The Fourteenth International Symposium on Artificial Life and Robotics 2009 (AROB 14th '09),
B-Con Plaza, Beppu, Oita, Japan, February 5 - 7, 2009

Motion Planning of Mobile Robots Using Laser Range Finder

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Abstract: We design a mobile robot with distribution structure for the intelligent life space. The mobile robot is constructed using aluminum frame. The mobile robot has the shape of cylinder and its diameter, height and weight is 40 cm, 80cm and 40kg. There are six systems in the mobile robot, including structure, avoidance obstacle and driver system, software development system, detection module system, remote supervise system and others. In the avoidance obstacle and driver system, we use NI motion control card to drive two DC servomotors of the mobile robot, and detect obstacle using laser range finder and laser positioning system. Finally, we control the mobile robot using NI motion control card and MAXON driver according the programmed trajectory. The mobile robot can avoid obstacle using laser range finder, and follow the programmed trajectory. We develop the user interface with four functions for the mobile robot. In the security system, we design module based security devices to detect dangerous event, and transmit the detection results to the mobile robot using wireless RF interface. The mobile robot can move the event position using laser positioning system.

Keywords: Mobile robot、NI motion control card、Laser range finder、Laser positioning system

1. INTRODUCTION

With the robotic technologies development with each passing year, Mobile robots have been widely applied in many fields. Such as factory automation dangerous environment detection, office automation, hospital, entertainment, education, space exploration, farm automation, military and security system. Recently more and more research takes interest in the field especially intelligent mobile robot. There are some successful examples, ASIMO, KHR, QRIO, WABIAN-2R and AIBO. In our lab, we have been designed a mobile robot (ISLR-I) to fight fire source [1, 2].

The autonomous mobile robot and automatic guide vehicle are a growing interest and a popular subject. They have been implemented widely in many areas. But in the real world, the surrounding environment is unconstructive and complex. So how to program the motion trajectory and obstacle avoidance problem is fundamental, yet the important part of the autonomous or the semi-autonomous navigates mobile robot. How to plan the mobile robot efficiently to complete missions is an important task in the home and building.

In the recently, many exports research in the autonomous mobile robot. Some researches addressed in developing intelligent system of mobile robots [3, 4, 5]. Javier Minguez et al. proposed a navigation method to drive an autonomous mobile robot in unknown or uncertain environment [5]. Yoichi Shimosasa et al. developed autonomous guard robot [6, 7] which integrate the security and service system, the robot can guide visitors in daytime and patrol at the night. There are many methods to be developed in the motion trajectory of mobile robots. In the paper, we use laser range finder to avoid obstacle on the mobile robot, and locate the position of the mobile robot using laser position device.

The paper is organized as follows: Section II describes the system structure of the mobile robot, and describes the avoidance obstacle and position system using laser range finder and laser positioning device. Section III presents the principle of the motion planning of the mobile robot according to the programmed trajectory. The user interface is described in section IV. Section V presents the experimental results of the proposed method. Section VI presents brief conclusion remark.

2. SYSTEM ARCHITECTURE

The mobile robot is constructed using aluminium frame. The contour of the mobile robot is cylinder. The diameter is 40 cm, and height is about 80cm. Fig. 1 shows the hardware configuration of the mobile robot (ISLR.-I). The main controller of the mobile robot is industry personal computer (IPC). In the paper, we are interesting in the motion trajectory planning, avoidance obstacle and security detection of the mobile robot.

The hardware devices of the mobile robot have GSM modern, batteries, NI motion control card, MAXON drivers, laser range finder, laser positioning system, wireless LAN interface, alarm device, GSM modem, detection module, touch screen, remote supervised computer, wireless RF interface, driver system and some hardware devices [8]. The mobile robot can communicate with the remote supervised computer through wireless Internet.

