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著者(和文)	顧宗超
Author(English)	Zongchao Gu
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論 文 要 旨

THESIS SUMMARY

専攻： Department of	人間環境システム　専攻	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of　（　工学　）
学生氏名： Student's Name	Gu Zongchao	指導教員（主）： Academic Advisor(main)	大佛 俊泰
		指導教員（副）： Academic Advisor(sub)	

要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Thesis Summary

In the modern urban space, underground pedestrian space plays an important role of providing space for transferring, shopping and dining behaviors of people. Obtaining pedestrians' movement and spatial distribution in underground space is an essential issue for underground space planning and administration. Clarifying pedestrian crowd conditions is also necessary for numerically evaluate the performance of pedestrian space. In view of above background, a method of estimating pedestrians' spatio-temporal distribution in underground space was proposed.

In Chapter 1 of introduction, we briefly illustrated current situation of underground space in modern city and the importance of clarifying pedestrians' movement in underground space. Spatio-temporal distribution data was introduced to describe people's time-specific distribution in a certain space. We discussed the necessity of estimating pedestrians' spatio-temporal distribution data in underground space and possibility of applying spatio-temporal distribution data for evaluating pedestrian space. Based on the previous research, this thesis proposed a method of estimating pedestrians' spatio-temporal distribution data based on pedestrian traffic survey data in underground space.

Tenjin underground shopping street was selected as the study area. A pedestrian traffic survey data which contains link flow count data collected at part of streets in study area. In Chapter 2 "Estimating Pedestrians' Origin-Destination Information", a numerical analysis approach was proposed to estimate pedestrians' O-D matrix based on observation data. To exclude the influence of predetermined route choice patterns, a network-simplification approach was proposed to obtain determined link/link-couple flow count constraints. Pre-determined route choice model is excluded from OD estimation stage. Estimation results with a better model fitness were achieved through the proposed approach. Different trip distribution tendencies were found in the estimated OD matrix of different time intervals. We also discussed the relation between trip counts and trip distance based on the estimated OD matrix. Predetermined route choice pattern and its influence to OD estimation and spatio-temporal distribution estimation were discussed in view of the trip assignment experiment results.

In Chapter 3 "Estimating pedestrians' route choice probability", we firstly reviewed and discussed the existing route choice models. We also discussed the methods for calibrating route choice probability in a complex pedestrian network. A dynamic discrete route choice model was adopted to describe pedestrians' route choice behaviors in underground space. Pedestrians were modeled to perform the sequential route choice actions in view of the subsequent utilities to destination. Based on estimated data and route choice model, a numerical estimation approach was proposed to calibrate pedestrians' destination-specific route choice probability in pedestrian network. Using Absorbing Markov process we established the functional relation between unknown variables and obtained data. Taking transition utility as unknown parameter, pedestrians' route choice probabilities were calibrated through minimizing the difference of estimated and observed state flow counts. Calibration method was evaluated in view of the fitness of estimation results. We examined the relation between spatial attributes and estimated transition utility through linear regression analysis. A generalized model with satisfying model fitness was obtained and used to examine the relation between spatial parameters and route choice patterns.

Based on estimated OD matrix and route choice probability, Chapter 4 introduced the method of estimating

pedestrians' time-specific position data through agent-based simulation approach. In view of the study purpose, two formats of pedestrians' spatio-temporal distribution data in underground space were estimated. Ignoring agents' interaction and their detail movement, pedestrians' spatio-temporal distribution in network was obtained. Pedestrians' spatial motion frequencies in different time intervals were briefly discussed in view of time-varying trip purposes. Considering pedestrian space as 2-dimension, stress model was adopted to describe pedestrians' interactions and detail movements. Pedestrians' spatio-temporal distribution data and their spatial distribution in 2-dimension pedestrian space were obtained. Pedestrian spatial distribution frequency was visualized to approximately illustrate pedestrian flows movement tendency. Pedestrians' spatio-temporal distribution tendency is discussed.

In Chapter 5, we introduced two examples of applying pedestrians' spatio-temporal distribution for numerically evaluating the performance of pedestrian space. Applying pedestrians' spatio-temporal distribution data in network, pedestrian network congestion was evaluated through the definition of spatial/stress density. Risk conditions of street space were clarified based on the variation of congestion degree. Simulation experiments were operated to examine the assumed measurements to improve street space congestion. In the microscopic view, pedestrians' individual/crowd condition parameters were defined to evaluate pedestrian space performance in the aspect of efficiency, comfort and safety. Spatial distributions of pedestrian condition parameters illustrated the areas with low service level. Direction-specific analysis furtherly studied and evaluated the pedestrian space performance in view of pedestrian flow movements.

Chapter 6 gave a summary of the outcomes in doctoral research and stated the conclusions in each chapter. Proposed spatio-temporal distribution estimation method and spatial evaluation applications are hoped to provide necessary data and give reference for underground space planning.