Usability Evaluation of Operating Devices for Electric Wheelchairs

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***Abstract*— In recent years, much research has been conducted on automated wheelchair technology. However, few automated wheelchairs have been commercialized. In addition, there is a lack of research on devices to operate wheelchairs manually or by steering wheel as well as automatically. The purpose of this study is to develop a wheelchair that makes everyday life more comfortable. First, we considered what kind of shape and sensors should be used for the operating device in developing the wheelchair. New input methods were considered for new sleigh operation devices, including a type with a small joystick, a fingertip input type, and a regular operation device.**

***Keywords*— operating device, automated wheelchair, Electric Wheelchairs**

I. INTRODUCTION

Currently, automated wheelchairs are becoming automatic operation level 4. The automatic operation levels are divided into six levels of automatic operation (0~5), and the subject of the motor task and the driving area are determined for each level. Level 4 is the stage where fully automated driving by the system is possible under certain conditions. However, the places where the system can operate at this Level 4 are limited, and the system has only been used in some facilities such as Haneda Airport. Therefore, the system has not yet been used by people who use electric wheelchairs daily, which is a problem. To solve this problem, various companies are working on demonstration tests on public roads, aiming to solve the problem. Advances in this area of research will relieve the stress that many electric wheelchair users face when going out, allowing them to enjoy their outings in greater comfort and stress-free conditions. In previous research, self-location is recognized by combining the driving environment stored in advance and the surrounding information detected by the LRF. This method can automatically calculate the route to the destination, avoiding obstacles as it goes. However, because it runs along a predetermined route, it is not able to respond to changes in road surface conditions and other circumstances. Therefore, the purpose of this study is to drive a self-made Level 4 automated wheelchair on public roads.

In this study, a device was developed to avoid obstacles and move the wheelchair to the destination by analyzing location information obtained by GPS and obstacle detection by camera and LiDAR sensor using Raspberry Pi to determine its own position and posture. This electric wheelchair differs from previous studies in that instead of moving through a pre-memorized driving environment, it uses GPS to set the destination and observe the driving environment in real time, allowing for greater freedom of movement.

II. ELECTRIC WHEELLCHAIRS SYSTEM OUTLINE

Figure 1 is a photograph of the exoskeleton of the device. The electric wheelchair is 680 mm wide, 990 mm deep, and 950 mm high, weighs 43 kg, and is powered by a 12 V battery. The front wheels have a diameter of 190 mm and the rear wheels have a diameter of 400 mm. The seat is 420 mm wide and 420 mm deep, and the backrest is 385 mm long. The motor was a brushless gear motor, 12 V, 250 W, 2950 RPM, and 2.5 A no-load current. The motor was controlled by an H-bridge dual motor driver (Binogram PWM module 36V 30A IRF3205). Figure 2 shows a block diagram of the automatic electric wheelchair to be manufactured this time. In addition, the automatic operation is planned to detect navigation paths using position information from GPS and to detect and avoid obstacles using a camera and LiDAR sensor.

Fig.1 Appearance of the device

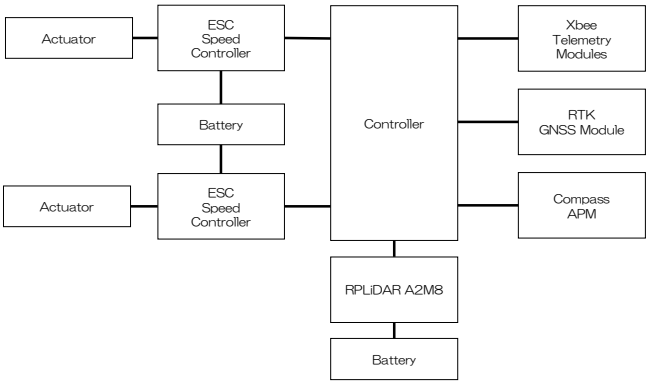

Fig.2 Control system of the device

III. Experiment

In this development, we investigated the optimal shapes and methods of operating devices for electric wheelchairs. Figure 3 shows the three types of input devices currently under development. a) is an ordinary joystick type, b) is a touch panel type input device, and c) is a palm-sized input device using a small joystick (Dual-axis Joystick joystick module). c) is a palm-sized input device using a small joystick (Dual-axis Joystick module). The small joystick type determines the direction by reading the output values of two potentiometers in the x and y axes. The joystick can be attached to an existing actuator. The touch panel type (2.8" TFT inch LCD display) enables movement in the direction traced by a fingertip. The newly installed small joystick type and touch panel type are designed to read sensor values into the Arduino to control the motor.

In the experiment, we confirmed the feeling of operation by actually sitting in the electric wheelchair. The subjects were five male adults. They sat in the electric wheelchair one by one, actually used the control device, and then completed a questionnaire.

IV. Results and Discussion

This study examined the usability of the control devices. As a result, the respondents answered that the small joystick-type device was easy to use because it fits in the palm of the hand and can be operated with only the thumb. In the case of the touch screen, it was found that it was difficult to use the device, although the operation feeling could be improved to some extent by setting it to the individual's position. In the case of a normal joystick, the respondents said that it was difficult to move the joystick because they had to move their wrists widely.

These results clearly indicate that the use of a small joystick is a good method of operation.

V. Conclusion

This study examined the usability of control devices for an automated electric wheelchair by having the users operate the devices. As a result, it became clear that a small joystick was easy to operate. However, since we confirmed the usability of the joystick with a normal person, we are planning to examine the usability of the joystick with a person who uses an electric wheelchair.

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a) Joystick type b) Touch panel type input device

c) a small joystick

Fig.3 Three types of operating devices

a) Joystick type b) Touch panel type input device

c) a small joystick

Fig.3 Three types of operating devices in use