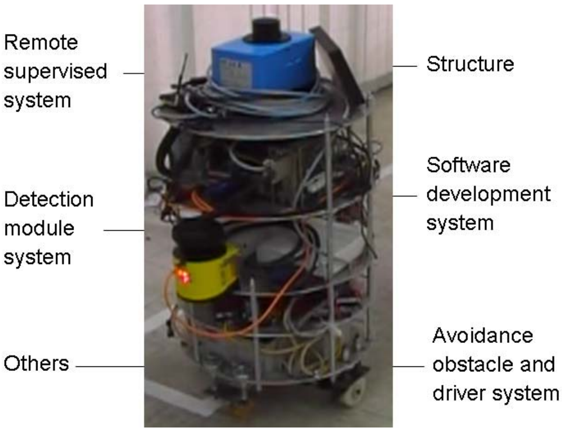


Fig. 1 The structure of the mobile robot

In the motion control function, the user can orders command to control two DC servomotors through motion control card and MAXON driver devices. In the avoidance obstacle function, the mobile robot can use laser range finder to detect obstacle, and locate the position of the mobile robot using laser positioning system. In the detection system, there are fire detection device, gas detection device, digital input device, power detection device and environment detection device, etc. The transmission interface between the detection device and the mobile robot is wireless RF interface (RS232), and the transmission interface between the mobile robot and the remote supervised computer and the mobile robot is wireless Internet.

3. THE MOTION PLANNING

The obstacle detection device of the mobile robot is laser range finder. The type is S200 that is produced by SICK. The device S200 is an optical sensor that its surroundings in two dimensions using infrared laser beams. The maximum distance is about 30 m. The location device of the mobile robot use laser positioning system. The type is NAV200 that is produced by SICK, too. The NAV200 laser positioning system continuously determines its own position and orientation with an industrial area using fixed reflectors. The measured range is about 30m.

How to locate the position of the mobile robot? We can use the geometry relation to calculate the orientation and displacement of the mobile robot. We can define the initial position of the mobile robot is at the start point (x_i, y_i), and move to the next point (x_{i+1}, y_{i+1}). It is shown in Fig. 2. The mobile robot can acquire the position axis (x, y) from the laser positioning system. We can use the equation (1) to modify the orientation angle of the mobile robot, and control the mobile robot move to the next point (x_{i+1}, y_{i+1}).

$$\theta = Tan^{-1}\frac{y-y_i}{x-x_i} - Tan^{-1}\frac{y_{i+1}-y}{x_{i+1}-x} \qquad (1)$$

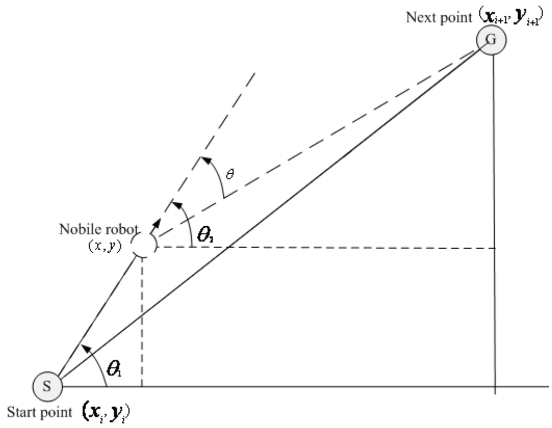


Fig. 2 The structure of the mobile robot

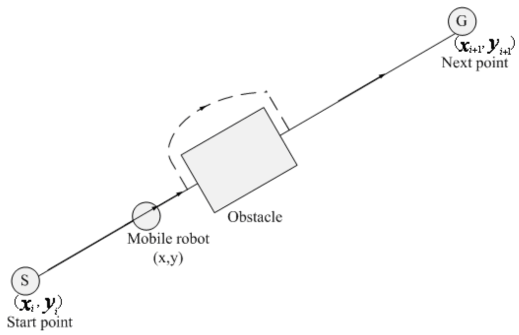
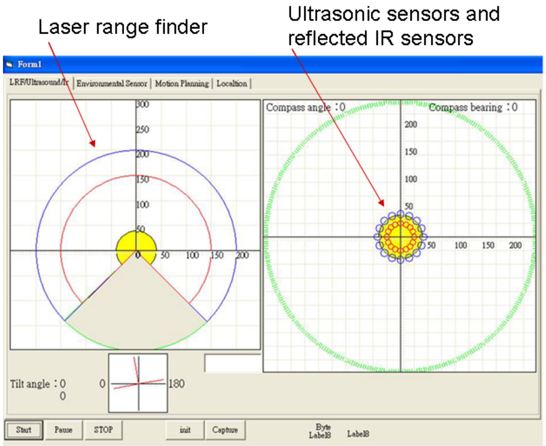


