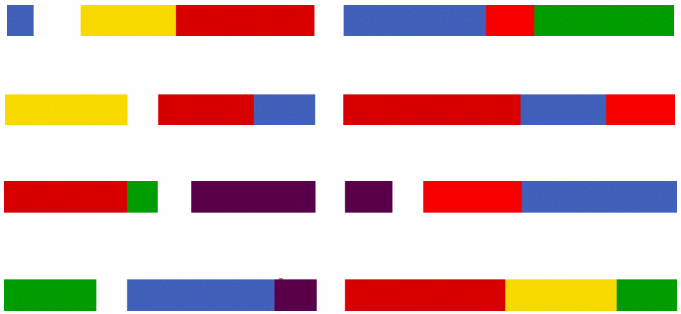
A Study for Agent-based Modeling of Migration Behavior of Shoppers



Kay Kitazawa, Hiroyuki Tanaka, Ryosuke Shibasaki

University of Tokyo kitazawa@iis.u-tokyo.ac.jp

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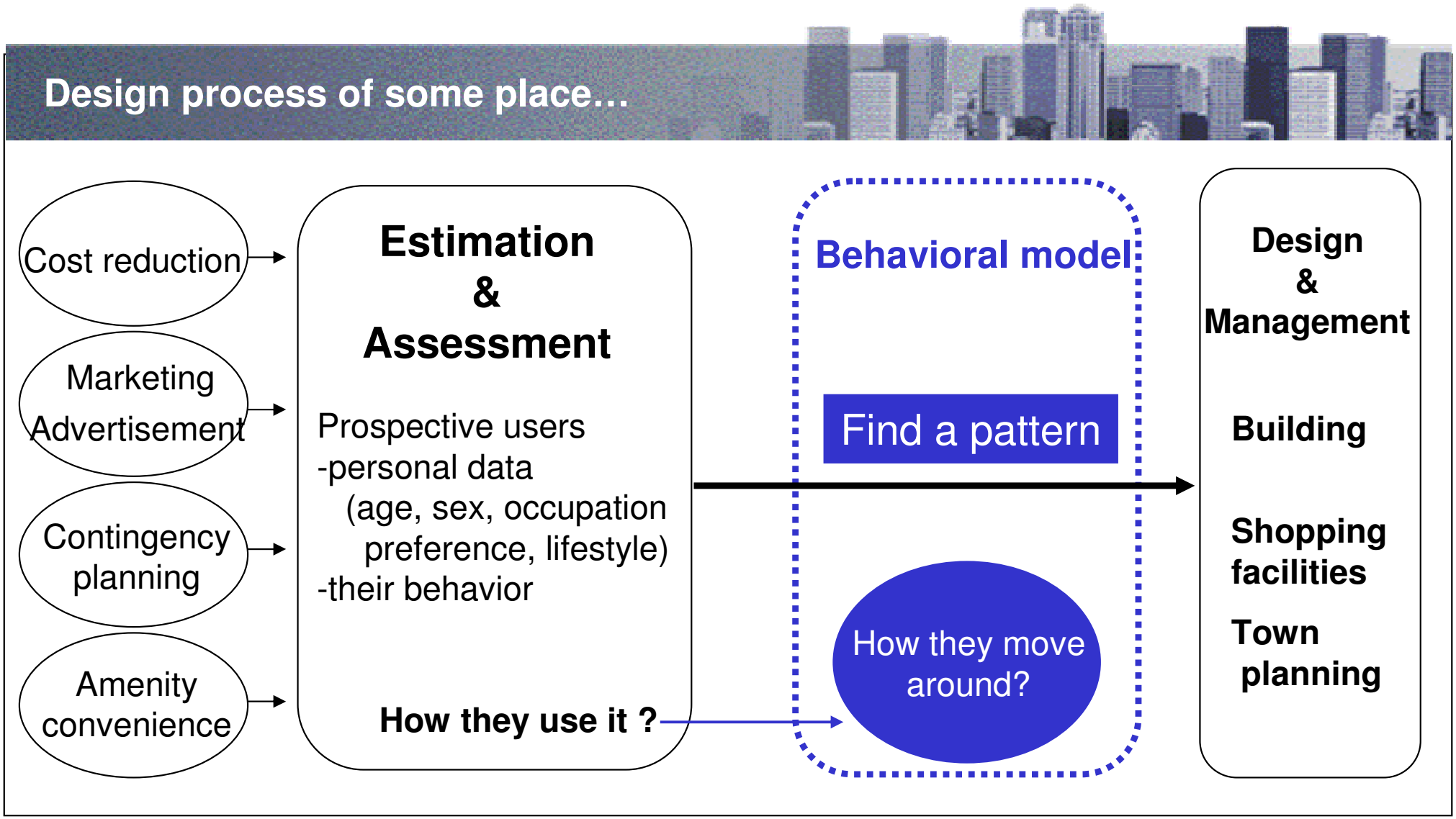
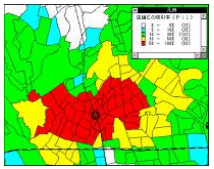
Why behavioral modeling ?



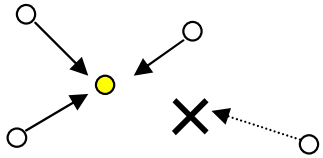
Current spatial model

Marketing **Traffic management**

Huff model
Disaggregate logit model



Location planning

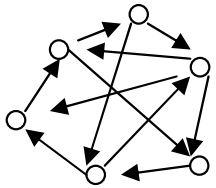


Probability of choice

Marcov chain model
Poisson regression model

Several destinations

Probability of transition



Single task **Choices are always rational** **Based on "nodes"**

One objective?

No error? Perfect?

Between nodes?

Combination and switch of several objectives

Limited-rationality based on lack of information

Focus on smaller scale

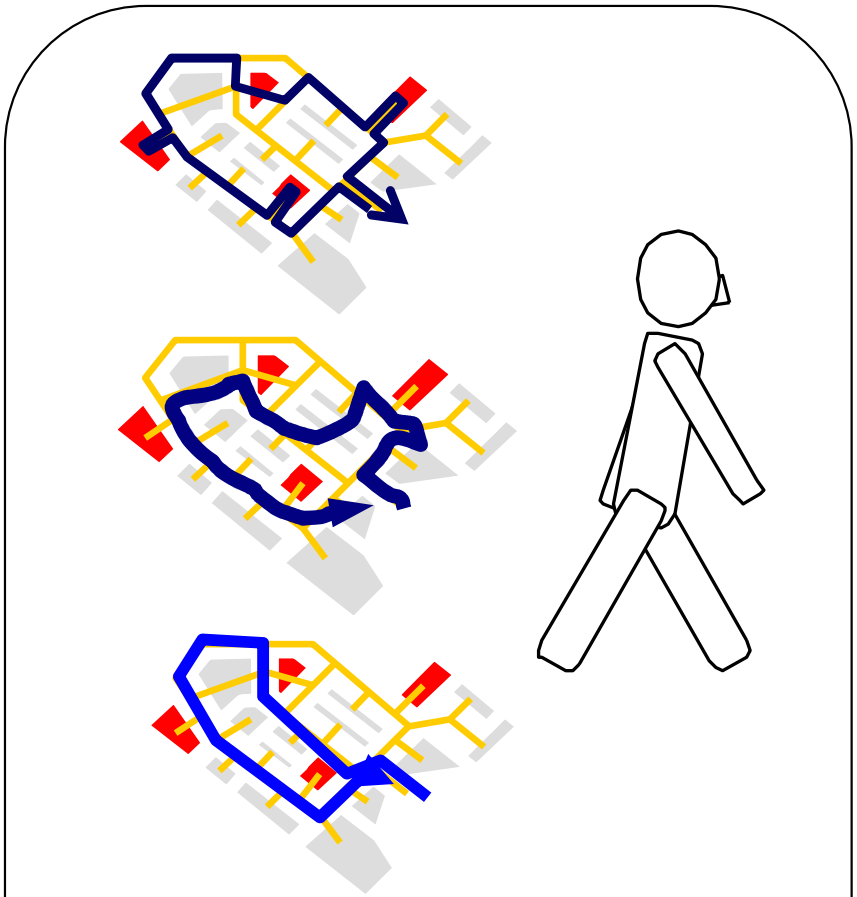
New behavioral model is needed

Spatial data mining & Modeling

Possible factors

$$P_{ij} = (\alpha_j K_j M_j / D_{ij} T_{ij} \lambda) / \Sigma (\alpha_K j \cdots$$

