Pedestrian Behaviour Modelling

An Application to Retail Movements
using Genetic Algorithm

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Background

- Urban planning
- Spatial marketing
- Location-based services

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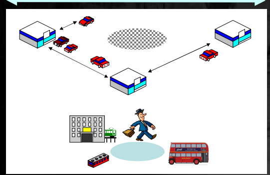
Background

- Urban planning

Not-compact city



Compact city

Lively town centres

⇨ Pedestrian-oriented planning

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Background

- Pedestrian-oriented urban planning

✓Safety — less crime, fewer traffic accidents

✓Convenience — accessibility to transport, shops, services

✓Amenity — comfortable walking environment

Actual movements
Necessary information
Influential factors

⇨ Needs for Pedestrian behavior model

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Background

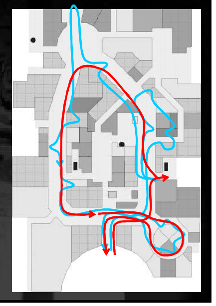
- Spatial marketing

✓Tenant strategy (leasing, fee)

✓Improvement of -floor plans
-signage system

Actual movements
Influential factors

⇨ Needs for Pedestrian behaviour model



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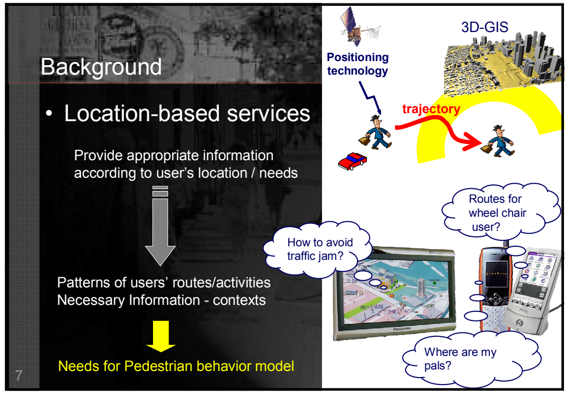
Background
Location-based services
Provide appropriate information according to user's location / needs
Patterns of users' routes/activities
Necessary Information - contexts
Needs for Pedestrian behavior model
3D-GIS
Positioning technology
trajectory
Routes for wheel chair user?
How to avoid traffic jam?
Where are my pals?
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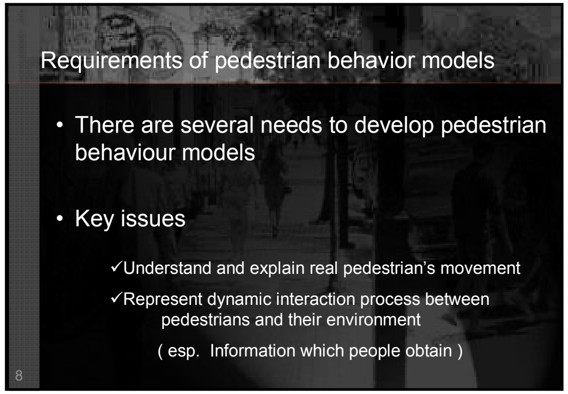
Requirements of pedestrian behavior models
There are several needs to develop pedestrian behaviour models
Key issues
✓Understand and explain real pedestrian's movement
✓Represent dynamic interaction process between pedestrians and their environment
(esp. Information which people obtain)
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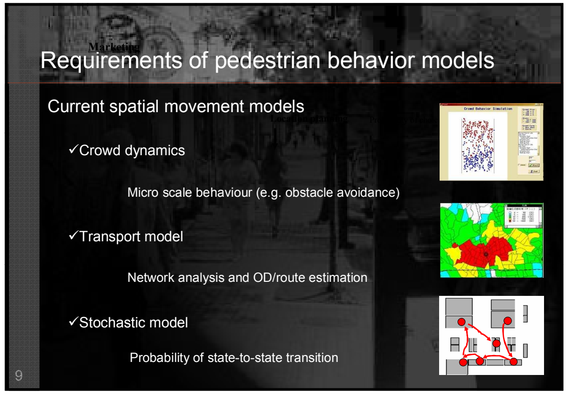
Requirements of pedestrian behavior models
Current spatial movement models
✓Crowd dynamics
Micro scale behaviour (e.g. obstacle avoidance)
✓Transport model
Network analysis and OD/route estimation
✓Stochastic model
Probability of state-to-state transition
