The development of the Omnidirectional Home Care Mobile Robot

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***Abstract*:** Rapid progress of standard of living and health care resulted in the increase of aging population. More and more elderly people do not receive good care from their family or caregivers. Intelligent mobile robot combining sensing technologies and wireless communication technologies is very important in reducing the cost of medical resources.

The first objective of this research is to develop a service mobile robot for taking care of elderly people. The kinematic equations of the robot platforms will be developed in this research. The PC-based controller can control the mobile robot platform. This service mobile robot is equipped with "Indoor positioning system" and obstacle avoidanc e system. The indoor positioning system is used for rapid and precise positioning and guidance of the mobile robot. The obstacle avoidance system can detect static and dynamic obstacles.

***Keywords*:** Home care; intelligent mobile robot; Indoor Localization; remote control.

I. INTRODUCTION

In the last few years, intelligent robots were successfully fielded in hospitals [1], museums [2], and office buildings/department stores [3], where they perform cleaning services, deliver, educate, or entertain [4]. Robots have also been developed for guiding blind people, as well as robotic aids for the elderly.

Today, the number of elderly in need of care is increasing dramatically. As the baby-boomer generation approaches the retirement age, this number will increase significantly. Current living conditions for the majority of elderly people are already unsatisfactory, and situation will worsen in the future. [5]

Rapid progress of standard of living and health care resulted in the increase of aging population. More and more elderly people do not receive good care from their family or caregivers. Maybe the intelligent service robots can assist people in their daily living activities. Robotics aids for the elderly have been developed, but many of these robotics aids are mechanical aids. [6] [7] [8]. The intelligent service robot can assist elderly people with many tasks, such as remembering to take medicine or measure blood pressure on time.

The main objective of this research is to develop a service mobile robot for taking care of elderly people. This service mobile robot is equipped with "Indoor positioning system". The indoor positioning system is used for rapid and precise positioning and guidance of the mobile robot. Five reflective infrared sensors are placed around the robot for obstacle avoidance.

The wireless IP camera is placed on the top layer of this robot. Through the internet remote control system, the live image of the IP camera on the robot can be transferred to the remote client user. With this internet remote control system, the remote client user can monitor the elderly people or the home security condition. On the aid of this system, remote family member can control the robot and talk to the elderly. This intelligent robot also can deliver the medicine or remind to measure the blood pressure or blood sugar on time. We hope this intelligent robot can be a housekeeper or family guard to protect our elderly people or our family.The functions of the proposed robot are illustrated as follows:

1. Deliver medicine or food on time
2. Remind to measure and record the blood pressure or blood sugar of the elderly on time
3. Remind the elderly to do something important
4. Assist the elderly to stand or walk
5. Send a short message automatically under emergency condition
6. With the remote control system, remote family member can control the robot and talk to the elderly.

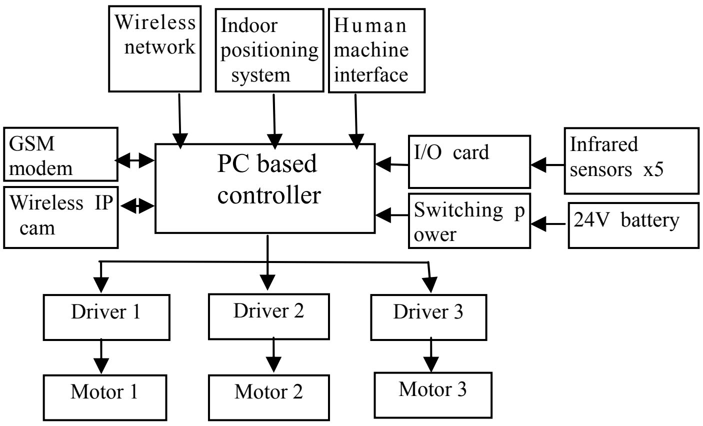


Fig.1. Hardware structure of the service mobile robot for taking care of elderly people.

