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題目(和文)	エビデンスに基づくウォーカブルな街路デザインに向けて：人々の知覚と嗜好を反映した街路レベルのウォーカビリティのための体系的・自動的アプローチ
Title(English)	Toward an Evidence-Based Walkable Street Design: A Systematic and Automatic Approach for Street-Level Walkability Reflecting People's Perceptions and Preferences
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論 文 要 旨

THESIS SUMMARY

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

A walkable environment plays a crucial role in encouraging urban residents to engage in walking activities, delivering a wide range of social, economic, and health benefits. Given the profound influence of walkability on everyday life, cities around the world are increasingly emphasizing walking environments in their urban planning strategies. In recent years, an increasing number of studies focus on street-level built environments, with growing attention to the perceived aspects of walkability. Furthermore, the emergence of new urban data and artificial intelligence (AI) technologies creates opportunities for quickly capturing evidence of spatial changes and guiding evidence-based design. However, there are still few automated measurement methods for different types of walkability factors, and the application of non-linear machine learning or emerging generative AI in evidence-based walkability design remains insufficient. Therefore, this study proposes three research questions: (1) How can urban big data and AI algorithms be used to systematically and automatically capture both physical and perceived walkability features at street-level? (2) How can non-linear statistical methods enhance our understanding of the impact of physical attributes on perceived walkability at street-level, and how can this knowledge guide better street design? (3) How can AI generative methods achieve automated street design and help enhance perceived walkability at street-level?

This dissertation consists of seven chapters. In Chapter 1, the dissertation first introduces the research background and defines the core concepts, followed by a description of the conceptual framework, research questions, and research structure.

Next, Chapter 2 reviews existing studies from three aspects: selecting and measuring street-level walkability, understanding the relationship between street-level factors and perceived walkability, and using generative AI to inform design, to understand the extent and limitations of current research. Furthermore, in Chapter 3, we organize and describe the street-view data, GIS data, and crowdsourcing survey data used in the study, and provide a brief and preliminary explanation of the analysis methods employed in the dissertation.

Chapter 4 aims to address the first research question. We investigate how urban big data and AI algorithms can systematically and automatically capture both physical and perceived walkability features. Initially, we identify suitable factors for automated measurement based on existing street-level indices. To quantify physical walkability, this chapter proposes targeted automated measurement methods for different types of factors. This includes distinguishing between quantifiable and non-quantifiable streetscape factors, utilizing semantic segmentation and object detection for quantification; constructing regression models to predict maintenance quality by adjusting the output layer and loss function of a deep learning image classification model; employing object detection with monocular measurement methods to estimate sidewalk width; and leveraging GIS tools

and plugins to calculate topological relationships and other indicators. For perceived walkability, we apply Deep Convolutional Neural Network (DCNN) alongside image crowdsourcing surveys to capture perceptual preferences for walking. A case study in Hong Kong tests the practical applicability of these methods, successfully achieving our research objectives.

Chapter 5 builds on the findings from Chapter 4, addressing its concerns by using non-linear regression to explore the key factors influencing perceived walkability from the perspective of walking preferences. This chapter demonstrates how non-linear statistical methods can enhance our understanding of the impact of physical walkability on perceived walkability and inform street design. Using Setagaya ward in Tokyo as a case study, we measure streetscape factors as independent variables and walking preference as the dependent variable. We utilize XGBoost regressor, a highly efficient implementation of gradient boosting tailored for regression tasks, to investigate non-linear relationships between streetscapes and walking preferences. Our findings reveal that the significance of specific streetscape factors varies across different street segments and intersections. The XGBoost analysis uncovers diverse patterns, including upward trends, downward trends, and threshold effects, highlighting the complex interplay between urban design elements and walking preferences. This approach allows us to identify critical influencing factors and optimal design interventions with precision, a capability that traditional linear methods lack.

In Chapter 6, addressing the third research question, we develop a workflow for automatically generating street scenes using the Stable Diffusion model, combined with Low-Rank Adaptation (LoRA) technology—a potent and efficient approach for fine-tuning large models. This combination enables the creation of immersive and revitalized street environments that enhance perceived walkability. Unlike statistical methods, which are unable to create tailored, optimized, and visually intuitive design schemes for specific street scenes, Stable Diffusion offers photorealistic previews of expected outcomes and generates a wide range of alternative design options, which are beneficial in the early stages of design. Our approach also addresses the need to control specific spatial proportions in design by incorporating three-dimensional models to achieve effective control. We conduct experiments on LoRA outputs, ControlNet outputs, and 3D model control outputs to validate optimal parameters. To demonstrate the design workflow's effectiveness, we use the trained preference prediction models for evaluation, confirming that our workflow and models can optimize street scenes while improving perceptual and behavioral preferences, thus achieving our research objectives.

Finally, in Chapter 7, we summarize the findings of the three core chapters. Additionally, we discuss the methodological and practical contributions of the dissertation from a holistic perspective.