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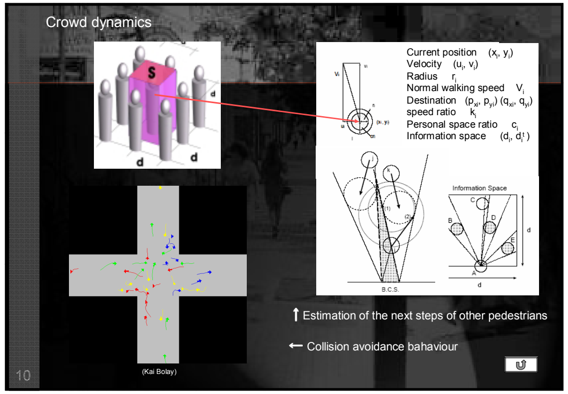
Crowd dynamics
Current position
Velocity
Radius
Normal walking speed
Destination
Personal space ratio
Information space
Information Space
Estimation of the next steps of other pedestrians
Collision avoidance bahaviour
(Kai Bolay)
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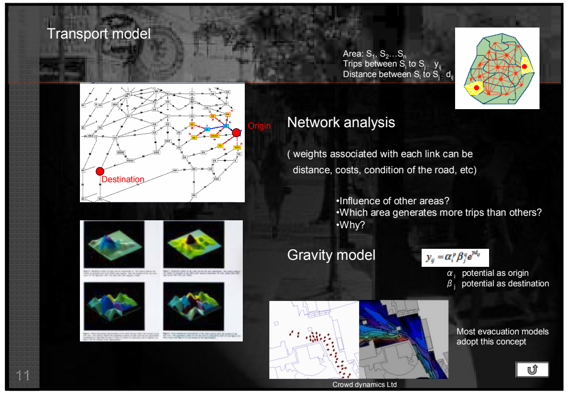
Transport model
Origin
Destination
Network analysis
(weights associated with each link can be distance, costs, condition of the road, etc)
•Influence of other areas?
•Which area generates more trips than others?
•Why?
Gravity model
potential as origin
potential as destination
Most evacuation models adopt this concept
Crowd dynamics Ltd
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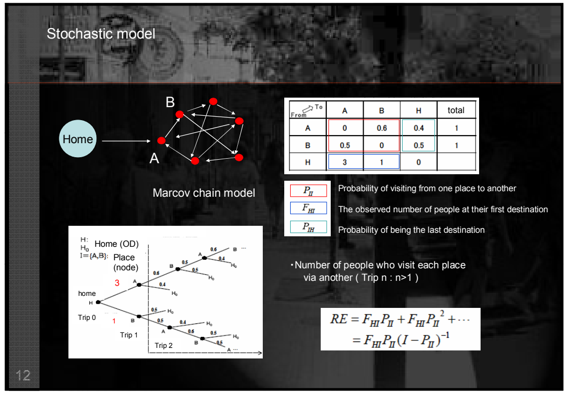
Stochastic model
Home
B
A
Marcov chain model
Probability of visiting from one place to another
The observed number of people at their first destination
Probability of being the last destination
•Number of people who visit each place via another (Trip n : n>1)
Home (OD)
Place (node)
Trip 0
Trip 1
Trip 2
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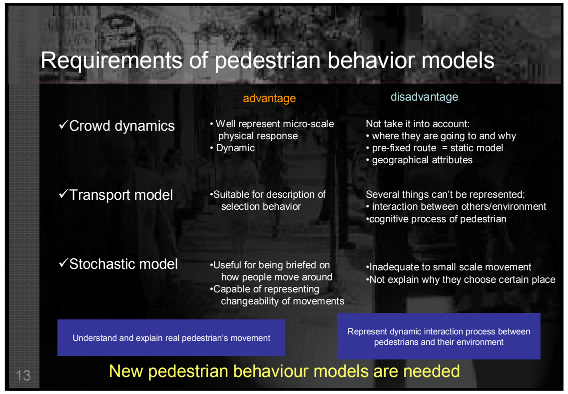
Requirements of pedestrian behavior models
advantage
disadvantage
✓Crowd dynamics
• Well represent micro-scale physical response
• Dynamic
Not take it into account:
• where they are going to and why
• pre-fixed route = static model
• geographical attributes
✓Transport model
•Suitable for description of selection behavior
Several things can't be represented:
• interaction between others/environment
•cognitive process of pedestrian
✓Stochastic model
•Useful for being briefed on how people move around
•Capable of representing changeability of movements
•Inadequate to small scale movement
•Not explain why they choose certain place
Understand and explain real pedestrian's movement
Represent dynamic interaction process between pedestrians and their environment
New pedestrian behaviour models are needed
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Research Aim and Objectives
To develop a new pedestrian behavior model
✓be capable of explaining real pedestrian's movement
Every factors should be determined based on observed data