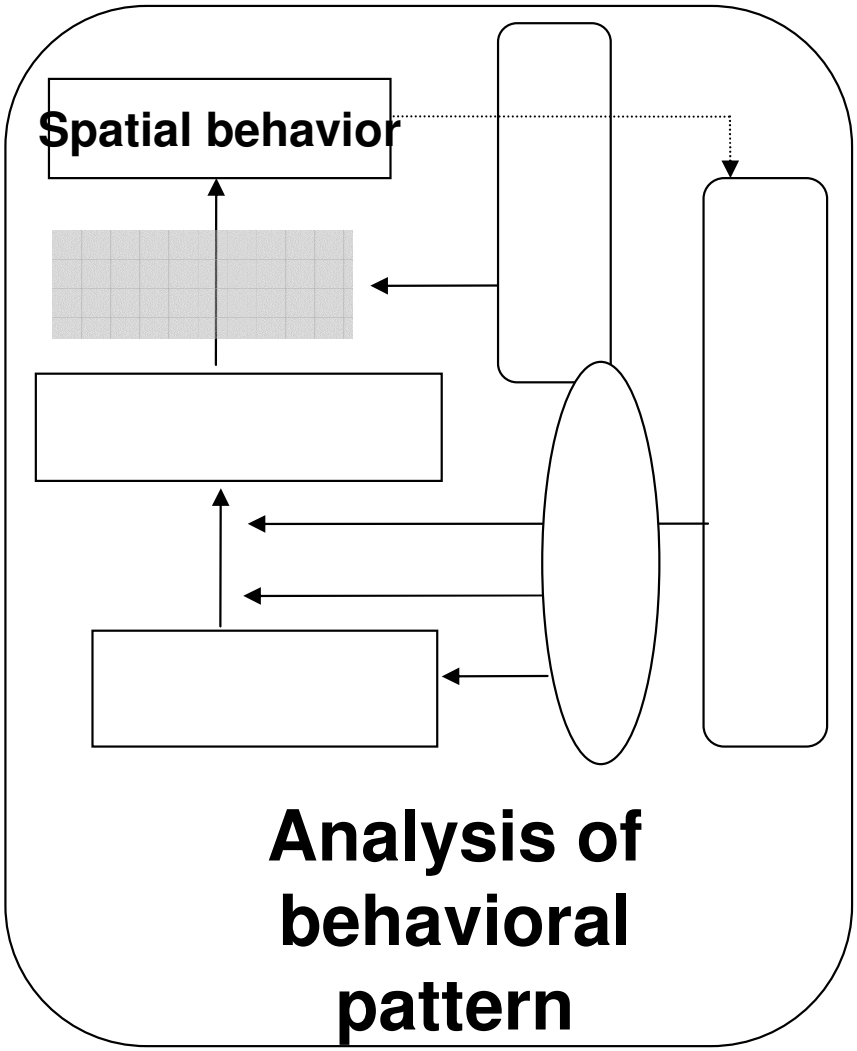
Spatial data mining



Paths of pedestrians

patterns

Modeling

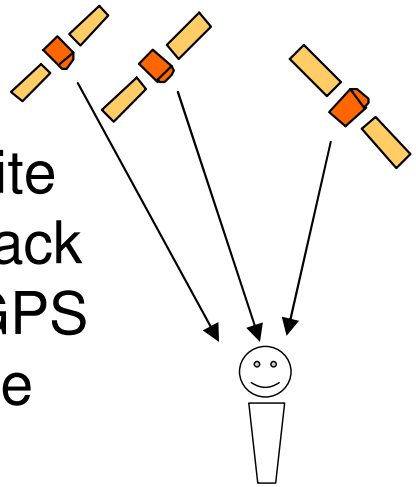


Analysis of behavioral pattern

Current positioning system

GPS-based technology

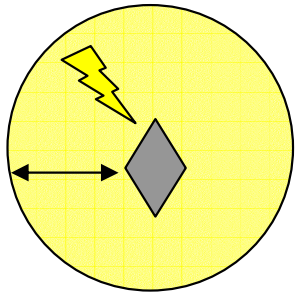
GPS
DGPS
Pseudolite
Snap Track
Indoor GPS
GPS One



advantage	weak point
- global standard - high accuracy	- unavailable in some area - multi path problem

“base station” technology

PHS
Ultrasonic waves
RFID Tag
Beacon
(GI Stone)



advantage	weak point
- can be used everywhere	-Cost -Not standar-dized

Tracking technology

Magnetic direction sensor
Gyro sensor
Video image processing
Laser scanners

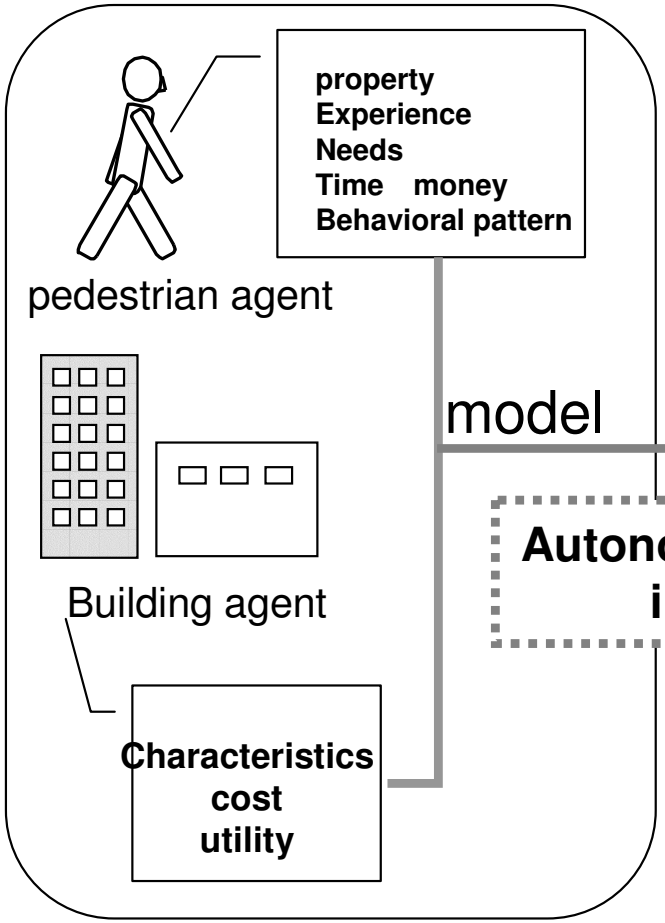
advantage	weak point
-can be used everywhere - detailed data	-Size -Low accuracy

