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Article / Book Information

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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 ）

As future mobilities are gradually introduced into human society, mixed spaces with multiple road users will increase with new problems. In fact, problems like electric scooter accidents have crept into human life, it is urgent to consider human-machine coexistence and pedestrian safety in new circumstances. Based on the contributions and limitations of previous studies, this research proposes the envelope theorem from physical and mental perspectives to provide a theoretical basis for handling mixed traffic and ensuring a safe and comfortable walking environment for pedestrians. For future utilizations, the envelope theorem will be applied for handling human-machine interactions, evaluating comfortable quality of spaces, and considering the rule-making and space utilizations in the future, which will contribute to improving the human-machine coexistence.

This dissertation is organized into six chapters to introduce this research.

Chapter 1 introduces the background of this research in terms of the social tendency and problems of human-machine coexistence, the limitations and controversies of previous studies, and the current situation and possible problems of mixed traffic in Japanese society. The objectives, research scope, and structure of this dissertation are also presented.

Chapter 2 describes the published research findings and opinions related to this research from three perspectives of concept design, conceptual validation, and application effect validation. For the concept design, the contributions and limitations of the robot envelope, interpersonal space, and the ethical boundary between humans and machines are introduced. For conceptual validation, methodologies, and related factors in studies of transportation and robotics fields are referenced. For the application effect validation, studies about secondary developments of the social force model and related factors of improving the reality of simulation are introduced. These previous studies are important references for this research.

Chapter 3 presents the contents of the envelope theorem. The envelope is divided into physical and mental envelopes (PE and ME) in this research. In the ME, there are subject mental envelopes (SME) and object mental envelope (OME). The attributes of PE and ME are also introduced, including the strength of PE and ME, four different expressions of ME, and the relationship between PE and ME. For the possible applications of ME, it can be used as an indicator for evaluating space comfortable quality from different perspectives and a new perspective of rule-making, which will contribute to improving the humanization of machines' movements. Moreover, the envelope theorem for realizing OME and related proof further explain the idea of a kind of OME's application taking effect for multiple road users in public space, which is instructive for further study of OME.

Chapter 4 focuses on demonstrating the perceptual existence of ME and exploring the structural relationships among ME and influencing factors. The online questionnaire survey is used for the exploration. The results show that the idea of OME expressions is accepted by participants, and is greater affected by negative emotions (stress and danger) than SMEs. The characteristics of SME are consistent with previous studies, indicating that SME can be described as a substitution of IPS in the definition. These results are in line with the definition. Also, the relationship between SME and OME is found, showing that OME positively affects SME. The reciprocal causation of OME and subjective priority order showing in results will be beneficial to explore the future application of OME.

Chapter 5 introduces the development of the envelope theorem and presents the related applications in considering future public space through the simulation study. We consider different types of envelope spaces as possible forms of future public spaces, and develop a simulator to reproduce them. The simulation results clearly represent the movements of objects in different situations by animations, and show the effects of envelope spaces under different social goals through outputs of efficiency and safety/comfort evaluation indicators. For future applications, this simulator can be applied to help people directly observe and discuss public space utilization and management, and find possible problems for preparing in advance. Based on the simulation results, this research also discusses the desired future public space forms and future expectations, and provides some recommendations for applying the envelope theorem.

Chapter 6 presents the conclusion of this research in terms of the major findings, contributions, and limitations. The recommendation for future works is also proposed, including the further expansion of ME's concept, the more comprehensive proof of envelope theorem, the further exploration of ME forms and expansion of its application, and the further development of the envelope spaces.

For the future outlook, the envelope theorem is expected to be developed and applied in various fields, not only limited to solving traffic problems and human-machine relationships in physical space. It is also desired to inspire more consideration from researchers, which will pave the way for the coexistence of humans and machines or even new things in the future.