The Omni-directional Wheelchair for The Elderly

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***Abstract*— This omni-directional wheelchair was designed for the less abled elderly to move more flexibly in narrow spaces, such as elevators or small aisle. We have constructed one dexterous three-wheeled wheelchair with smooth omni-directional motion. It does not only keep the merit of the existing manual and electrical operated wheelchair, but also with a novel omni-directional mobility system. Elderly people can easily operate such device in most environments. We implemented the dexterous and complicated mechanisms to allow such an electrically operated wheelchair to move forward at any direction that is far easier manoeuvred than any traditional electronic wheelchairs.**

We carried on improvements for design, mechanical and control system of this electrically operated wheelchair, and the development of smart automatic charge system and lastly a collision-evading system.

Key words: Wheelchair, electrically operated wheelchair, omni-directional movement.

I. INTRODUCTION

In recent years, several kinds of mobile robots have been used widely in many applications [1-2]. Among these mobile robots, the omni-directional ones have attracted much attention since they can move forward and rotate simultaneously and independently [3-5]. A typical application of omni-directional mobile robots is the annual international Robocup competition (http://www. robocup.org/), in which omni-directional mobile robots are used to play soccer-like games. This function of moving flexibly in a narrow space which comes from omni-directional mobile robot, was a very notable technological development. But until now, except for some research and development of mobile robot and vehicles, such system had not been successful adopted for wheelchair. Since the longevity society is hastily emerging around the developed world, the mobility aid that can be easily operated in limited space with smoothly omni-directional motion wheels would be very practical and commercially viable. [6-9].

II. METHODS

A. Systems structure and control function

The structure this three-wheeled omni-directional wheelchair in this study is shown in Figure 1. This wheelchair is mainly equipped with a microprocessor, two 12V serial batteries, three omni-directional wheels, and three DC servomotors with encoders and drivers. The microcomputer is used to implement the proposed methods and determine the control signals for the desired angular velocities of the three wheels. These control signals are then transformed into the corresponding voltage commands and are sent to the DC servomotors to drive the omni-directional wheels.

Fig. 1 The mechanical structure of the omni–directional wheelchair

The kinematics of the wheelchair is illustrated in Figure 2, in which fixed axes [xw, yw] are defined. The axes denote a frame that can be referenced and the moving-frame is a frame attached to the center of the gravity of the wheelchair. From the transformation between these two frames and the illustration in Figure 2, it is easy to generate the inverse kinematic equations of the omni-directional wheelchair as follows:

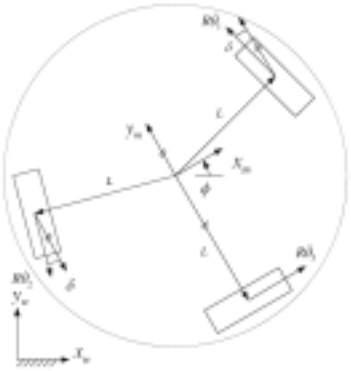

Fig. 2 A diagram to illustrate the kinematics of the omni–directional mobile robot

$$R\dot{\theta}_1 = -\sin(\delta+\phi)\dot{x}_w + \cos(\delta+\phi)\dot{y}_w + L\dot{\phi} \quad (1)$$

$$R\dot{\theta}_2 = -\sin(\delta-\phi)\dot{x}_w - \cos(\delta-\phi)\dot{y}_w + L\dot{\phi} \quad (2)$$

$$R\dot{\theta}_3 = \cos(\phi)\dot{x}_w + \sin(\phi)\dot{y}_w + L\dot{\phi} \quad (3)$$

where (θ1, θ2, θ3) are the angular positions of the wheels, R is the radius of the wheels, L is the distance from the center of gravity of the robot to the center of each wheel along a radial path, φ is the orientation of the robot with respect to the fixed axes, and δ is the offset angle of the two front wheels from ym. According to the specifications of the mobile robot in Fig. 1, the values of R δ and L are found to be 0.05 m; and 0.23 m, respectively. Substituting these values into Eq. 1 through Eq. 3, one obtains

$$\begin{bmatrix} \dot{\theta}_1 \\ \dot{\theta}_2 \\ \dot{\theta}_3 \end{bmatrix} = \begin{bmatrix} \omega_1 \\ \omega_2 \\ \omega_3 \end{bmatrix} = \frac{T(\phi)}{0.05} \cdot \begin{bmatrix} \dot{x}_w \\ \dot{y}_w \\ \dot{\phi} \end{bmatrix} \quad (4)$$

Where

$$T(\phi) = \begin{bmatrix} -\sin\left(\frac{\pi}{6}+\phi\right) & \cos\left(\frac{\pi}{6}+\phi\right) & 0.23 \\ -\sin\left(\frac{\pi}{6}-\phi\right) & -\cos\left(\frac{\pi}{6}-\phi\right) & 0.23 \\ \cos(\phi) & \sin(\phi) & 0.23 \end{bmatrix} \quad (5)$$

Multiplying both sides of Eq. 4 by the inverse of T (φ) the kinematic equations of the robot are then obtained as

$$\begin{bmatrix} \dot{x}_w \\ \dot{y}_w \\ \dot{\phi} \end{bmatrix} = 0.05 \cdot T^{-1}(\phi) \cdot \begin{bmatrix} \omega_1 \\ \omega_2 \\ \omega_3 \end{bmatrix} \quad (6)$$

In considering of user's convenience and comfortableness, an electrically operated rotatable swing foot pedal is installed. This swing instalment may be reversed for user to be seated normally, and to release down as for user's foor rest. The Figure 3 has shown the rotatable electrically operated swing foot pedal instalment.

Fig. 3 The rotatable electrically operated swing foot pedal installment

B. The Control joystick and wheelchair motion

The control joystick of this wheelchair is similar to those of computer games, shown in Figure 4. It will convey the user's command for moving in desired direction to the wheelchair. These motions include directional motion, rotation, and analog speed control.

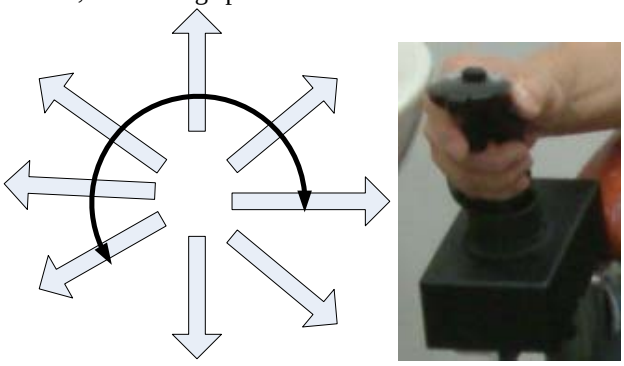

Fig. 4 The omni-directional joystick controller and it's movement directions

III. RESULTS AND DISCUSSION

The prototype of this omni-directional motion wheelchair had been completed with full function. This subject not only kept the merit of the existing manual and electrically operated wheelchair, but also innovated a novel omni-directional wheelchair system for elderly.This dexterous three wheeled wheelchairs will provide a very smooth and compact omni-directional mobility for the senior and handicap people. This dexterous electrically operated wheelchair can move forward in free direction far easier then the traditional electronic wheelchair. From Figure 5 to Figure 7 are showing the excellent mobility of this omni-directional of this wheelchair.

Fig. 5 The wheelchair moves from a narrow door thru a small aisle .

Fig. 6 The wheelchair moves to a desk

Fig. 7 The wheelchair slips through the narrow aisle

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