It can deal with more complex behavior (e.g. shopping)
✓represents dynamic interaction between pedestrians and their environment
To deal with not only pre-determined route-choice
but also people's cognitive process or other changeable events
✓can be used as a simulation model
To visualize, To make the model easy to understand, more transferable
✓be validated through comparison between actual trajectories
It should be different from playing with beautiful animation
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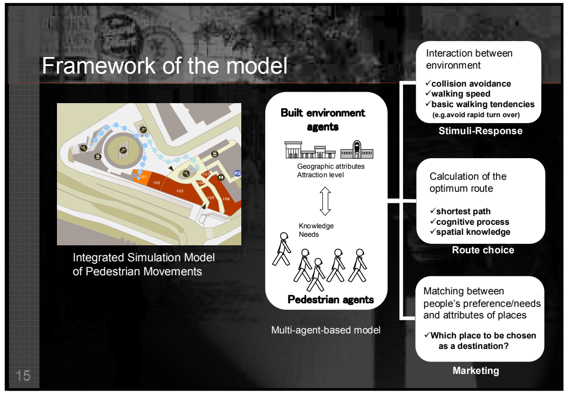
Framework of the model
Interaction between environment
✓collision avoidance
✓walking speed
✓basic walking tendencies
(e.g.avoid rapid turn over)
Stimuli-Response
Built environment agents
Geographic attributes
Attraction level
Knowledge
Needs
Pedestrian agents
Calculation of the optimum route
✓shortest path
✓cognitive process
✓spatial knowledge
Route choice
Integrated Simulation Model of Pedestrian Movements
Multi-agent-based model
Matching between people's preference/needs and attributes of places
✓Which place to be chosen as a destination?
Marketing
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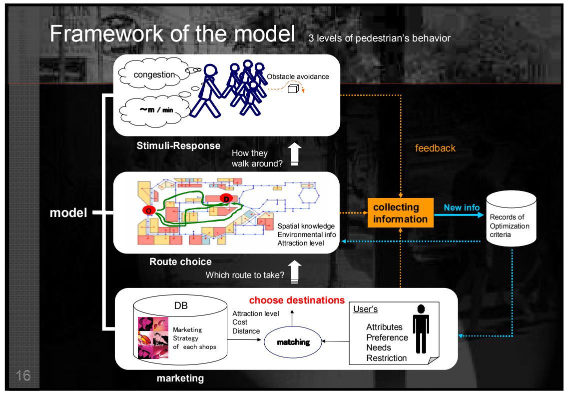
Framework of the model
3 levels of pedestrian's behavior
congestion
Obstacle avoidance
Stimuli-Response
How they walk around?
feedback
model
Spatial knowledge
Environmental info
Attraction level
collecting information
New info
Records of Optimization criteria
Route choice
Which route to take?
choose destinations
DB
Attraction level
Cost
Distance
Marketing Strategy of each shops
matching
User's
Attributes
Preference
Needs
Restriction
marketing
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Methodology
Survey of pedestrian movement in public spaces
Stimuli-response
Measurement systems / sensors
•Trajectory → walking patterns
Surveys of route-choice behaviour
Route choice
Route A
Route B
Route C
DESTINATION
Marketing research
Marketing
Geo-demographic Database
•Develop DB of attributes of the place
•Analysis on relationship between the shop's attributes and those of individuals
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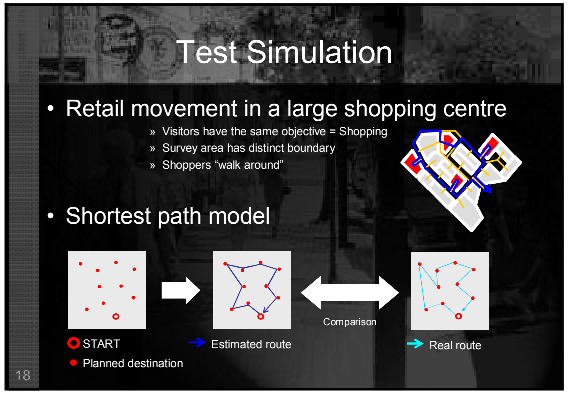
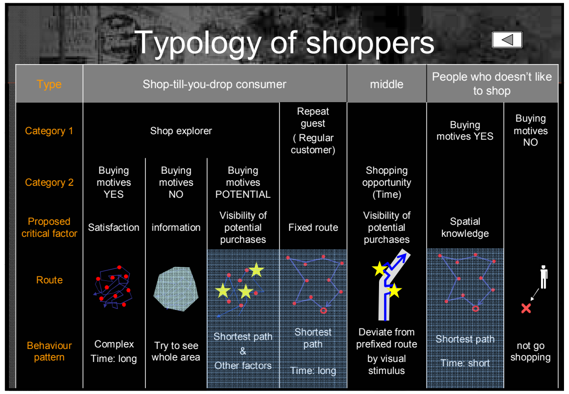
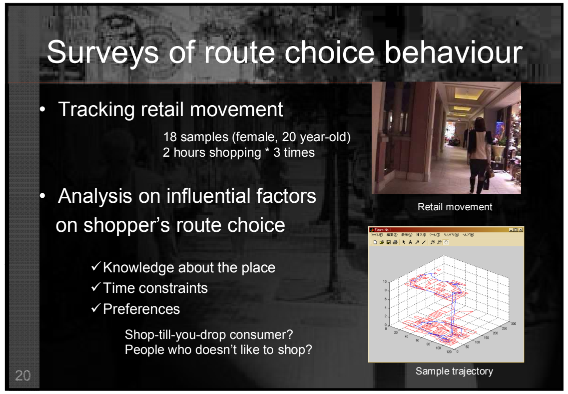