Hardware structure of the service mobile robot for taking care of elderly people is shown in Fig. 1. A PC based controller was used to control three DC servo motors. The indoor positioning system was used for rapid and precise positioning and guidance of the mobile robot. Five reflective infrared sensors are connected to an I/O card for sensor data acquisition. The GSM modem can send a short message automatically under emergency condition. The live image of the wireless IP camera on the robot can be transferred to the remote client user. The subsystems of this robot are explained in the next section.

II. The Robot Mechanism

The proposed service mobile robot for taking care of elderly people is shown in Fig. 2. The main body of this robot is consisted with five layers of hexagonal aluminum alloy board. Many wheeled mobile robots are equipped with two differential driving wheels. Since these robots possess 2 degrees-of-freedom (DOFs), they can rotate about any point, but cannot perform holonomic motion including sideways motion[9]. To increase the mobility of this service robot, three omni-directional wheels driven by three DC servo motors are assembled on the robot platform (see Fig. 2). The omni-directional mobile robots can move in an arbitrary direction without changing the direction of the wheels.

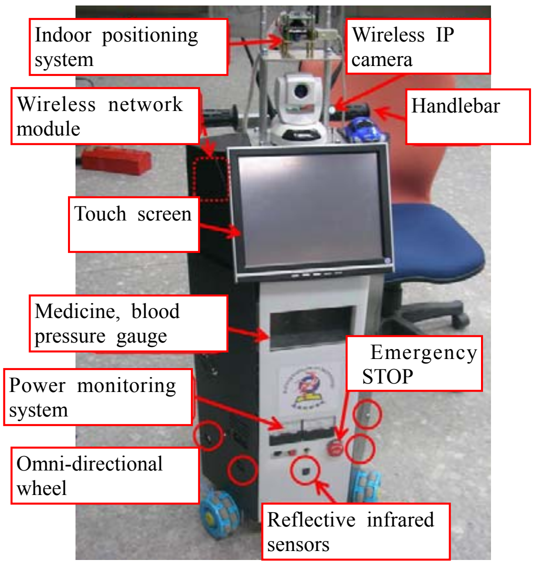


Fig.2.Structure of service mobile robot for taking care of elderly people.

The three-wheeled omni-directional mobile robots are capable of achieving 3 DOF motions by driving 3 independent actuators [10] [11], but they may have stability problem due to the triangular contact area with the ground, especially when traveling on a ramp with the high center of gravity owing to the payload they carry.

Fig. 3(a) is structures of the omni-directional wheel, Fig. 3(b) is the motor layout of the robot platform. The relationship of motor speed and robot moving speed is shown as:

$$V_1 = \omega_1 r = V_x + \omega_p R$$
$$V_2 = \omega_2 r = -0.5V_x + 0.867V_y + \omega_p R$$
$$V_3 = \omega_3 r = -0.5V_x - 0.867V_y + \omega_p R \quad (1)$$

Where:

V_i=Velocity of wheel i
ω_i=rotation speed of motor i
ω_P= rotation speed of robot
r=radius of wheel
R=distance from wheel to center of the platform

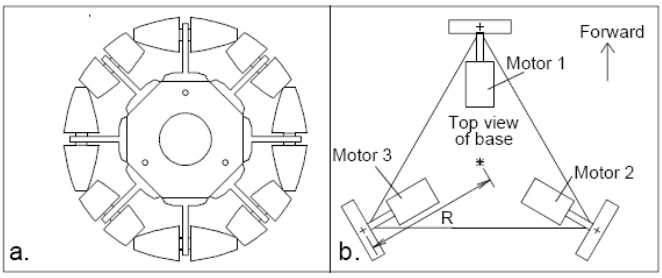


Fig.3. (a) Structure of Omni-directional wheel; (b) Motor layout of Robot platform

As shown in Fig. 4(a), 3D CAD software (SolidWork) was used to design the robot platform. An omni-directional wheel composed of passive rollers or balls was driven by a DC servo motor. Fig. 4(b) is the photo of the robot platform with three omni-directional wheels. The omni-directional robot platform can move in an arbitrary direction and can rotate about any point. The omni-directional robot platform can enhance the mobility of mobile robots.

