Maneuvering Method for the All-directional Indoor Electric Wheelchair

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Abstract

It is an important issue to develop an easy and high-performance electric wheelchair for the growing population of elderly people. If there is insufficient space in the indoor environment, it is difficult for a normal electric wheelchair to change direction and maneuver. It is important that the wheelchair can be moved in all directions with easy operation. In this research, a new type of all-directional electric wheelchair has been designed. This electric wheelchair consists of three motors to drive and to change the orientation of the wheels. With this wheelchair, it becomes possible to operate wheelchairs more easily without the use of special wheels. The drive units are encased inside of the body, therefore, there is the advantage of a lower risk of the wheel rolling over the user's feet.

Keywords

electric wheelchair, all-directional, battery driven, human interface, simple control

1. INTRODUCTION

Among the growing population of elderly people, it is a key issue to develop a simple and high performance electric wheelchair [Masuzawa et al., 2005]. Inconvenient factors of previously used electric wheelchairs include the lack of all-directional performance and the complicated joystick lever for control. The usual electric wheelchair, as shown in Figure 1, must be operated through a series of repeated complicated movements, and also it is necessary to have enough space for such maneuvering. Regarding the guidelines of the Ministry of Land, Infrastructure, Transport and Tourism Japan [2003], the necessary space for a commercially available electric wheelchair to turn 360 degrees, without complicated maneuvering, is a circle of 180 cm in diameter. Compared to a manual wheelchair, which requires a space of 150 cm in diameter, a larger space is necessary for the electric wheelchair. The normal electric wheelchair must be operated in a way that the front direction of movement is the desired direction. If there is an electric wheelchair which can move in all directions, even without changing the original orientation, the action of complicated changing direction can be omitted, therefore, it is possible to achieve efficiency of movement. Especially in an indoor environment where there is not enough space, it is an important factor to be able to move in all directions with simple control.

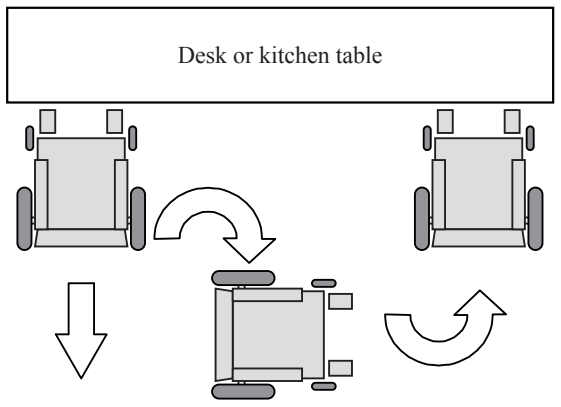

Fig. 1 Maneuvering method of normal electric wheelchair

Recently, the development of various welfare equipment to support elderly people and physically impaired people is attracting attention. Also, much research is being performed about usability because wheelchair users require the wheelchair for daily life. [Fujii and Wada, 2001; Kato et al., 2012; Sakamoto et al., 1990] One of the main areas of research is about maneuvering. In the situation of being in the house, where space is limited, electric wheelchair users hope to move without too much maneuvering. Therefore, in previous research of an all-directional electric wheelchair, Iida et al. [2009] developed a ball-type of wheel, but it was unstable for going straight and turning. Ichikawa [2005] used an omni-wheel. However, the demerit is that the wheel which is not related to the drive course is only idling and drive loss occurs. Kamata et al. [2001] has shown a drive unit constructed of a drive wheel and a dual-wheel caster drive

system connected with a motion unit and rotary joint made by casters on the right and left. The device is not yet in practical use.

Concerning these matters, there is some advanced research but they are still not useful. The purpose of this research is to develop an all-directional electric wheelchair without changing the original orientation to the objective course.

2. MECHANISM

The mechanism is shown in Figure 2. This experimental wheelchair consists of two drive motors connected to the wheels directly and the rotation units to keep the posture direction are installed inside of the body. The rotating unit can move the wheelchair in directions shown by the arrows. This rotation makes it possible to keep or change the posture direction independently to the wheelchair movement direction. Figure 3 shows the installed drive unit, seat and rotating units.

2.1 Suspension

The unique suspension units, which are connected to the drive unit and the seat, play a role in maintaining the stability of driving because, even if the road surface is irregular, the drive unit tires are in contact with the ground. Four suspension units make it possible to adjust the stroke of the spring. This is shown in the photograph of Figure 4.