Test Simulation
• Retail movement in a large shopping centre
» Visitors have the same objective = Shopping
» Survey area has distinct boundary
» Shoppers "walk around"
• Shortest path model
Comparison
START
Planned destination
Estimated route
Real route
18


Typology of shoppers
Type
Shop-till-you-drop consumer
middle
People who doesn't like to shop
Category 1
Shop explorer
Repeat guest (Regular customer)
Buying motives YES
Buying motives NO
Category 2
Buying motives YES
Buying motives NO
Buying motives POTENTIAL
Shopping opportunity (Time)
Proposed critical factor
Satisfaction
information
Visibility of potential purchases
Fixed route
Visibility of potential purchases
Spatial knowledge
Route
Behaviour pattern
Complex Time: long
Try to see whole area
Shortest path & Other factors
Shortest path Time: long
Deviate from prefixed route by visual stimulus
Shortest path Time: short
not go shopping


Surveys of route choice behaviour
• Tracking retail movement
18 samples (female, 20 year-old)
2 hours shopping * 3 times
• Analysis on influential factors on shopper's route choice
✓Knowledge about the place
✓Time constraints
✓Preferences
Shop-till-you-drop consumer?
People who doesn't like to shop?
Retail movement
Sample trajectory
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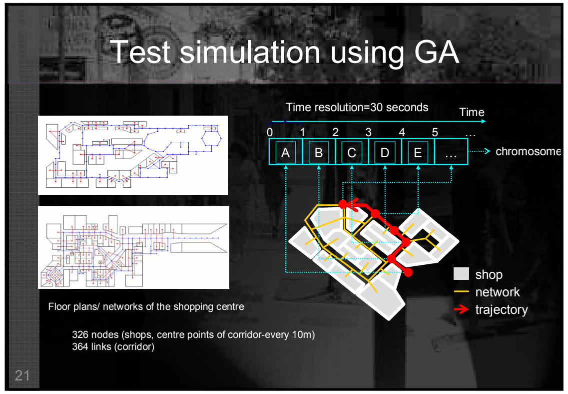
Test simulation using GA
Time resolution=30 seconds
Time
0 1 2 3 4 5 ...
A B C D E ...
chromosome
shop
network
trajectory
Floor plans/ networks of the shopping centre
326 nodes (shops, centre points of corridor-every 10m)
364 links (corridor)
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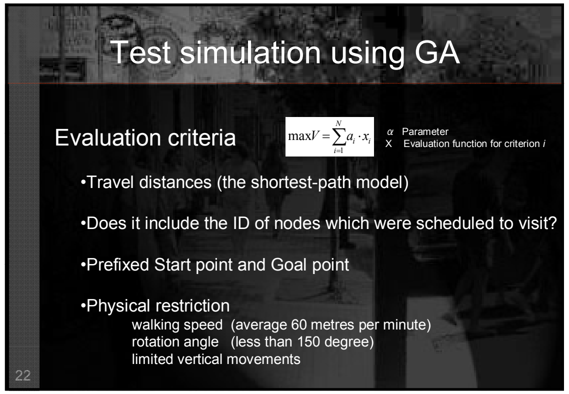
Test simulation using GA
Evaluation criteria
$\max V = \sum_{i=1}^{N} a_i \cdot x_i$
α Parameter
X Evaluation function for criterion i
•Travel distances (the shortest-path model)
•Does it include the ID of nodes which were scheduled to visit?
•Prefixed Start point and Goal point
•Physical restriction
walking speed (average 60 metres per minute)
rotation angle (less than 150 degree)
limited vertical movements
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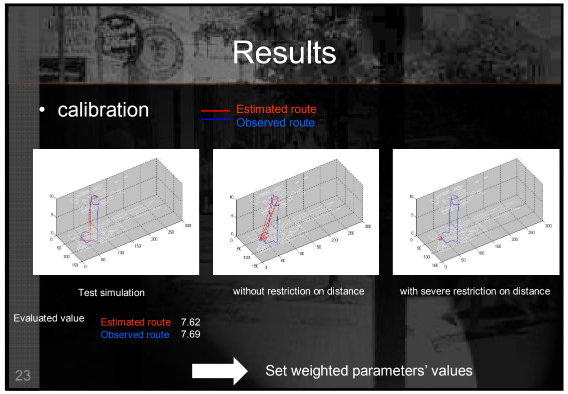