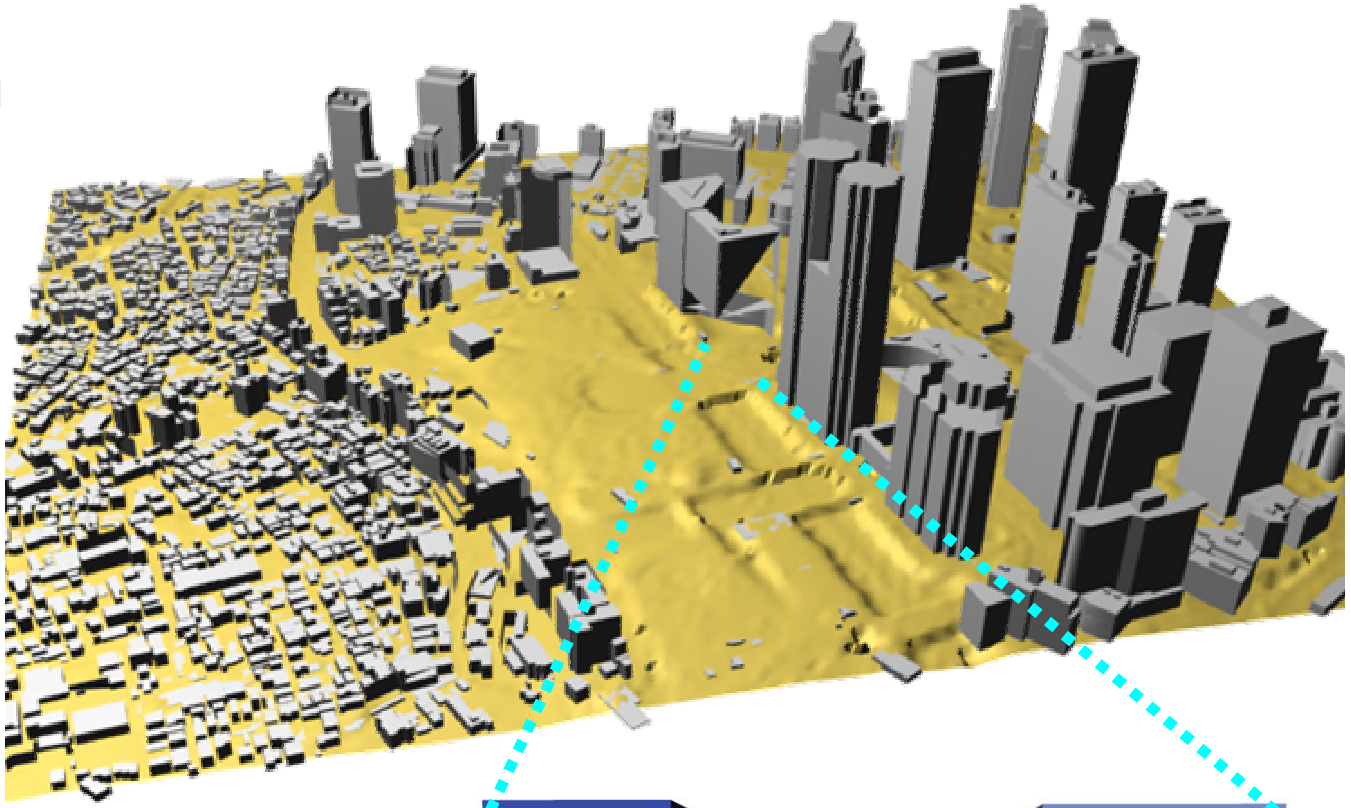
Data collection

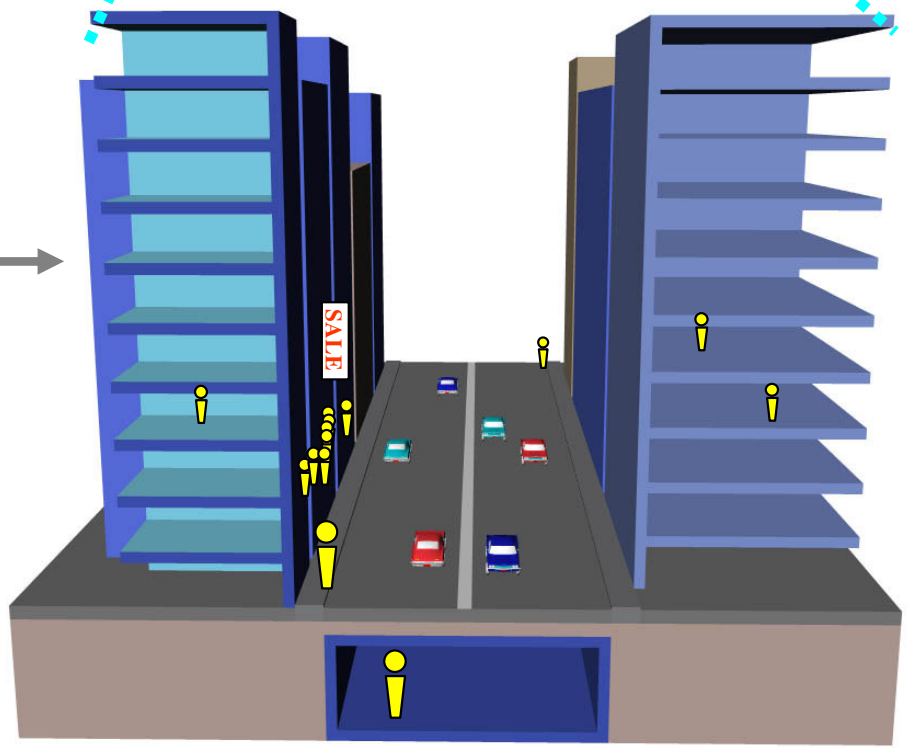
Multi-agent simulation

-testing of the models
(with observed data)

- calibration of the values
of parameters







Aim of the study

Objective

Develop a framework of multi-agent-based models for investigating pedestrian movements in more microscopic environment

- Subject

  Migration behavior of shoppers in a shopping center

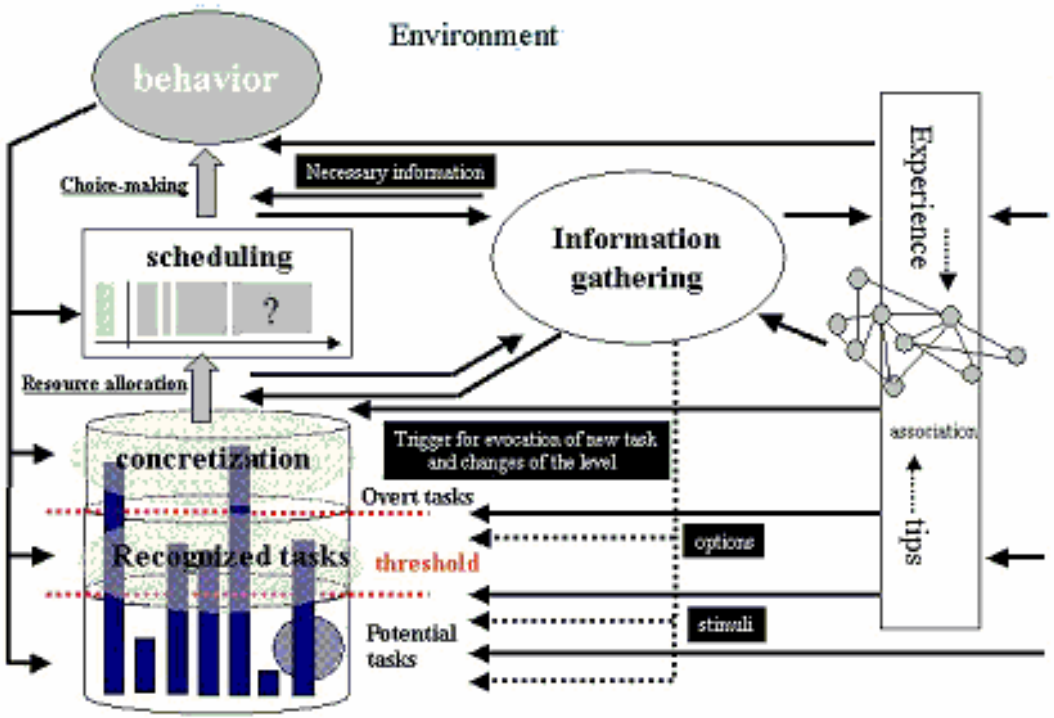
- Method

  1. Review of current behavior models → **Requirements for new models**
  2. Surveys of migration behavior → **Spatial data mining**
  3. Basic analysis on profiles of shoppers

