The study of path error for an Omnidirectional Home Care Mobile Robot

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***Abstract*:**
The first objective of this research is to develop an Omnidirectional Home Care Mobile Robot. The PC-based controller can control the mobile robot platform. This service mobile robot is equipped with "Indoor positioning system" and obstacle avoidance 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.

In order to understand the stability of three wheeled omni-directional mobile robot, we make some experiments to measure the rectangular and circular path error of the proposed mobile robot in this research. From the experiment results, the path error is smaller with the guidance of the localization system. The mobile robot can return to the starting point. The localization system can successfully maintain the robot heading angle along a circular path.
***Keywords*:** Home care; intelligent mobile robot; omni-directional; localization system; heading angle.

I. INTRODUCTION

Nowadays, 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.

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. [5] [6] [7]. The intelligent service robot can assist elderly people with many tasks, such as remembering to take medicine or measure blood pressure on time.

A service mobile robot for taking care of elderly people was developed in out laboratory [8]. This service mobile robot is equipped with "Indoor positioning system". Five reflective infrared sensors are placed around the robot for obstacle avoidance.

On the aid of an internet remote control 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.

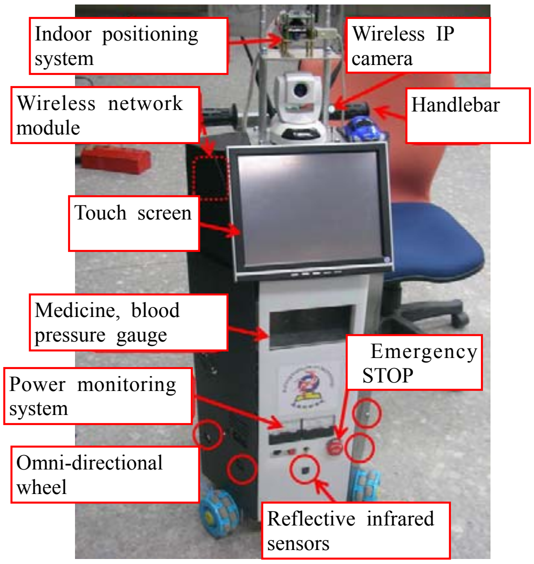


Fig.1.The proposed Omnidirectional Home Care Mobile Robot.

The proposed service mobile robot for taking care of elderly people is shown in Fig. 1. Hardware structure of the proposed mobile robot is shown in Fig. 2. 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.

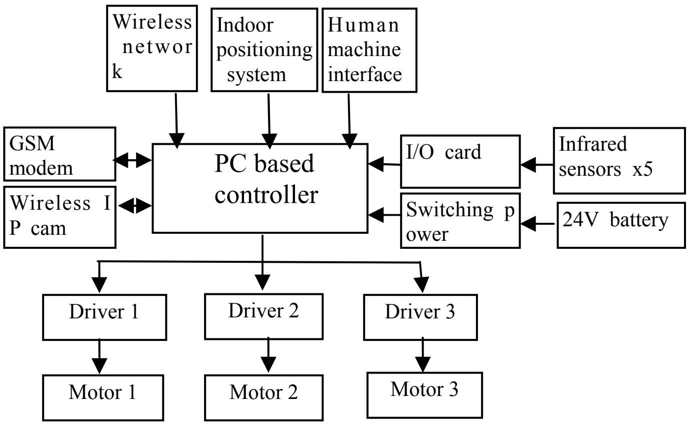


Fig.2. Hardware structure of the Omnidirectional Home Care Mobile Robot.

II. The Omni-directional Robot Platform

The proposed omnidirectional home care mobile robot is shown in Fig. 2. 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. 1). The omni-directional mobile robots can move in an arbitrary direction without changing the direction of the wheels.

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.

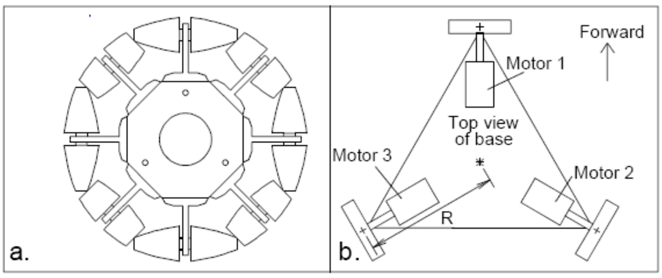


Fig.3. (a) Structure of Omni-directional wheel; (b) Motor layout of Robot platform

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:

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

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

III. Indoor Localization System

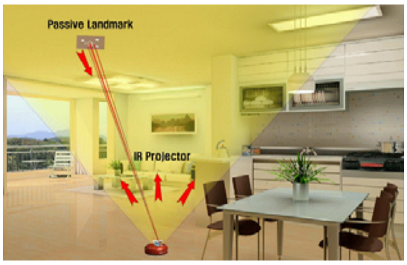


Fig. 4. Indoor localization system (Hagisonic co.)

