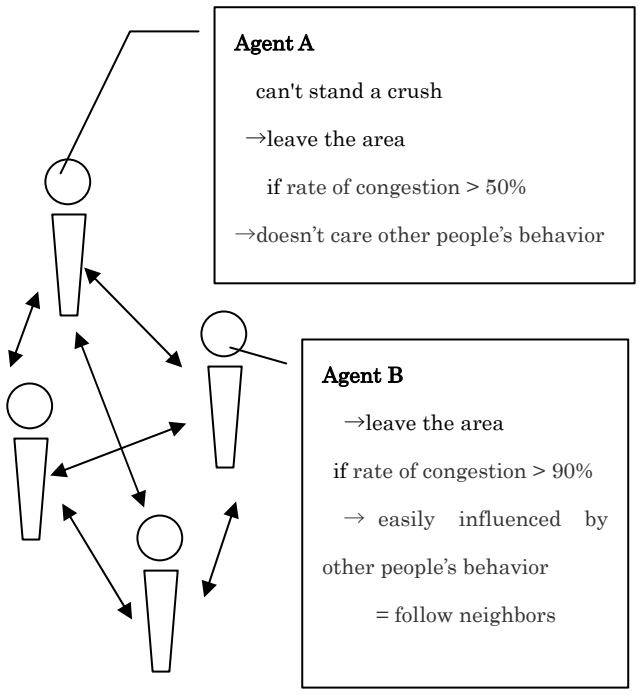
■ Type 3

Multi-agent simulation (e.g. SimCity)

The human behavior model used in Multi-agent simulation describes each person's movement as it is. That means an actor in the simulation, called "agent", reflects each person's characteristics, personality, his/her background and personal habit etc so that patterns of behavior (set of stimulus – response) can be set. There should be brought an interaction among many agents in the simulation, each of which has its own behavioral rule, autonomously acts, and changes its behavior according to the situations (including other agent's movements), which causes an unexpected event in the simulation as it does in the real world. Although there have been many simulations that illustrate different causes-and-effects, most of them can hardly deal with unspecified factors generated by mutual actions among factors. Since every phenomenon in the urban area is more than just the sum of all activities, its representation has to include the complexity of various actors and factors tangled with each other. Besides the ability of representing a phenomenon more realistic, the model used in Multi-agent simulation has an important advantage; items consists of each agent's "personality" can be easily modified or combined. When planners want to know how people driving the car behave in the situation of traffic jam, for example, the item which determines to what degree each agent can stand the feeling of discomfort without trying to get away from the congestion may be added to the agent's property, as well as the one of economical way of thinking (cost-benefit analysis).



Crowd behavior simulation



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Measures to get behavioral data for development of models

Whichever models are to be used in an urban planning, they have to reflect the actual human behavior with as high fidelity as possible, because the effectiveness of the plan depends totally on how correctly they could presume the activities of users. It becomes important, thus, to get reliable data for modeling. Existing measure of collecting data of human behavior in urban areas are as follow.

- Questionnaire
- Analysis of diary or schedule of a day
- Count of the number of the traffic in the area or at several points (traffic census)
- Sampling from images of Video or Photo
- Records of In/Out of entrance gate of the station (Train, Bus, Taxi)
- Diagram of spatial movement

The common problems of all these measures are concerned with cost and time. Since they entail works of data mining, that is an extraction of necessary parts from raw data, to get useful data for behavior modeling by these measures may be tiresome work. And even worse, since the data obtained by these measures are discrete, details of one's spatial movements can't be seen.

As information technology has been developed, some positioning technologies makes it possible to detect user's current position by using a certain kind of mobile telecommunication apparatus. If we can get the positioning data continuously, whole trajectory of human behavior can be easily obtained at by far less cost and time. Supported by strong needs for tracking spatial movements, increasing number of positioning systems being developed these days and accuracy of each is improving.

name	GPS	PHS/cellular phone
System	Calculation of the distance from 3 satellites, making use of the time required to catch the signals from each of them.	Detection of the nearest antenna or base transceiver station & Calculation of the distance from it
Accuracy	2-3m	20-500m
Merit/Demerit	Low cost, prevailing Not available in underground inside of the building	Easy to use Low cost Low accuracy

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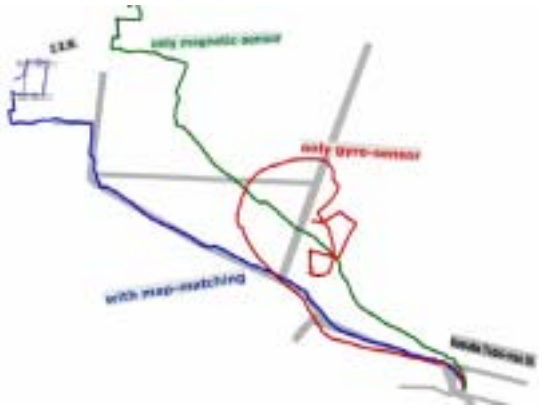
name	RFID-Tag	Pseudolite
System	When person with ID-tag comes near the receivers placed in the area, ID is read by radio-wave and recorded.	Setting small transmitter of GPS-like signals in urban areas (on the roof of building, underground passage, etc)
Accuracy	Depends on the interval of receivers	10-30cm
Merit/Demerit	Easy to maintenance High cost	Can be used as a complementary system of prevailing GPS

Besides the technologies above, let me introduce a new measurement system that has been developed in our laboratory.

Personal Positioning Systems

This system consists of a gyro sensor, magnetic direction sensor, and barometer. Under the notion of pedometer, relative position from the start point is calculated at each step so that whole trajectory of the movement can be obtained. We try to get mental process that has big influence on one's behavior by combination of Eye-motion capturer or electroencephalograph (monitor for brain wave) with PPS.



Trajectory obtained by PPS

Personal Positioning Systems

Future works

It is important to develop more faithful and easy-to-use human behavior model in order to make an accurate estimate of how the area will be used. Effective measures for collecting data are necessary as well as deep insights into the nature of human beings, a view from cognitive phase to think about what brings people comfortableness or so. After all, good urban planning is equal to provide better environment to all actors in the urban areas.

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