論 文 の 内 容 の 要 旨

論文題目　Shared Control of an Electric Wheelchair Considering Physical Functions and Driving Motivation
（身体機能と操縦意欲を考慮した電動車いすの協調制御）

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Recently, the number of individuals with severe disabilities and elderly persons is increasing in Japan. Their continuously decreasing physical and cognition functions can easily lead to mobility problems which will have a negative effect on their life-range and Quality of Life (QOL). Electric wheelchair (EW) is one of the most widely used devices for them. However, for individuals with weak physical functions, even with the specially designed input devices, there is no guarantee that they can accurately operate the EW as intended especially when the straight and turning motion of an EW should be simultaneously adjusted. Automatic driving partly solves the problem although excessive reliance on automatic driving is not conducive to maintaining their residual physical functions and may cause more serious diseases. Shared control technologies offer another possibility wherein a user and machine work together to operate an EW to the destination.

This research aims to propose a novel shared control methodology for individuals who have difficulties in driving an EW. Many shared control methodologies of the EWs have been developed in the previous researches, most of their designs are based on the characteristics of the environments and some commonly used indexes like safety and comfort. However, for individuals with weak physical functions, it is important to utilize their residual physical functions and maintain motivation when using the shared control system. Therefore, the purpose of this research is to propose a novel shared control of an EW for individuals with weak physical functions considering their residual physical functions and driving motivation.

To solve such a problem, this research first summaries the design requirements based on analyzing the characteristics of the target users. Then, the concept, framework and theoretical design of the shared control system are proposed considering the design requirements. Subsequently, the characteristics of the proposed shared control system and the user machine interactions are investigated

through simulations and experiments. Finally, a method to utilize physical functions and maintain driving motivations are proposed based on the simulation and experimental results and the effectiveness of the method is proven by verification experiments.

In this way, this research proposes a novel shared control system for individuals with weak physical functions considering their residual physical functions and driving motivation.

The dissertation consists of three parts: the requirement part, the shared controller design part and the performance analysis and practical application of the controller. The details are shown below:

Chapter 1 [Introduction] introduces the research background and purposes for the mobility for individuals with mobility problems.

Chapter 2 [Construction of the shared control] first introduces and compares the different categories of the shared control system for the EWs. The target users and the driving environments are then summarized based on the characteristics of potential users who have difficulties in driving an EW. Finally, the requirements of the shared control system and several important definitions like “safety”, “physical function” and “driving motivation” are introduced.

Chapter 3 [Shared control system considering physical functions and driving motivation] describes the design process of the shared control system based on the characteristics of the target users and system requirements which are discussed in Chapter 2. Specifically, the modeling of EW that is used in the shared control system is first introduced. Subsequently, the design concept of the novel shared control system is introduced based on the process of the EW driving, the characteristics of the target users, and the design requirements. Finally, the framework of the novel shared control system is proposed based on the design concept.

Chapter 4 [Shared control system using Reinforcement learning] describes the design of the shared control system by considering the system requirements, different users, and environments via reinforcement learning. The basic characteristics, structure and previous researches of reinforcement learning are first introduced. Subsequently, the application of reinforcement learning in this study is introduced. Then, the reward design, the state design and the algorithm design are mainly discussed because they are important to realize the design purpose.

Chapter 5 [Simulation studies: effectiveness and important parameters of the

shared control system] first shows the effectiveness of the proposed shared control that the controller gradually adapts to users' operating characteristics via several trials of training. Subsequently, the effects of several significant factors are discussed.

Chapter 6 [Experimental studies: interaction characteristics between user and machine] are carried out for two purposes. The first one is to analyze interaction characteristics between user and machine. The second one is to propose a "Guidance" after fully understanding the characteristics of the shared control system and the different users.

Chapter 7 [Conclusions and future work] describes the conclusions of this paper and the prospects.