# 論 文 の 内 容 の 要 旨

論文題目　Motion Control of a Power-Assisted Wheelchair and Implementation
- Human-friendly Control System to Improve Safety, Mobility and Ease of Use -
（パワーアシスト車椅子のモーションコントロールとその実用化
ー安全性・移動性・便宜性向上のための人間親和型制御システムー）

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The wheelchair is an important device that offers a method of transport to mobility-impaired people. There are many kinds of wheelchairs being developed to minimize injury while improving maneuverability. Power-assisted wheelchairs were developed for the same reason. The power- assisted wheelchair is an electric wheelchair that has a motor in each of the two main wheels and a torque sensor in each handrim. When the user pushes a handrim, the user’s pushing force is measured by the torsion sensor in that handrim. The motors will output assist torque, which is calculated in the assistive control system. The power-assisted wheelchair lightens the physical burden on the user by providing power assistance, while encouraging maintenance of arm function as well as improvement of health and fitness through handrim use. Furthermore, it is possible to apply control systems to power-assisted wheelchairs. By controlling both motors appropriately, wheelchair functionalities as well as performance factors such as safety, comfort, handling and mobility can be enhanced. In this thesis, human-friendly control systems - assistive control, yaw motion control and one-handed propulsion control - are proposed to improve safety, mobility, and ease of use.

First, a novel two-dimensional assistive control for power-assisted wheelchairs considering linear and rotational motion decomposition is proposed in this thesis. To improve performance, many assistive control systems were proposed. One of the conventional assistive control strategies, proposed by Seki et al., is designed for translation, but is inconvenient for rotation. The proposed assistive control is designed for wheelchair both linear and rotative motion. Assist rate and time constant of translation and rotation, are adjusted independently. Therefore, power assist performance in rotating motion is improved compared to this conventional systems.

Second, yaw motion control under lateral disturbance environments is proposed in this thesis to improve safety and quality of life of the wheelchair user. On lateral slopes, disturbances make the wheelchair's speed as well as direction difficult to manage, which can cause accidents and may lead to injury. To overcome this problem, two-degree-of-freedom yaw motion control is proposed. Using the proposed yaw motion control, a wheelchair does not be subject to influence from yaw directional disturbances, and hence overall performance of the wheelchair is improved. To demonstrate the effectiveness of the yaw motion control, two kinds of experiments have been performed: going straight on the slope, and turning on the slope. Effectiveness of the proposed control system has been verified by experiments.

Third, one-handed propulsion control system for a power-assisted wheelchair is proposed. For people also with hemiplegia or a hand/arm injury, a wheelchair operable with one hand is necessary. However, it is impossible to control a standard manual wheelchair or power-assist wheelchair with only one hand. The one-handed propulsion control system for a power-assisted wheelchair was proposed previously. Conventional one-handed propulsion control system allows the user to go straight, do pure rotations, and turn while running. However, turning movement is different from general turning movement of wheelchair in conventional systems. Wheelchair users feel a sense of incompatibility with the conventional control system. In this thesis, an improved one-handed propulsion system that realizes advanced turning motion is proposed. Advanced turning motion is focused on two-handed propulsion wheelchair. Analysis results of human torque in two-handed propulsion is applied to turning motion in one-handed propulsion control system.

Last, the implementation of the proposed control systems is introduced in this thesis. There are difficulties to apply novel control system to daily use welfare device. There are many aca- demic researches on welfare devices, however, not all of them interact with the end-user of these instruments. A gap between valuable academic research and daily use technology is one of the difficulties in practical application. Another difficulty comes from the cost of the components. It will be hard to use devices, if the cost is high, even though the device is helpful. Good devices, such as sensors with high resolution, are expensive. In this research, a new wheelchair system is constituted for practical application. Proposed assistive control, yaw motion control and one- handed propulsion control are applied to the new wheelchair system. To lower the cost, yaw motion control using rotary encoders instead of a gyroscope is considered. Effectiveness of the implementation is verified by subject experiments of yaw motion control and one-handed propulsion control. Three group of people - advanced wheelchair users, beginners, and researchers - participated in the experiments and answered the questionnaire. Effectiveness of the implementation has been verified by experiments and questionnaire.