As shown in Fig. 4, Indoor localization system [12], which used IR passive landmark technology, was used in the proposed service mobile robot. The localization sensor module (see Fig. 5) 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. 5. localization sensor module (Hagisonic co.)

IV. Experimental Results

In order to understand the stability of three wheeled omni-directional mobile robot, an experiment for the straight line path error had been discussed [8]. From these experimental results, when the robot moves faster or farther, the straight line error will increase. We make some experiments to measure several different paths error of the proposed mobile robot in this research.

1. Rectangular path error test for the omni-directional robot platform.

In this experiment, the proposed mobile robot will move along a rectangular path with or without the guidance of the indoor localization system. As shown in Fig. 6, the mobile robot moves along a rectangular path (a→b→c→d→a) without the guidance of the localization system. The localization system is only used to record the real path in this experiment.

In Fig. 6, solid line represents the ideal rectangular path, dot lines (■:Test1, ▲:Test2) are the real paths of the mobile robot without the guidance of the localization system. The vertical paths (path b→c and d→a) have larger path error. Finally, the mobile robot cannot return to the starting point "a".

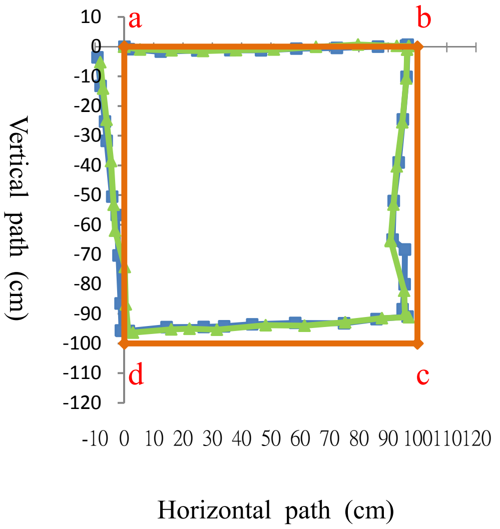


Fig. 6 Rectangular path error without the guidance of the localization system.

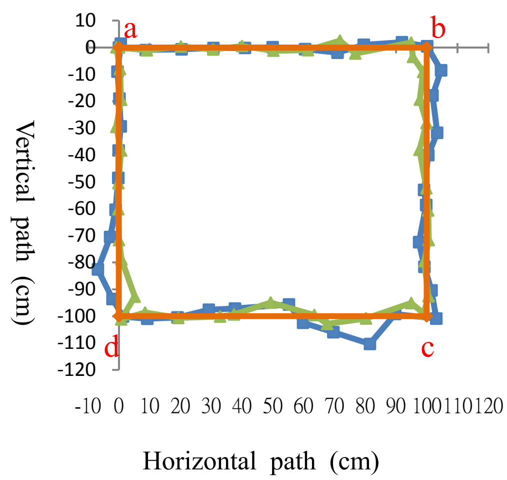


Fig. 7 Rectangular path error with the guidance of the localization system.

As shown in Fig. 7, the mobile robot moves along a rectangular path (a→b→c→d→a) with the guidance of the localization system. In Fig. 7, solid line represents the ideal rectangular path, dot lines (■:Test1, ▲:Test2) are the real paths of the mobile robot with the guidance of the localization system. With the guidance of the localization system, the mobile robot can pass through the corner points a, b, c, d. The rectangular path error in Fig.7 is smaller than that in Fig. 6. The maximum path error is under 10 cm in Fig.7. Finally, the mobile robot can return to the starting point "a". The rectangular path is closed at point "a".

2. Circular path error test for the omni-directional robot platform.

The omni-directional mobile robot can move in an arbitrary direction without changing the direction of the wheels. In this experiment, the proposed mobile robot will move along a circular path with or without the guidance of the indoor localization system. As shown in Fig. 8, the mobile robot moves along a circular path without the guidance of the localization system. The robot heading angle is 90°(upwards) during this test. The localization system is only used to record the real path in this experiment.

