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A Study on the Electric Wheelchair Hands-Free Control System using the Laser Range Scanner

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Abstract: This paper presents a semi-automatic control system for electric wheelchair using laser range scanner. The user of this system is supposed as severe disabilities paraplegic who cannot move the body under the neck. They can use the surface electromyography (s-EMG) of the facial muscle for controlling the electric wheelchair. When they are controlling the electric wheelchair with the s-EMG signals, to avoid the obstacle is difficult. Therefore, we developed the semi-automatic assist system for avoiding the obstacle. The proposed system is composed by laser range scanner. The electric wheelchair could increase safety by using our proposed assist system. We tried the experiments of driving in the hallway of the building. Our proposed system was confirmed that the electric wheelchair did not clash with the hallway of the building.

Keywords: Surface Electromyogram Signal, Electric Wheelchair, Laser range scanner, Motion Control Command Rule, Semi-Automatic Control

1 INTRODUCTION

An electric wheelchair is indispensable for disabled people. In recent years, the joystick type of electric wheelchair is very popular. However, for persons with severe disabilities who find it difficult to operate the joystick of electric wheelchair, in the other hand, the new types of devices for disabled people have appeared, for example the voice, brain waves and surface electromyogram (abbr. s-EMG) signals etc. Disabled people who have the problem of limbs can use these types of devices, but the well adjustment of the driving route by using these devices is difficult. In addition, the user of electric wheelchair must be safe driving. Disabled people are hard to check the safety around. Thus, it is necessary to check safety using sensors.

This paper presents a semi-automatic control system for the electric wheelchair by using a laser range scanner [1]. The user of the proposed system is supposed as serious disabled people who cannot move the body under the neck. They cannot control the electric wheelchair with hands or legs, but they can use the Bio-signal in their face. For example, the Bio-signal system is the s-EMG system [2][3].

This system can be controlled by using the face s-EMG signals. This system can recognize face motion (a left wink, a right wink and a bite) by using s-EMG sensors. The method of controlling the electric wheelchair in this system is shown in Table 1. This system is attached with a laser range sensor for the safety, and the electric wheelchair could be speed controlled, but this system cannot avoid the obstacle automatically. Thus, the user has to control the electric wheelchair to avoid the obstacle every time. Therefore we developed the automatic control system for avoiding the obstacle.

Table 1. The way of controlling the electric wheelchair.

State of electric wheelchair \ Movement of face	Left wink	Right wink	Bite
During a stop	**Turn left**	**Turn right**	**Foward**
During a forward	**Forward to the left**	**Forward to the right**	**Stop**

2 THE PROPOSED SYSTEM

2.1 Sensor Position

The proposed system is composed by a laser range scanner (HOKUYO AUTOMATIC CO., LTD, sensor model URG-LX04). The specification of this sensor is shown as Figure 1. The measurable range of this sensor is maximum 4 meter in 120 degree left and right, and the sampling interval is 100 msec. The specification of this sensor is shown as Figure 1.

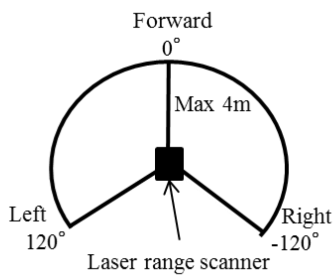

Figure 1. The range of the laser range scanner.

In the proposed system, the laser range scanner is attached on the brace by the 1.7m high from the ground (Figure 2). This position can measure the side of the electric wheelchair. The laser range scanner can recognize the obstacle even as large as a wall.

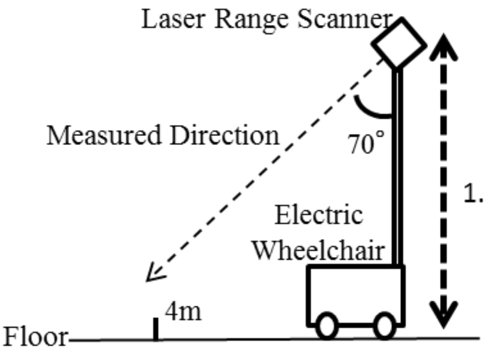

Figure 2. The position of the laser range scanner.

2.2 Pretreatment

First step, get angle values and distance values between the obstacle and the laser range scanner. Second step, convert the angle values and the distance values into Euclidean distance, and plot these values on the picture (width: 160 pixel, height: 160 pixel) with dots. 1 pixel represents 50mm. Thirds step, if the distance between two dots is less than the width of the electric wheelchair, these two dots will be connect with the line. The results of using these steps are shown in Figure 3. Figure 3(a) shows the actual scene. Figure 3(b) shows the measured values of the laser range scanner, and the center on the Figure 3(b) is the laser range scanner position. Figure 3(c) shows reformed values. Figure 3(c) is shown as the confirmation window on the personal computer.

Figure 3(a). Actual scene.

