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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)

Human activity-travel patterns have raised significant interest among researchers for a long time. The analysis and prediction of them have been conducted in various scientific disciplines, such as urban planning, traffic management, disaster prevention, epidemiology, geography, etc. In recent years, various data-collection technologies have been developed to infer people's activities and mobilities. However, there is not yet a universal method to describe and predict people's behaviors comprehensively. Our understanding of human activity-travel patterns is still limited. This dissertation develops and uses several models, from conventional Markov-chain-based to the recent transformer frameworks, to generate and predict human daily behaviors. Meanwhile, the ideas of utility and energy are applied to analyze the observations of generation results or other statistics.

Chapter 1: Introduction
Chapter 1 first introduces human activity-travel and provides an overview of the research related to human activity-travel modeling. Three main streams of analyzing human behavior patterns and three types of models to generate activity and mobility patterns are presented. Previous generation methods mostly focused on reproducing several statistics, such as the distribution of travel distance and visiting frequency. Many models were evaluated by these aggregated statistics, while the generated datasets could be remarkably different from reality. Moreover, our understanding of human behavior patterns is still limited. These conclusions motivate research in later chapters. The research targets and the structure of the dissertation are also provided in this chapter.

Chapter 2: Data Sources
This chapter presents the datasets used, including one survey data for people's daily activity-travel (the Person Trip survey data), two datasets about land use (the Land Use Subdivision data and the Detailed Digital Land Use Information data), and one dataset for land value (the Land Price data). Some descriptive statistics and data selection are provided.

Chapter 3: A General Understanding of Daily Human Activity-Sequential Patterns
Chapter 3 explores the sequential patterns of daily activities. Activity diaries are processed into sequences where the temporal information is discarded. We examine (1) the similarity between activities based on how they fit into activity sequences and (2) significant activity patterns. There are three main findings. First of all, working and educational-related activities are conducted in similar patterns, as well as shopping/entertainment and personal activities. Second, a limited number of activity patterns cover most people's behavior patterns. Third, three age groups and three occupation groups are observed in terms of daily activity patterns. Conclusions from this chapter provide evidence for the classification of activities and the classification of the population in later chapters.

Chapter 4: Generating and Understanding Daily Activity Sequences
Chapter 4 examines the time-varying Markov chain model for activity generation. Based on the conclusions from Chapter 3, activities are classified into three types, and the population is classified into four groups. It is observed that the time-varying Markov chain model generates daily activity sequences with high accuracy, especially for the worker and student groups. This suggests that future activities of people in these groups are likely to be independent from previous activities. The generation power is comparable to or slightly lower than a neural network model, depending on the task. We recognize the relationship between the time-varying Markov chain model and the multinomial logit model. Accordingly, a new mechanism is proposed for activity scheduling,

where people consider the overall utility of activity diaries and select the one with the lowest disutility. Moreover, a reconstruction method is proposed to build the time-varying Markov chain model with six parameters. Further analysis of the six parameters shows that the activity diaries are similar for people living in regions nearby.

Chapter 5: Generating and Understanding Daily Mobility Sequences

Chapter 5 proposes a two-step Markov chain model to synthesize daily mobilities. In the first step, people's future states are conditioned on previous travel patterns. In the second step, future locations are determined by their states. Evaluations suggest that human mobilities have been well-generated. Established on the characteristics of the two-step Markov chain model, a conclusion is drawn that people's future status can be roughly inferred based on the travel patterns they have made, regardless of exactly where they have traveled and when the trips happened. Moreover, the concept of energy has been adopted to explore stable statistics over the years. Using the stability of average energy expenditure, a simple regression model is proposed to predict the proportion of long-distance trips.

Chapter 6: Daily Travel Time-Fixed and Varying Statistics

The energy expenditure in Chapter 5 is essentially about travel time. Chapter 6 examines the distribution of daily travel time. It is observed that the travel time of each group of users (grouped by travel modes) distributes lognormally. Moreover, for each group, the distributions of travel time for different years and areas seem to collapse into a single curve after normalization, regardless of the year and the distance to the city center. We develop a utility model to explain how lognormal distributions emerge. People are assumed to maximize their utility by modifying their daily travel time. The parameters of the utility model are estimated using statistics about travel time, travel mode share, and manageable assumptions. The obtained utility curves (i.e., the amount of utility versus daily travel time) are similar to the shape of "overall benefits" (i.e., benefits versus daily travel time), a conceptual idea that researchers have assumed over the past decades. The proposed utility model provides a mathematical foundation for this idea.

Chapter 7: Incorporating New Frameworks-Learning Human Behaviors with Deep Learning Models

Chapter 4 and Chapter 5 evaluate conventional generation methods for human behaviors. To further improve the generation accuracy and make accurate predictions, machine learning approaches are adopted in Chapter 7. Transformer-based models are constructed to generate and predict human behaviors (including activities and mobilities). The outputs of models change as the settings of urban environments and societal factors vary. Thus, the models can be used for predicting behavior patterns given a scenario. The generation power and the prediction power of models are high. Moreover, the models seem to have learned the spatial structure of the city and the temporal relationships between daily behaviors. This study highlights the potential usefulness of transformer models for activity and mobility modeling.

Chapter 8: Discussion and Conclusions

Chapter 8 summarizes previous chapters and provides a discussion about the application of proposed models, limitations, and future topics.