The circular path without the guidance of the localization system is shown in Fig. 9. The shape of the real path is similar to a circle, but the starting point and the end point cannot overlap. The heading angle error with different circular angle (θ) of the robot is shown in Fig. 10. The maximum heading angle error is about 8°.

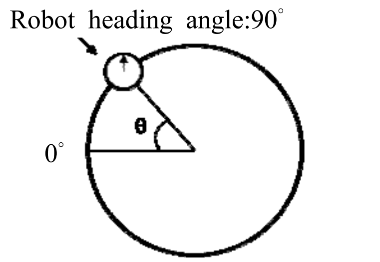


Fig. 8 Circular angle (θ) of the robot

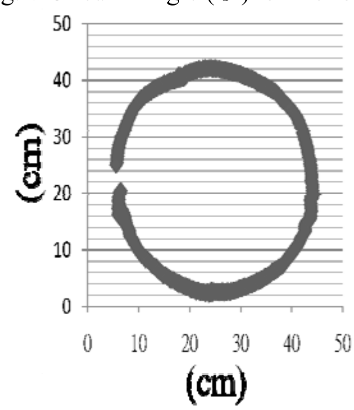


Fig. 9 Circular path without the guidance of the localization system.

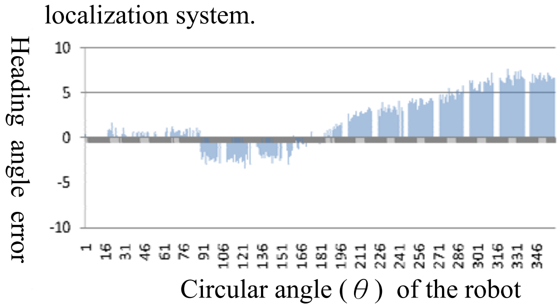


Fig. 10 Heading angle error with different circular angle (θ) of the robot

The circular path with the guidance of the localization system is shown in Fig. 11. The shape of this path is more similar to a circle; the starting point and the end point are overlapped. The heading angle error with different circular angle (Θ) of the robot is shown in Fig. 12. The maximum heading angle error is about ±1°. From this experiment result, the localization system can successfully maintain the robot heading angle along a circular path.

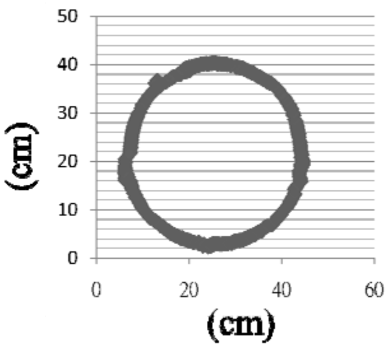
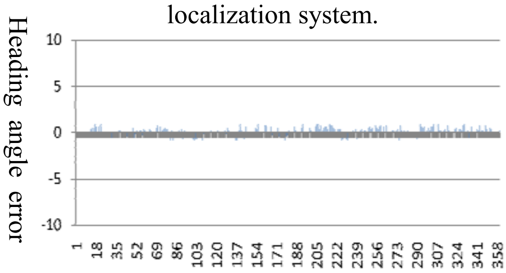


Fig. 11 Circular path with the guidance of the localization system.



Circular angle (θ) of the robot

Fig. 12 Heading angle error with different circular angle (θ) of the robot

V. CONCLUSION

The 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.

In order to understand the stability of three wheeled omni-directional mobile robot, we make some experiments to measure the rectangular and circular path error of the proposed mobile robot in this research.

Firstly, the mobile robot moves along a rectangular path without the guidance of the localization system. The experimental paths have larger path error. Finally, the mobile robot cannot return to the starting point.

With the guidance of the localization system, the mobile robot can pass through the corner points. The rectangular path error is smaller than that without the guidance of the localization system. The mobile robot can return to the starting point. The rectangular path is closed at point “a”.

Secondly, the proposed mobile robot can move along a circular path with or without the guidance of the indoor localization system. The circular path without the guidance of the localization system cannot be closed. The maximum heading angle error is about 8°.

The circular path with the guidance of the localization system is more similar to a circle; the starting point and the end point are overlapped. The maximum heading angle error is about $\pm 1°$. From this experiment result, the localization system can successfully maintain the robot heading angle along a circular path.

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