Shopping = Multi task activities

Requirements for new models

- Rules should be supported by observed data
- Models can explain Multi-task behavior
- Individual should be the unit of the model



Generic model

Disaggregate model

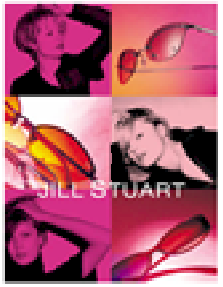
Individual
- Spatial behavior
- Cognitive process

Marketing strategy of shops

image、segmentation of the targets

e.g. Elegant
Sophisticated

e.g. Women
30'S

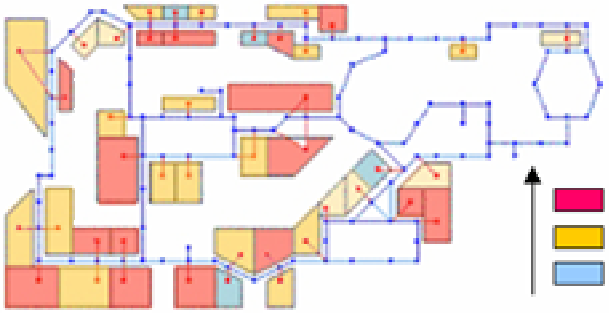


Profile & preferences **Questionnaire**

gender age magazine brand

matching

Prediction of possible destinations



Stated preference of each shop

Not my taste — Very fond of it

5 4 3 2 1

Preference survey

Any patterns or relations?

Correlation analysis

Events

Changes of shops

External info

Routes that shoppers took (Observed preference)

× 3 times **Survey on migration behavior**

Any influence on behavior?

Impressions on the shops they visited

Interviews

Working hypothetical model

spatial movements of shoppers = interactions among 3 agents; shoppers; shops and a network of passages

	Attributes used in this study	Attributes not used in this study
Shopper	· Objectives and tasks of the trip · Spatial knowledge about the place (the number of times of visiting)	· Physical strength · Degree of content or fatigue · Budgets and time limitation
Shop	· Coordinates (x,y,z) Suitability to each shopper's taste (preference) · Good/Bad valuation evaluated by each shopper based on her previous experience or impression	· Area of the shop · Targeting segments (e.g. age) · Cycle of changes in selection
Network	· Length of each link · Topological info (e.g. a lift to the 2nd floor)	· The number of shops around and other passage flow into it

Model 1 **Mixed logit model**

$$A_{in} = V_{in} + \varepsilon_{in} = V_{in} + \eta_{in} + \varepsilon_{in}$$
$$kV_{in} = \sum \beta_{is} x_{is} \qquad j \in J$$
$$\eta_{in} = \sum \mu_{ij} Z_{ij} \quad (i \neq j)$$

Stated preference ⟷ Observed preference

shoppers enter the shop;
when they approach the shop with high **attractiveness**
come within the area in which the shop is visible

Surveys

VENUE

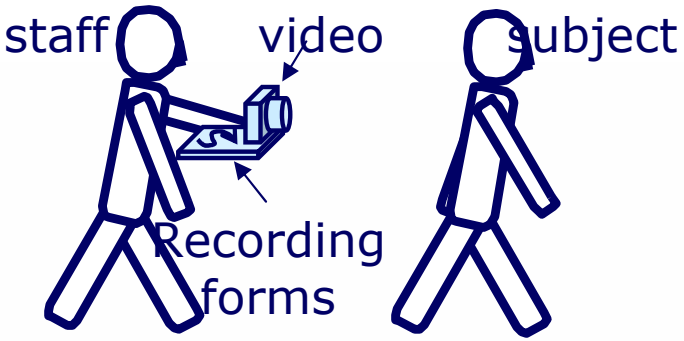
・A huge shopping malls which is composed of more than 140 shops for young women