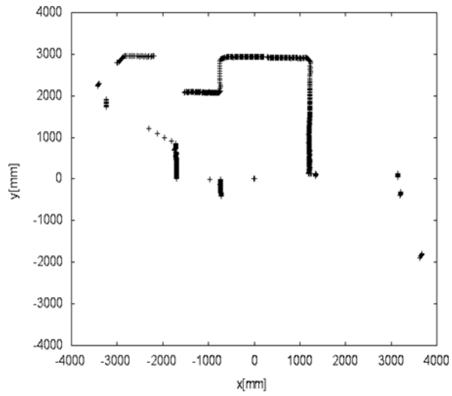

Figure 3(b). Measured values.

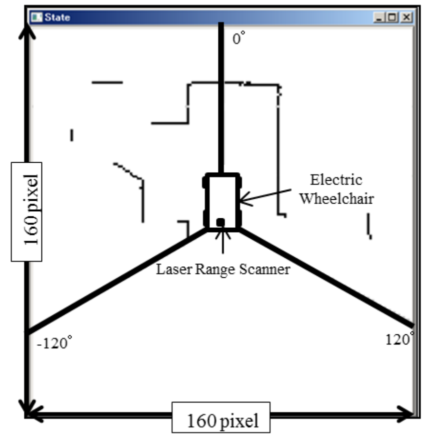

Figure 3(c). The confirmation window.

2.3 Speed Control

The speed of the electric wheelchair could be controlled ac-cording the distance between the obstacle and the laser range scanner. The area of controlling speed is separated into three parts by the distance from the front of the electric wheelchair to the obstacle (Figure 4).

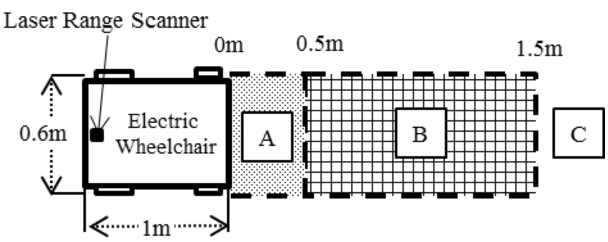

Figure 4. The separated area.

(a) Area A

The area A is less than 0.5 meter. If there is the obstacle, the electric wheelchair will be stopped. The electric wheelchair cannot go forward, but it can also turn on the spot. The electric wheelchair doesn't move until a turn command.

(b) Area B

The area B is less than 1.5 meter and more than 0.5 meter. If the obstacle exists in the area B, the speed of the electric wheelchair will be slowed down. In addition, for avoiding the obstacle, the area L_B and the area R_B are checked (Figure 5). When both the area L_B and the area R_B does not exist any obstacles, the electric wheelchair will turn to the left. If there is the obstacle in one side, the electric wheelchair will turn to the opposite direction. When both the area L_B and the area R_B exists the obstacles, the electric wheelchair will be slowed down the speed only.

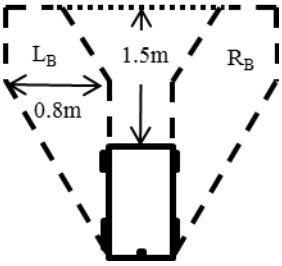

Figure 5. The search area in area B.

(c) Area C

If the obstacle does not exist in the area A and the area B, the proposed system will search the obstacle in the area L_C and the area R_C (Figure 6). The speed of the electric wheelchair is the normal speed. If the obstacle exists in the area L_C or the area R_C, the electric wheelchair will be controlled by the fine adjustment. To check these areas is in order to prevent approaching the wall.

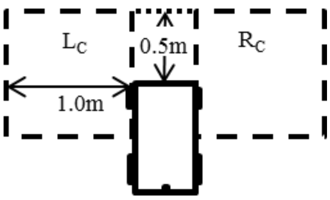

Figure 6. The search area in the area C.

(d) During a stop

When the user commands as the left or the right, the electric wheelchair turns on the spot. By checking the obstacle in the area L_D or the area R_D (Figure 7), the electric wheelchair turns slowly on the spot.

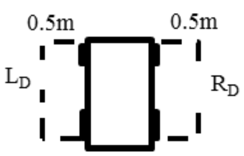

Figure 7. The search area during the stop.

3 EXPERIMENTS

3.1 Structure

The overall structure of the electric wheelchair is shown as Figure 8. The laser range scanner is attached on the electric wheelchair. The subject is attached S-EMG sensors. The data measured by the laser range scanner and s-EMG sensors can be analyzed on the personal computer. The flowchart of the control is shown as Figure 9. The user can command the electric wheelchair by using s-EMG sensors. The laser range scanner is checking the state of the obstacle around the electric wheelchair. The output command is judged on the personal computer by both using s-EMG sensors and the laser range scanner.