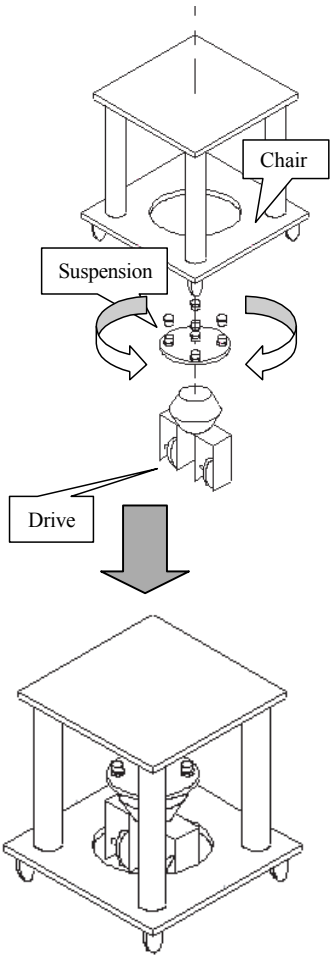

Fig. 2 Configuration of the drive wheels of the electric wheelchair

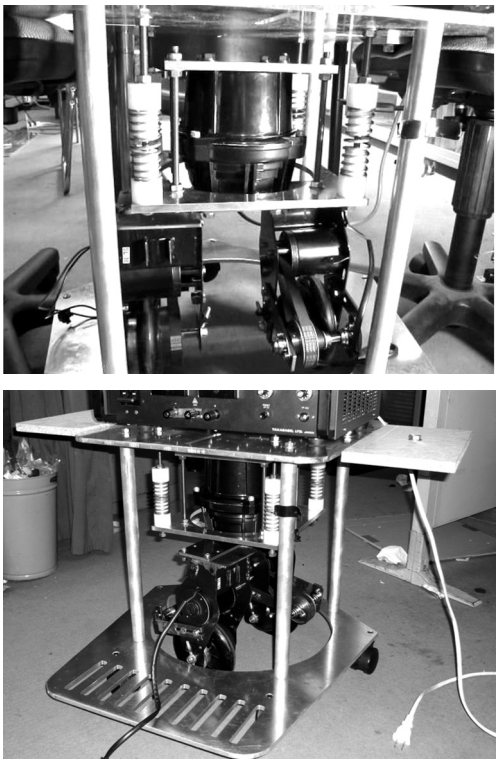

Fig. 3 Two drive wheels and the servo-motor for azimuthal motion

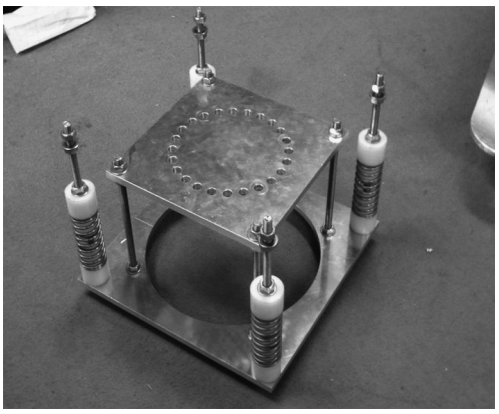

Fig. 4 A photograph of the suspension

2.2 Drive unit

The drive unit plays two roles. One is to drive the electric wheelchair and the other is to keep or to change the posture direction. The drive unit consists of two moving tires and two fixed tires on a mount which makes it possible to drive forward or backward, or turn to the right and left independently. The power

of the two DC motors used for driving is 100 W each by a 24 V PWM controller.

When changing the movement direction of the electric wheelchair centered on the posture direction, it is necessary for the drive unit to turn with two wheels. Regarding this point, it is possible to be accomplished by controlling with a servo-motor. Figure 5 shows the changes of the drive unit centered on the seat.