↓

simplify the analysis by eliminating the influence of age and gender

SUBJECTS

・18 shoppers, female graduate students



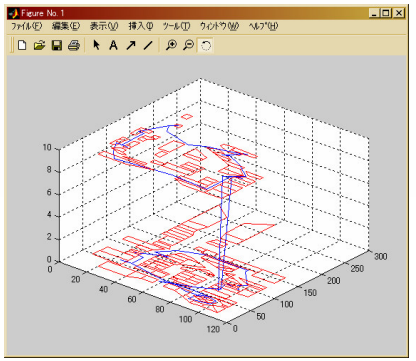
METHODOLOGIES

・shoppers were asked to shop around for 2 hours

・the routes they took were tracked and recorded by digital video cameras

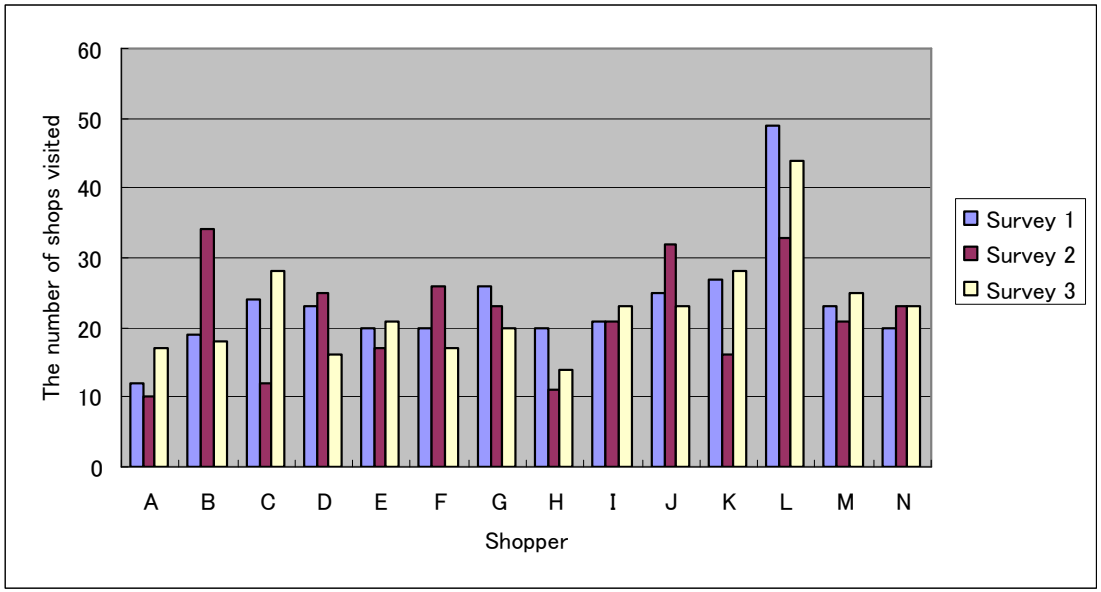
・questionaire & interview

Video image



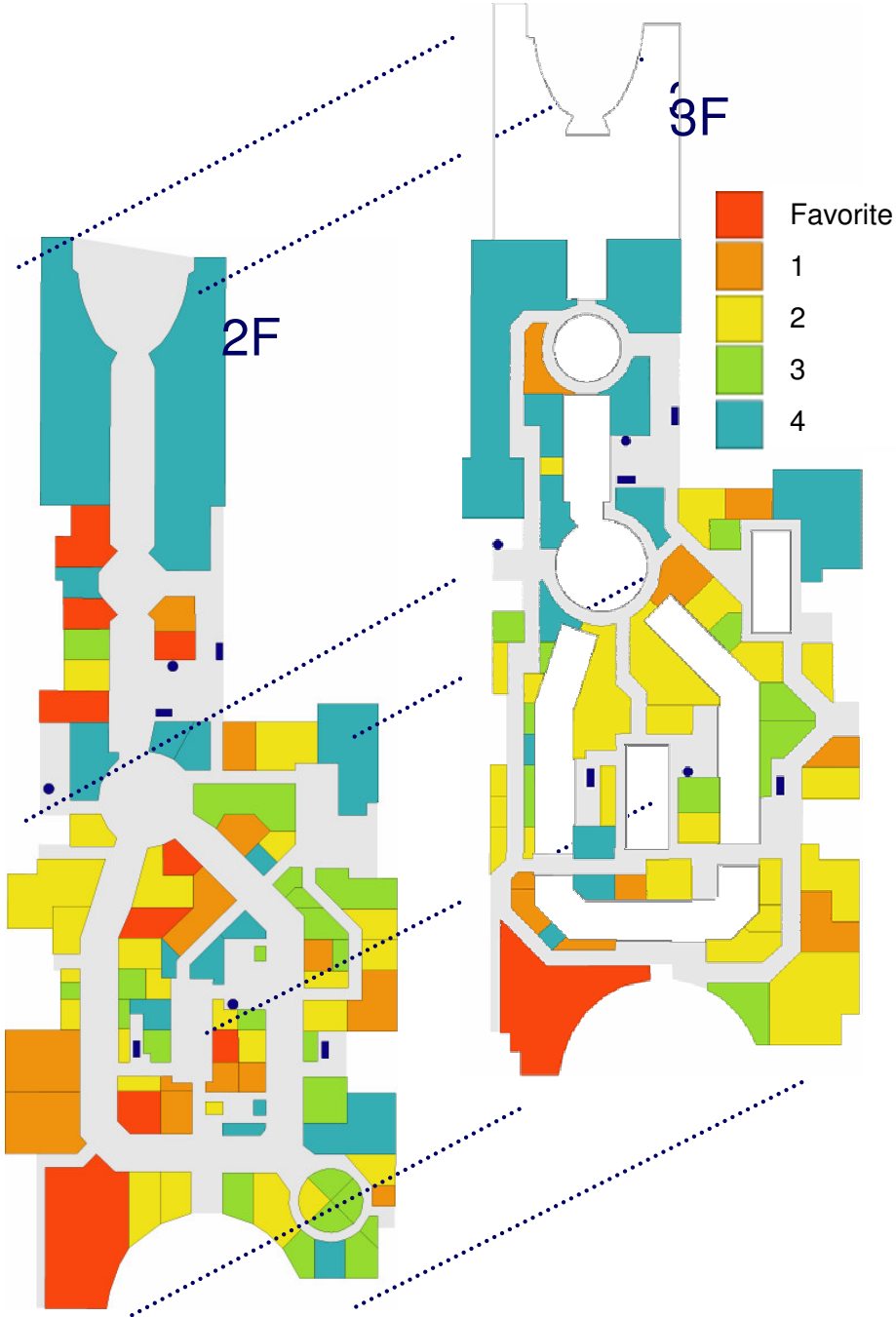
Reconstructed route

Result



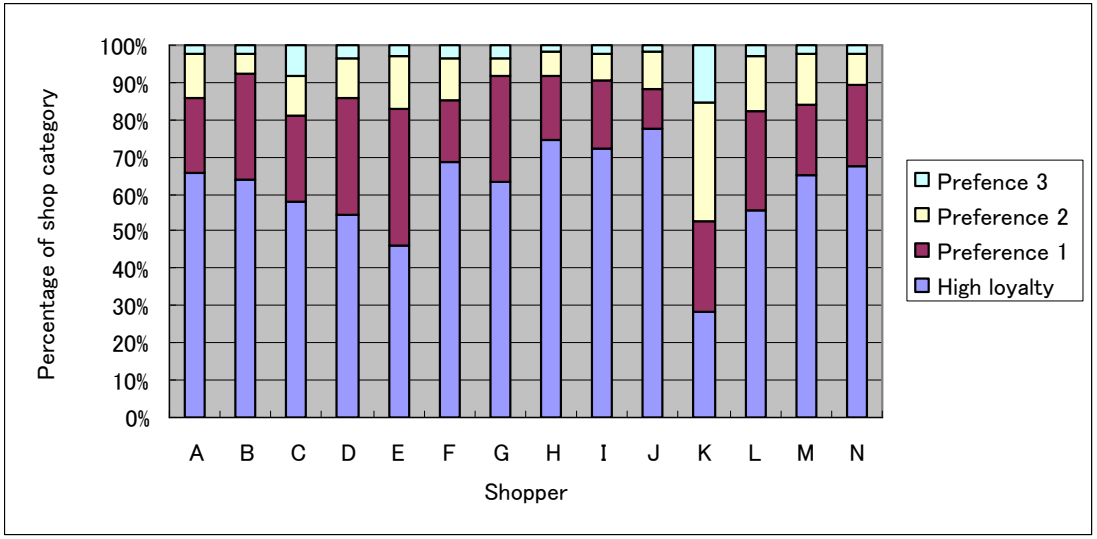
Half of the shoppers dropped by more shops during Survey 3 than other two.

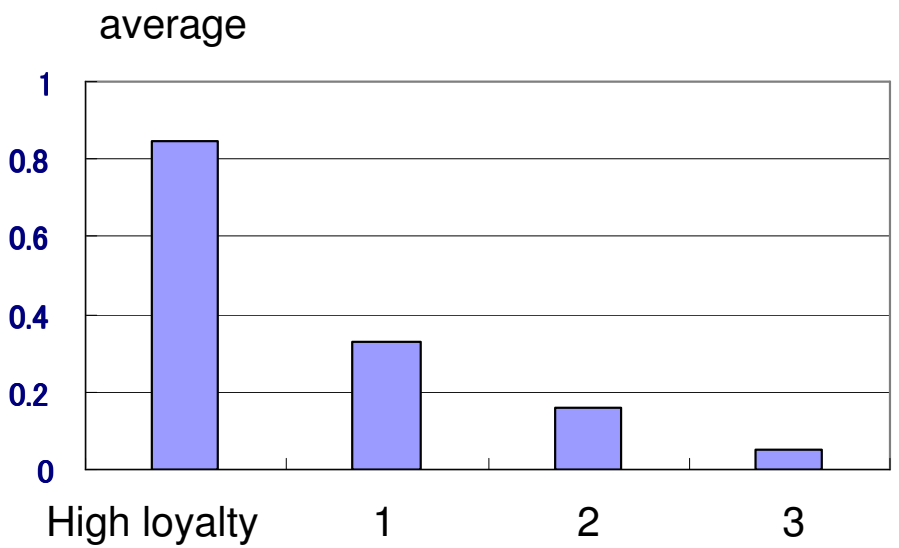
Influence of events and tasks
Impression on the last visit



Stated preference map

Result





The number of shops visited by each shopper during 3 surveys

↓

Preference 1 amount to 80%

most shoppers repeatedly visit the same shops (favorite, high loyalty)

<u>the shops with high loyalty were steadily chosen as a destination during shopping</u>

However, frequencies of visiting the same shop during surveys were not so high

→*Resource allocation*.

prioritize visiting another shops in category of Preference 1 due to the time restriction.

