Study on Environmental Control System for People with Serious Disabilities

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Serious disability may result in patients living in a bed ridden state with little ability of voluntary movement. For example their intentional muscular abilities maybe limited only to slight head movements, fingers movements and eye movements. Their daily lives are dependent on family members and care-givers. Interaction of these patients with society is extremely limited. Even if they lose their independence and communication abilities, they should enjoy their lives as individual human beings. In order to improve their quality of life, an environmental control system has been proposed and is efficient at enabling the control of home electric appliances as well as providing a computer interface. Usability and adaptability of the control system are important problems to be solved for such people with serious disabilities. Due to recent developments of information and computer technology, this environmental control system with advanced usability and adaptability has been achieved. Considering that the recovering of independence and communication abilities for such patients with serious disabilities is top priority, an environmental control system employing the recent information technologies has been developed.

This thesis consists of five chapters. In chapter 1, the situation of people with serious disabilities is considered and two patients are introduced to clarify the target patients of this research. One patient suffering from an incurable neurological disease (amyotrophic lateral sclerosis: ALS), his remaining muscular ability is significantly limited to slight finger movements and eye and head movement. He can make faint vocal utterances. His daily life is dependent on his wife and care givers. Another patient injured his spinal cord by accidentally falling. His remaining abilities are limited to movement above his neck. He needs an artificial respirator. His daily life is also dependent on the care givers. In order to improve these patients' quality of life, an environmental control system and input devices are discussed. This is purpose of this thesis.

In chapter 2, an environmental control system using a tablet computer with blue tooth communication function is proposed. The environmental control system consists of four parts, the tablet computer, input devices, an infrared controller to control home electric appliances and a bed controller. The efficacy of one proposed input device is operated by slight finger movement and is evaluated by ALS patients. Based on the evaluation, the efficacy of the proposed input device was confirmed.

In chapter 3, a vision-based computer input device is proposed. The user of the proposed input device can move the computer cursor by head movement and activate the click button by mouth opening and closing actions. A feature of the input device is robustness to the hazardous environment by introducing a multiple template matching method and an orientation code matching algorithm (OCM). The advantage of the proposed method over a conventional method was evaluated by experiments.

In Chapter 4, an input device using a joystick is introduced. The proposed input device enables wheelchair users to operate the computer settled apart from the wheelchair. A feature of the device is that the joystick control can be achieved by mounting a sensor unit on the wheelchair joystick without any modification of the wheelchair joystick controller. The principle of the sensing unit is to measure the inclination angle and the direction of the joystick with an acceleration and gyro sensors. The applicability of the proposed input device was tested by a wheel chair user.

In chapter 5, a SEMG (surface electromyography)-driven musculoskeletal model is proposed. The model is used to control an exoskeleton robot which is designed for lower body rehabilitation. This control framework of the exoskeleton rehabilitation robot has been successfully applied to assist rehabilitation by guiding motions to correct training, rehabilitation trajectories, or to provide additional force to support perform certain motions.

In chapter 6, the conclusions and future of this thesis are described. Firstly, an environmental control system using a tablet computer was proposed to assist people with serious disabilities towards been more independent. In addition, efficiency of an input device for people with slight remaining abilities on their fingers was proposed. The usability of the proposed environmental control system and input devices were confirmed by experiments.

Secondly, a vision-based input device using multiple template matching and orientation code matching algorithm was proposed as an effective device for people with serious disabilities. Comparison tests revealed the usability and robustness feature of the proposed device. Thirdly, an input device using a joystick mounted on a conventional wheelchair was proposed and the usability was confirmed.

In the final part, a control system framework based on a neuromusculoskeletal model was proposed. SEMG was used to sense the operator’s voluntary intention and proved to provide an intuitive control for the exoskeletal device. Compared with current control systems this would be significantly more intuitive user friendly and effective.