Results
• calibration
Estimated route
Observed route
Test simulation
without restriction on distance
with severe restriction on distance
Evaluated value
Estimated route 7.62
Observed route 7.69
Set weighted parameters' values
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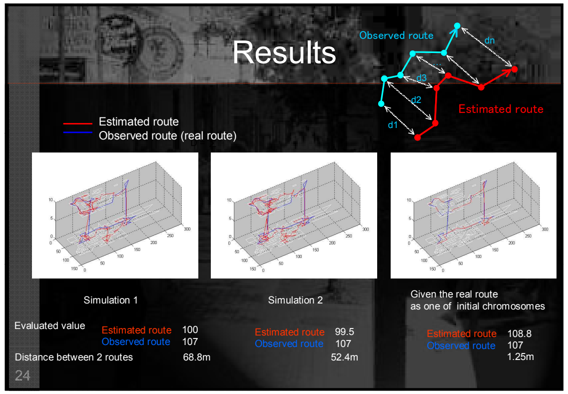
Results
Observed route
Estimated route
d1
d2
d3
dn
Estimated route
Observed route (real route)
Simulation 1
Simulation 2
Given the real route as one of initial chromosomes
Evaluated value
Estimated route 100
Observed route 107
Estimated route 99.5
Observed route 107
Estimated route 108.8
Observed route 107
Distance between 2 routes
68.8m
52.4m
1.25m
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Conclusion

- Shortest path model
  - capable of predicting outlines of the routes
  - other influential factors
  - Evaluation criteria and parameter values tested

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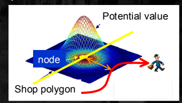
Future research

✓**Improving the simulation system**

- Combining network and potential distribution



- Network analysis
  - → factors in route selection
    - •width of corridor, visibility, connection to other network

✓**Marketing research**

- Develop DB of attributes of the place
- Analysis on relationship between the place's attributes and those of pedestrian
  - •What kind of people go to WHICH place (shop/restaurant)
  - •HOW often?
  - •WHY?

Implement simulation

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Current positioning technologies

✓GPS-based technology

✓Cell-based technology

✓Image processing

✓Autonomous-positioning

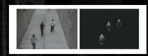
✓Laser scanning

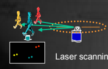
✓Ultra-sonic wave

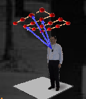
✓Traffic counter

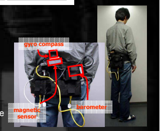

GPS


RFID tag


Thermal infrared


Laser scanning


Ultra-sonic wave



Autonomous positioning system

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Thank you!

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