→the attractiveness of shops might decrease after they are visited

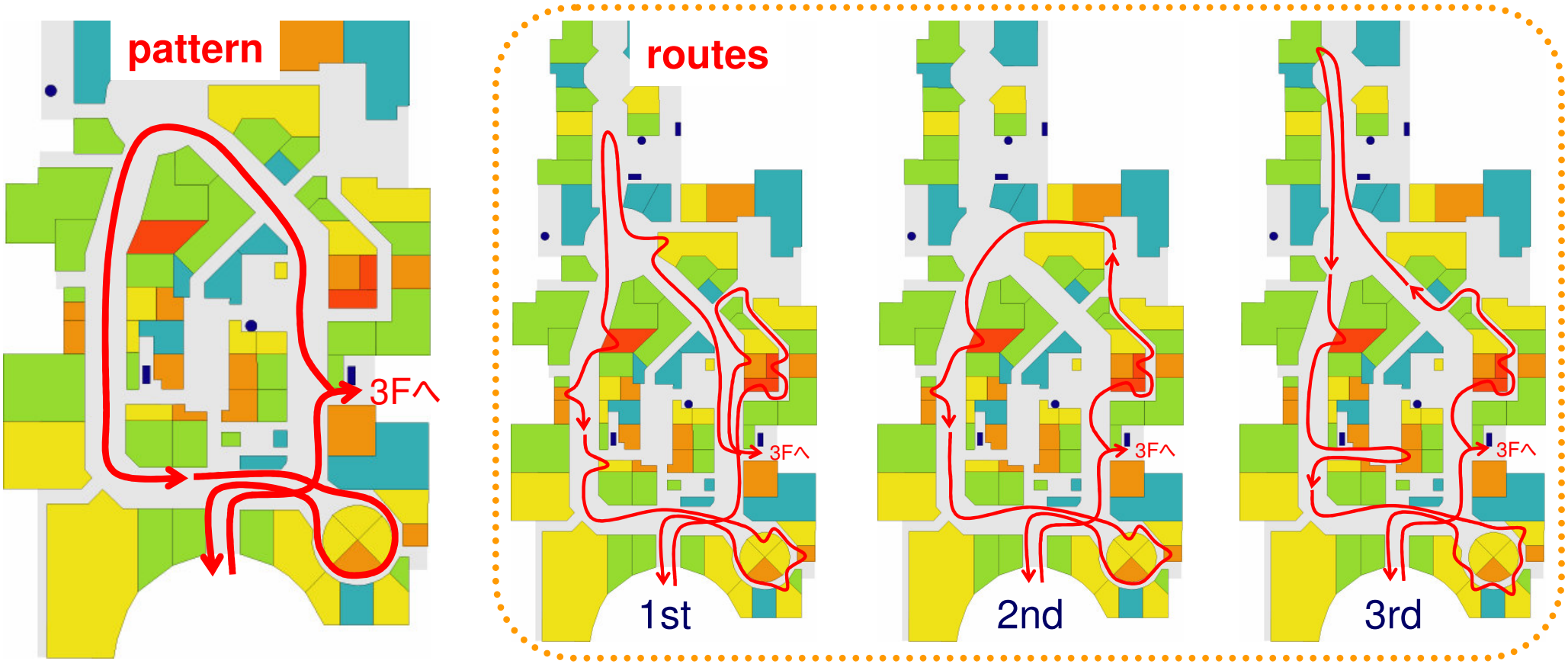
Result

1 Traveling in a regular route

→ shoppers seldom swerve from the prefixed course

2 Random walk.

→ shoppers are susceptible to external stimuli



Result

Factor A **tendencies to take regular routes**
Factor B **existence of any priorities during shopping**
(achievement of tasks or enjoying shopping itself)

	A	$\overline{A}$
B	Shoppers who have rough or no prefixed routes and enjoy window-shopping itself without any purposes of the trip	Shoppers who fix destinations and routes. The route differs each time according to the tasks
$\overline{B}$	Shoppers who fix destinations at the beginning of their trip and follow almost the same route every time	Shoppers who have rough or no prefixed routes but search for a certain products

Task-scheduling = a relatively simple *utility maximization* process

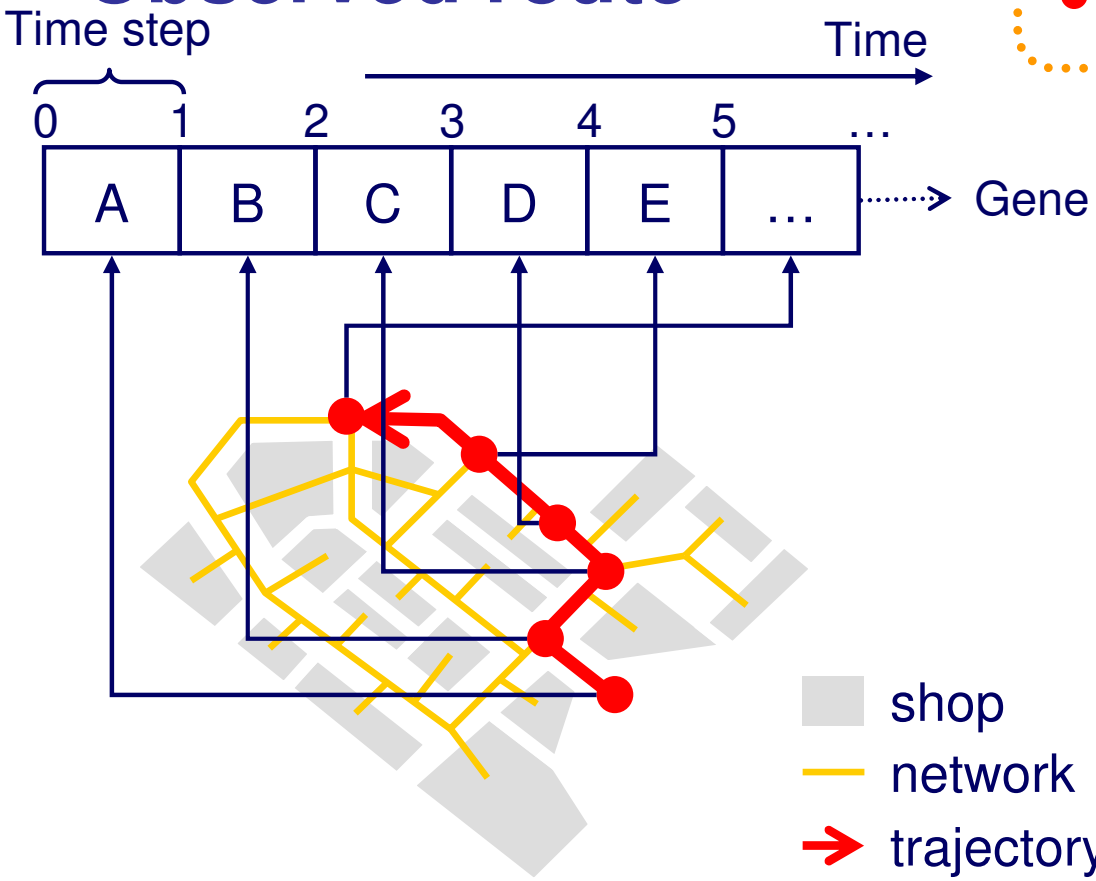
Simulation

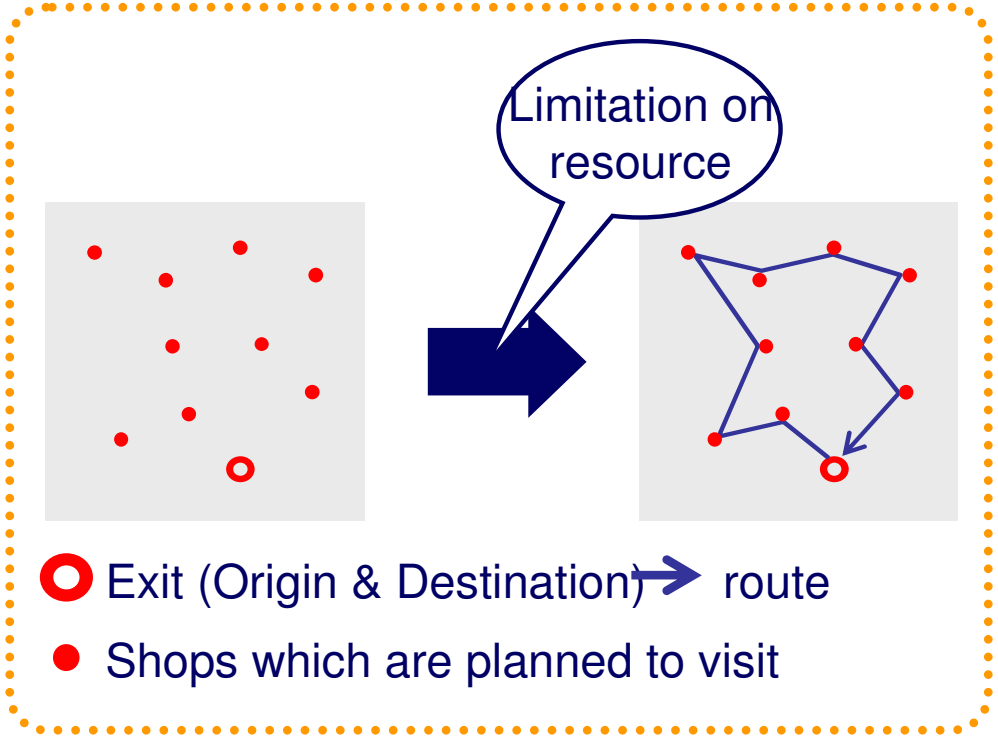
Comparison between

(visit all shops in schedule in the shortest distance)