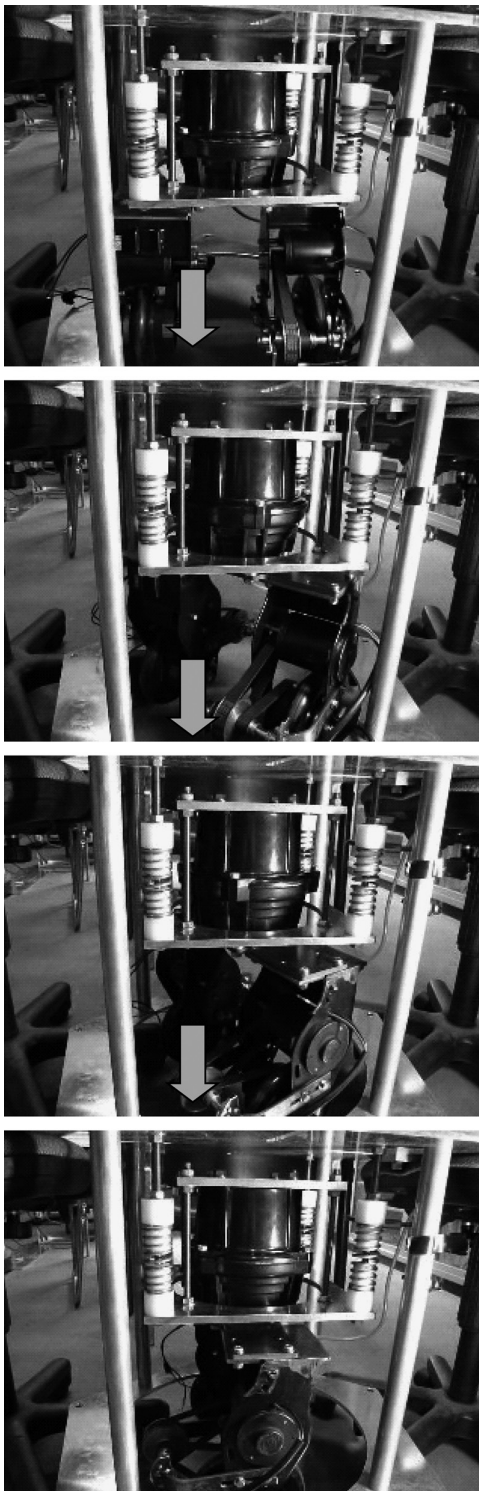

Fig. 5 Changes to the drive unit centered on seat

2.3 Control system

The control system consists of a "two drive unit system" and a "speed control system". The forward and back control is made by the two motors directly connected with two wheels. While the other drive unit is used to keep or change the posture orientation by moving the motion of the wheelchair seat azimuthally. The driver can change the forward and back motion of the wheelchair and the orientation independently to make the best maneuver to reach the optimized motion, Figure 6 shows a block diagram of the control system.

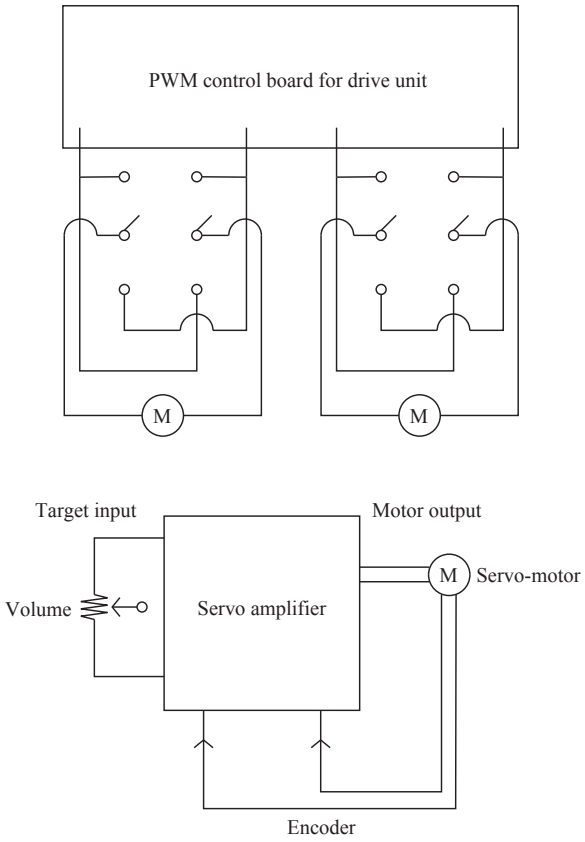

Fig. 6 Control block diagram

The rotating drive unit is controlled by the servo-motor which is installed in the drive unit. A set of servo-motors are used. The speed control system controls the drive speed. The speed of the wheelchair is controlled by DC voltage induced by pushing the joystick. The orientation of the wheelchair is determined by a signal of rotating command from a rotating small knob. The knob controlled by a driver keeps or changes the seat orientation.

3. RESULTS AND CONCLUSION

Normal electric wheelchairs cannot move perpendicular to the moving direction without changing the front direction to the desired direction, because the wheels

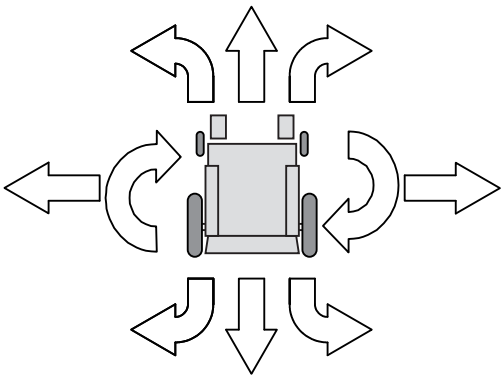

Fig. 7 Possible directions of movement

are connected to the two fixed motors. In other words, the posture direction and the movement direction are the same. However, depending on the environment, if the space is narrow, sideway motion is difficult and the maneuvering operation is complicated. If the change of sideway motion is easy, even regardless of the posture direction, especially using the wheelchair indoors, it would be quite effective in achieving freedom of movement. This method is simple and easy to be installed into the conventional electric wheelchair. This prototype electric wheelchair has shown that the system works well to enable both posture direction and movement direction independently, therefore, this wheelchair would provide a quite useful function to move the wheelchair in forward-back direction to the direction of the electric wheelchair. It consists of a drive unit, a seat and suspension units.
This electric wheelchair has the following advantages.

(1) Simple control because it just uses a motor unit with two drive motors and one servo-motor for changing direction.
(2) It is not necessary to use an omni-wheel or special wheels for right-left direction movement.
(3) All of the driving unit is installed inside the body, therefore, it is safe and there is lower risk of rolling over feet.

Regarding future research, it is complicated for the user to operate this electric wheelchair because it is necessary for each of the drive units to be operated separately. Therefore, to be used by elderly people, it is necessary for each of the drive units to work together. Also, for elderly people, it is necessary to make the structure of control simpler. There are still issues, but the development of an electric wheelchair which is able to move in all directions was accomplished without regulating the direction of the user's posture.

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