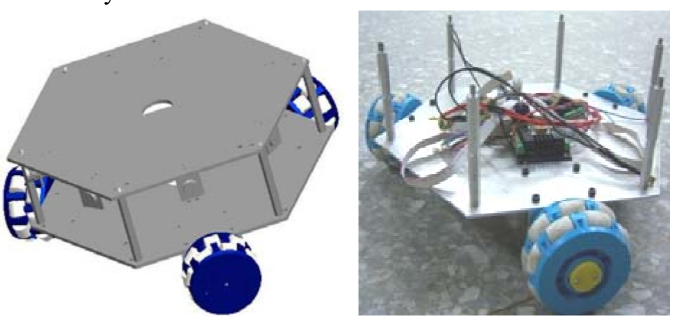


Fig.4. (a)3D CAD software was used to design the robot platform; (b) Photo of the robot platform with three omni-directional wheels

III. Indoor Localization System

Fig. 5. Indoor localization system (Hagisonic co.)

As shown in Fig. 5, Indoor localization system [12], which used IR passive landmark technology, was used in the proposed service mobile robot. The localization sensor module (see Fig. 6) can analyze infrared ray image reflected from a passive landmark with characteristic ID. The output of position and heading angle of a mobile robot is given with very precise resolution and high speed. The position repetition accuracy is less than 2cm; the heading angle accuracy is 1 degree.

Fig. 6. localization sensor module (Hagisonic co.)

IV. Human-machine interface (HMI)

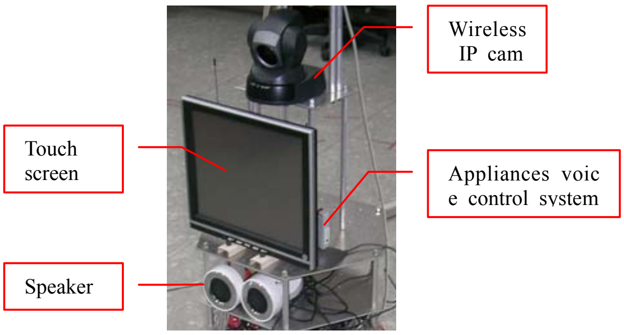


Fig. 7. Human-machine interface (HMI)

The human-machine interface (HMI) includes touch screen, speaker, and appliances voice control system. Touch screen can be regarded as input and display interface. Speaker can produce the voice of robot. Appliances voice control system can let users or the elderly to remote control the appliances by voice command.

V. Experimental Results

1. Path error test for the omni-directional robot platform.

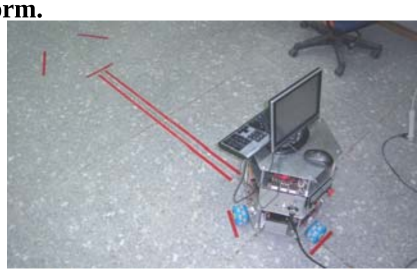
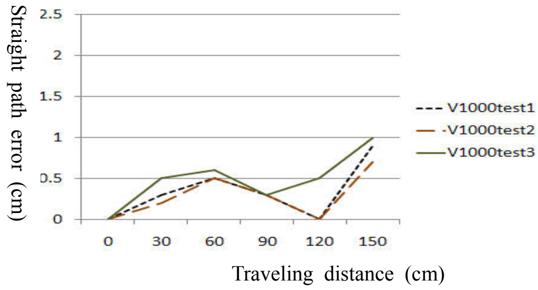
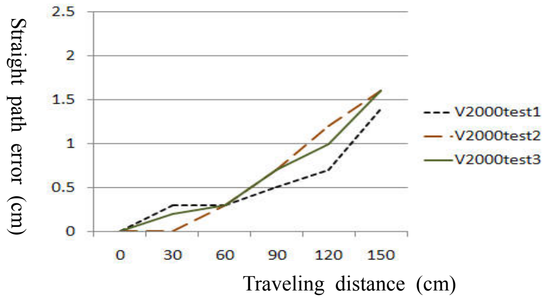