Optimum route ⟷

Observed route





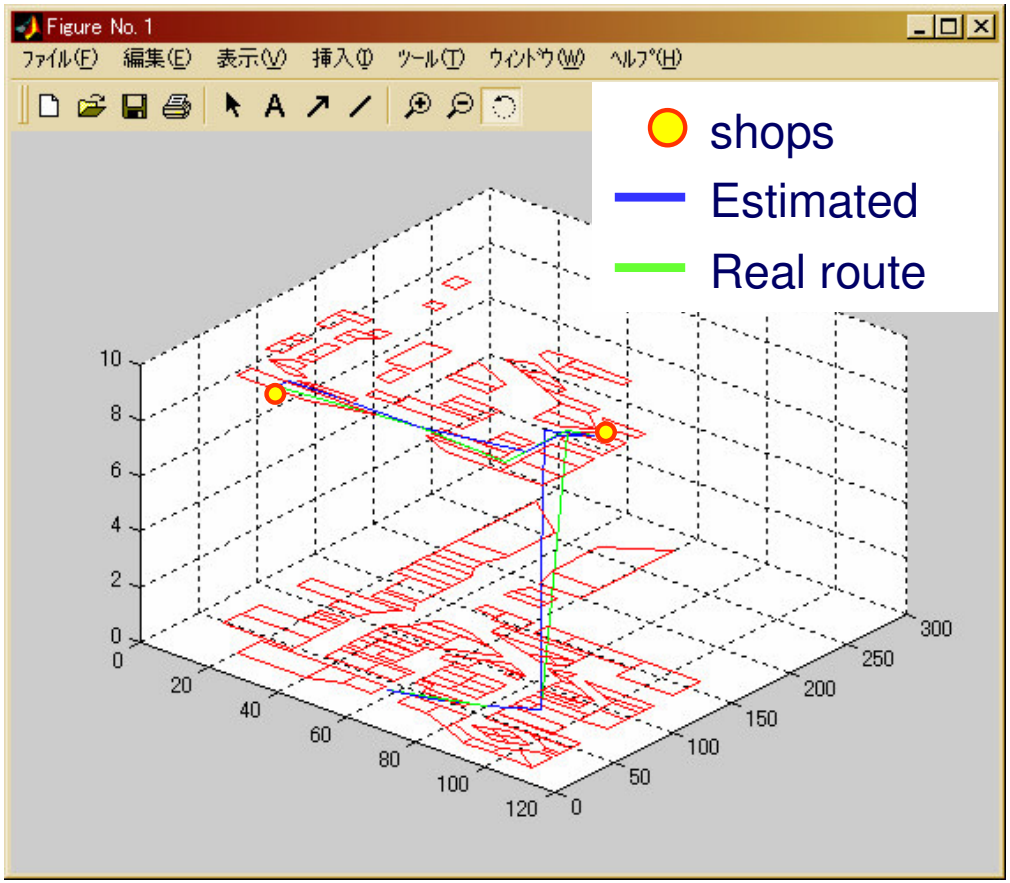
Genetics Algorithm

Gene = consequential
Spatio-temporal position

(nodes and links)

Simulation

- **Migration routes for 10 minutes (62 nodes、66 links)**



Every 30 seconds

■restriction

#walking speed ····· 60m/min
#movable distance ····· ○
#shops ····· ○
#OD ····· ○
#movable angle ····· ○
#network ····· ○
#Z-angle ····· ×

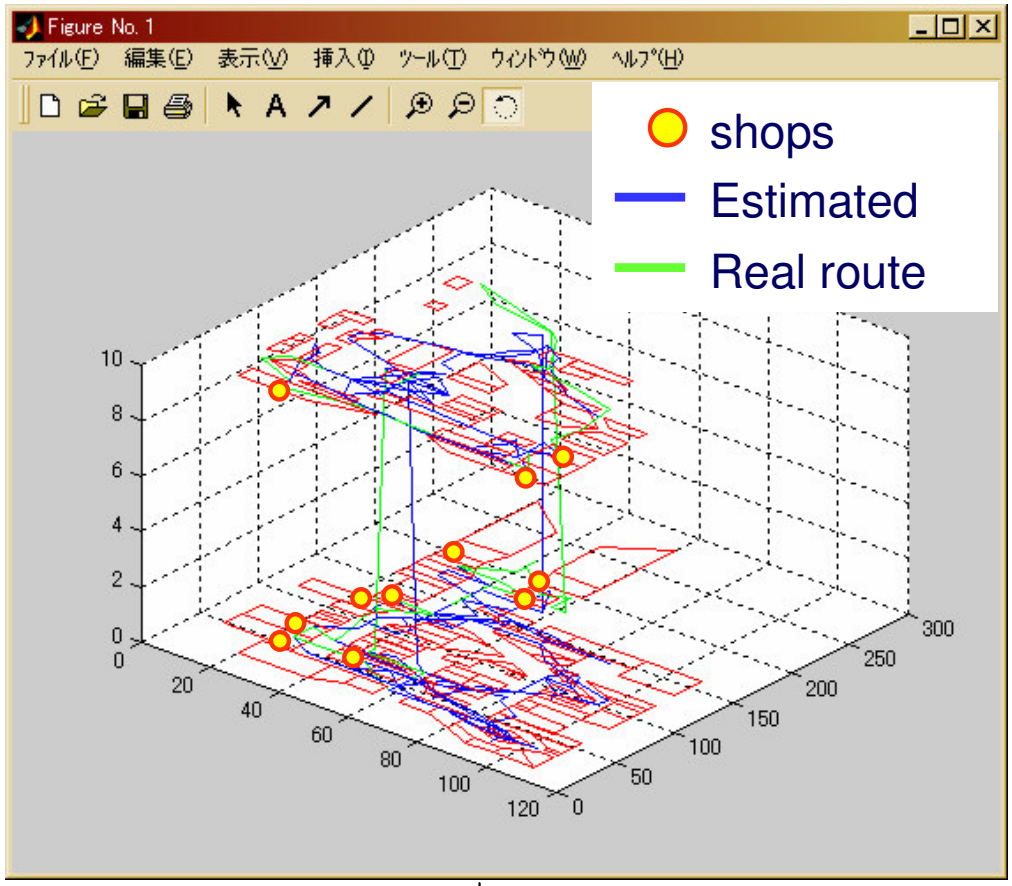
■algorithm

#SA ····· ×
#HC ····· ○
#smoothing ····· ×

Actual trajectory can be reproduced

Simulation

Migration routes for 120 minutes (326 nodes、364 links)



Every 15 seconds

■restriction

- #walking speed ····· 60m/min
- #movable distance ····· ○
- #shops ····· ○
- #OD ····· ○
- #movable angle ····· ○
- #network ····· ×
- #Z-angle ····· ○

■algorithm

- #SA ····· ×
- #HC ····· ○
- #smoothing ····· ×

Actual trajectory can not be reproduced

Conclusion and future works

- *Mixed Logit model* is effective to explain spatial behavior of shoppers.
-High correlation between the preference of the shops and choice of destination

Shopper's routing is influenced by

-Each shopper's loyalty to shops
-Knowledge about the environment or impression of each shop is also important
-External information obtained during trip and physical restrictions (e.g. fatigue)