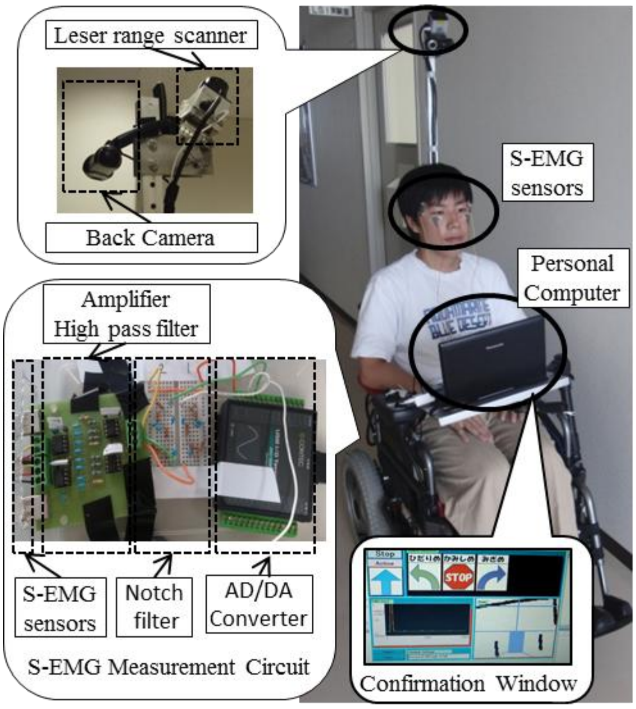

Figure 8. The structure of the proposed system.

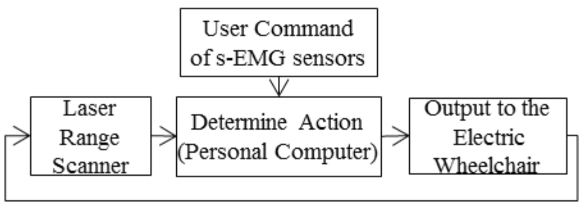

Figure 9. The flowchart of the control.

3.2 Experimental condition

We experimented with proposed system in the building corridor. The width of the building corridor is 1.9 meter. The subject is a healthy twenties male, and he agree to join in the experiments himself. He controlled the electric wheelchair by using s-EMG sensors. To check the proposed system, he is supposed as severe disabilities paraplegic who could use bite only.

4 RESULTS

We tried to drive the electric wheelchair with the proposed system. Actual scenes and driven routes are shown as Figure 10. The interval between two points is 2 second. The arrow in the figure shows the direction of driving the electric wheelchair.

The route of starting to the oblique angle against the wall is shown Figure 10(a). In the start position, the user commanded to start the electric wheelchair. When the electric wheelchair turned to the right with the proposed system, the user did not have commanded anything. In the goal, the electric wheelchair was stopped by the user command. In the case of this course, the electric wheelchair did not clash with the wall.

The figure 10(b) is shown as driving routes in the corridor. The area X is the straight corridor. The width of the area Y is larger than the width of the straight corridor. The electric wheelchair did not clash the wall.

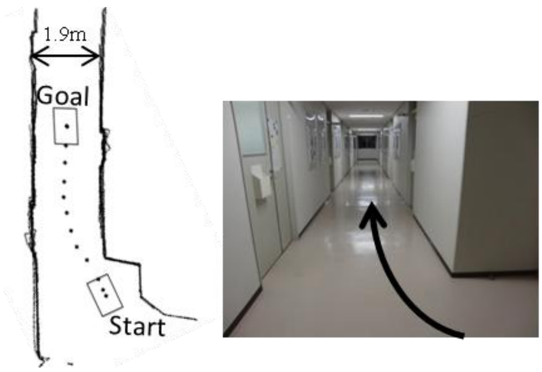

Figure 10(a). Starting to the oblique angle.

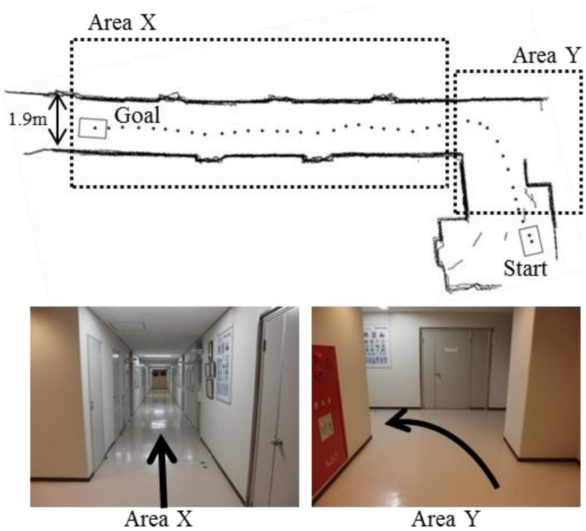

Figure 10(b). Driving routes in the corridor.

5 CONCLUSION

We tried to control the electric wheelchair with the proposed system. The electric wheelchair did not clash the wall. Using the laser range scanner, the user need not command for the fine adjustment. Therefore the electric wheelchair can drive smoothly in the narrow space such as the hallway of the building.

If the laser range scanner cannot measure the obstacle, the user needs to command the stop with s-EMG sensors himself. The proposed system provided the assist to the user. While the obstacle is found of the laser range scanner, the user doesn't need any command, the proposed system avoid the obstacle automatically. Now, we are trying the monitoring test for serious disabled people by using the proposed system.

But the wavelength of the laser range scanner is 785nm, and this wavelength cannot measure such as the glass. So the electric wheelchair needs another sensor such as the ultrasonic wave sensor to deal with the obstacles such as the glass.

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