Fig.8. Straight Path error test for the omni-directional robot platform

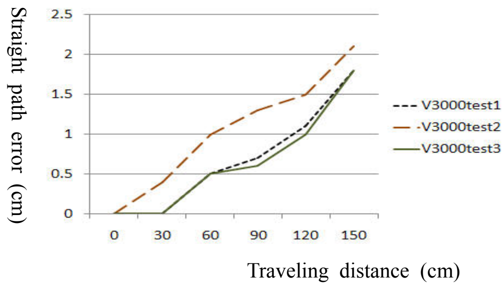
The three-wheeled omni-directional mobile robots are capable of achieving 3 DOF motions by driving 3 independent actuators, but they may have stability problem due to the triangular contact area with the ground. In order to understand the stability of three-wheeled omni-directional mobile robot, we made some experiments to measure the straight path error of the mobile robot. As shown in Fig. 9, the three-wheeled omni-directional mobile robot moved along a 150cm straight path. A chalk was used to record the robot moving path. The transverse path error can be measured between robot moving path (path recorded by a chalk) and the preset red line. The experimental results are shown in Fig. 9(a)-9(c).



(a) Straight path error (cm) test, motor speed:V1000



(b) Straight path error (cm) test, motor speed:V2000



(c) Straight path error (cm) test, motor speed:V3000

Fig. 9.Straight path error with different motor speed

Table 1 Robot traveling speed (m/s) according to different motor speed

Motor speed(rpm)	Robot traveling speed(m/s)
V1000	0.0833
V2000	0.166
V3000	0.25

In Fig. 9(a)-9(c), V1000, V2000 and V3000 are the motor speed. The robot traveling speed (m/s) according to different motor speed is shown in Ta ble 1. From these experimental results, when the ro bot moves faster or farther, the straight line error will increase.

2. Test of moving distance after motor stop

The omni-directional mobile robot using omni-directional wheels composed of passive rollers or balls. As shown in Fig. 10, this experiment is to measure the moving distance after motor stop. The mobile robot moves along a straight line with different motor speed. From the experimental results in Fig. 11, when the robot moves faster, the inertia force will let the robot to move a longer distance after the motors stop. If the motor speed is under 1500 r.p.m., the robot moving distance approaches zero after motor stop.

Fig.10. Test of moving distance after motor stop fo r different motor speed

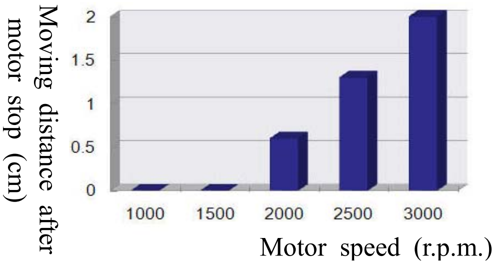


Fig.11. The moving distance after motor stop for di fferent motor speed

V. CONCLUSION

Today, the number of elderly in need of care is increasing dramatically. More and more elderly people do not receive good care from their family or caregivers. Maybe the intelligent service robots can assist people in their daily living activities.

The main objective of this research is to develop a service mobile robot for taking care of elderly people. This service mobile robot is equipped with "Indoor positioning system". The indoor positioning system is used for rapid and precise positioning and guidance of the mobile robot. Five reflective infrared sensors are placed around the robot for obstacle avoidance.

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