Improvement of the model

Identify relationship between shopper's attributes and preference

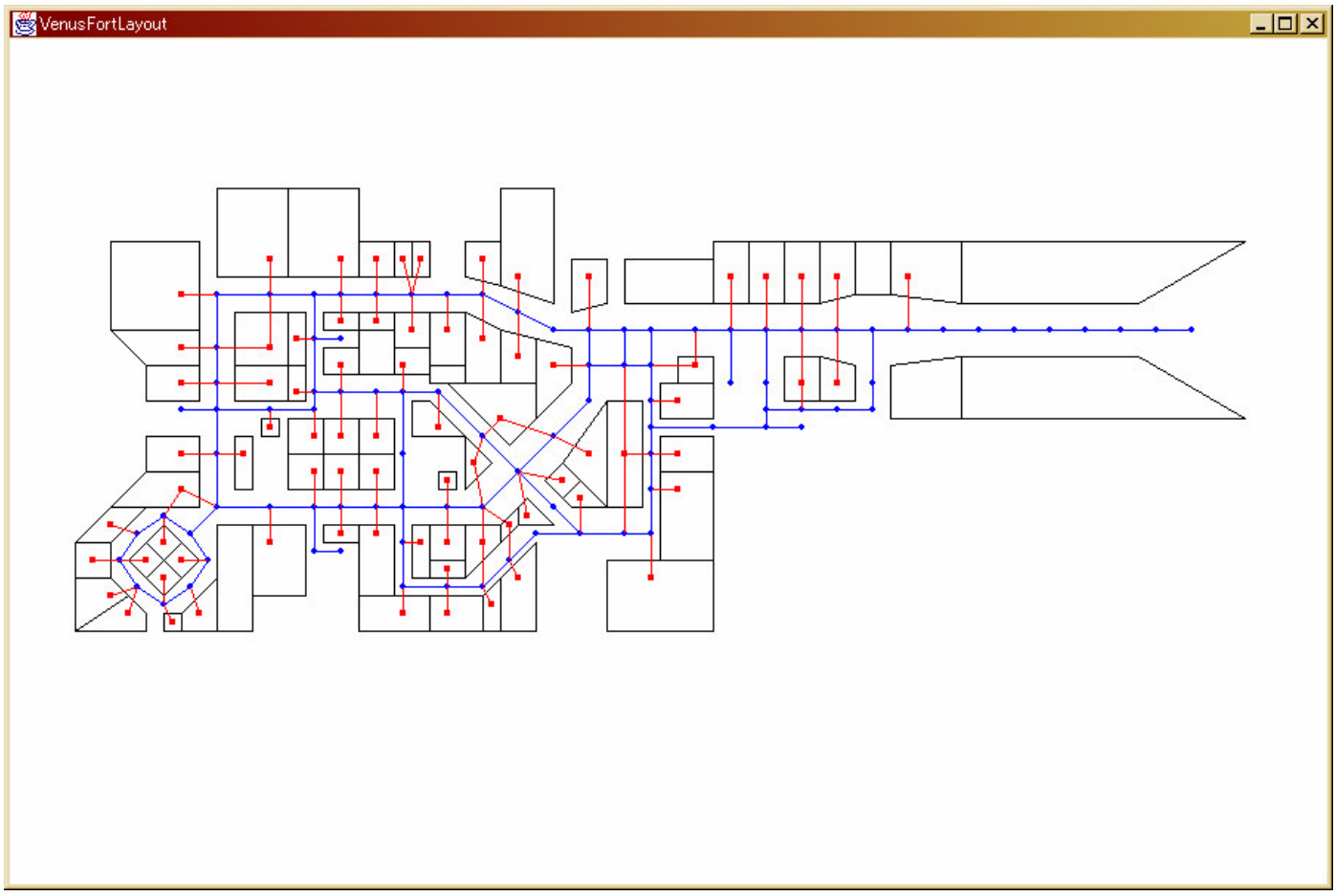
Improve measurement systems for bigger survey

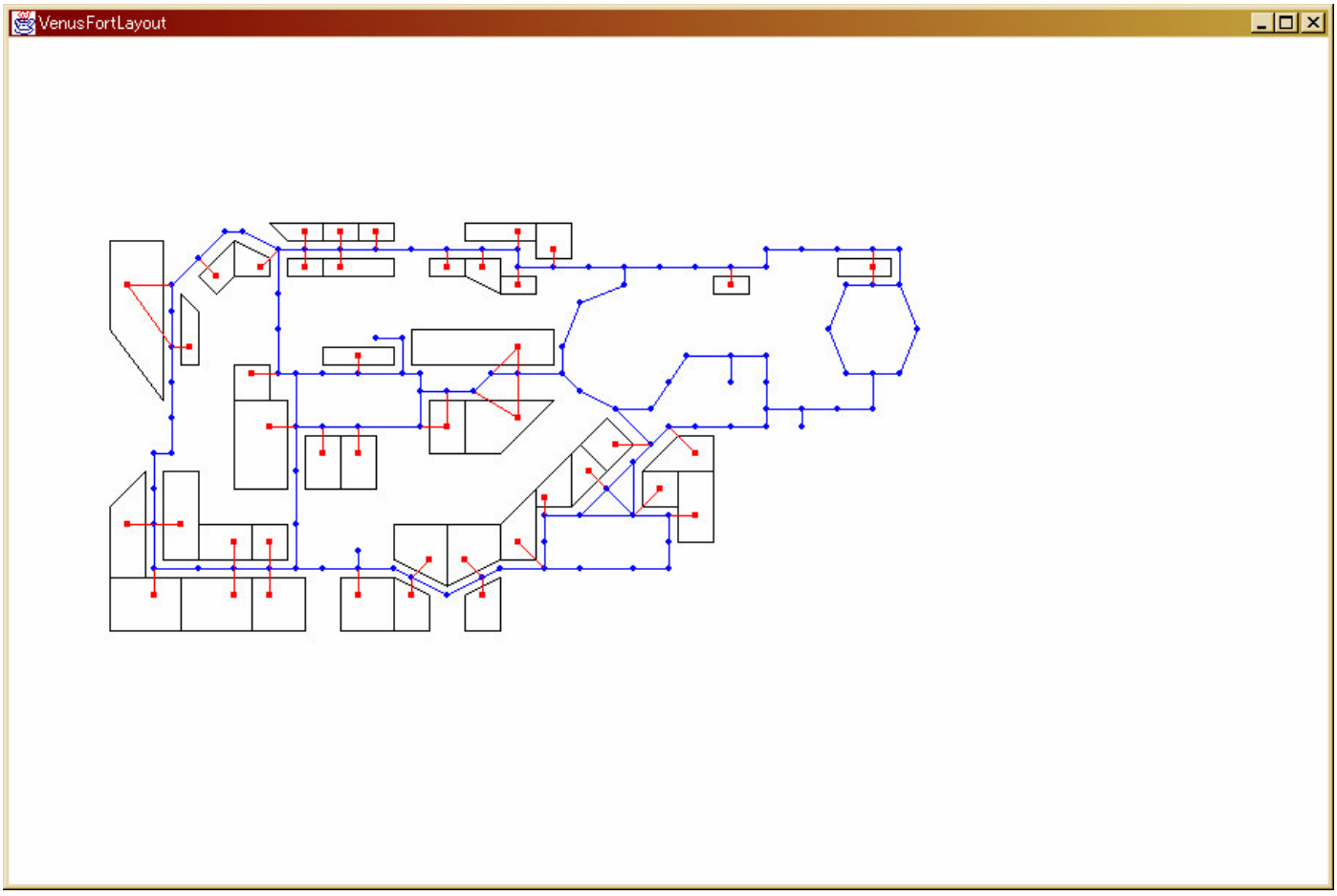
Develop algorithms of GA simulation
(improve the accuracy, deal with estimation of routes from preference)

Thank you

Kay Kitazawa, Hiroyuki Tanaka, Ryosuke Shibasaki

University of Tokyo kitazawa@iis.u-tokyo.ac.jp


VenusFortLayout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