Fig. 3 The structure of the mobile robot

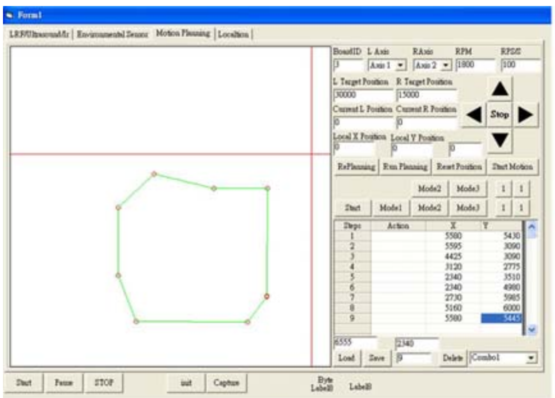
The motion trajectory of the mobile robot has obstacle, and the mobile robot must avoid obstacle using laser range finder. It is shown in Fig. 3. The mobile robot can measure the distance between the mobile robot and the obstacle using laser range finder. The distance is small than threshold, and the mobile robot can turn left about $\pi/2$. Then it can walk following the obstacle with fixed distance using laser range finder. Otherwise the mobile robot moves forward to the next point. The mobile robot arrives at the motion trajectory according to the laser position system, and it can turn left about $\pi/2$. Next it can move forward to the next point (x_{i+1}, y_{i+1}).

4. USER INTERFACE

The user interface of the mobile robot has four functions to be shown in Fig. 4. It contains obstacle detection interface, environment detection interface, motion planning interface and location interface. The obstacle detection interface is shown in Fig. 4(a). It can display surrounding status using laser range finder on the left side of the monitor. The right side of the monitor can display the measured values of the ultrasonic sensors and reflected infrared sensors. We can use these sensory data to enhance the accuracy using multisensor fusion algorithms.



(a) The obstacle detection interface



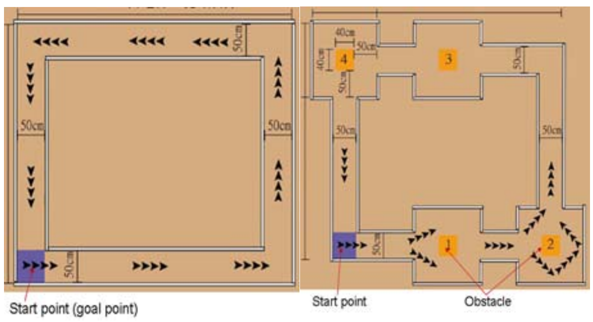
(b) The motion planning interface
Fig. 4 The user interface of the supervised system

The motion planning interface of the mobile robot is shown in Fig. 4(b). The user can program the motion trajectory on the left side of the monitor, and the position axis of the intersection can be listed in the right side. The parameter setting values of the motion planning function are programmed on the right side. The user can control the mobile robot on manual in the region.

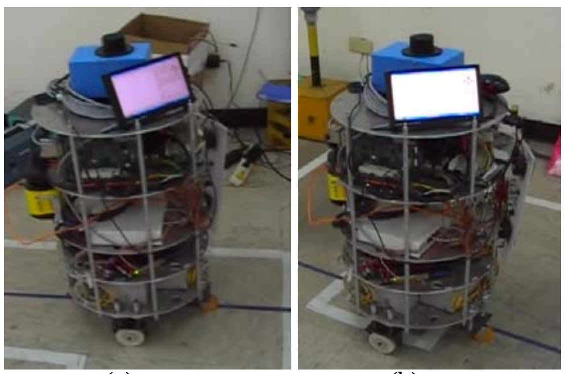
5. EXPERINMENTAL RESULTS

We design two experimental scenarios for the motion planning function of the mobile robot. The first term is motion trajectory experiment. We set the trajectory to be rectangle. It is shown in Fig.5(a). The other is avoidance obstacle experiment to be shown in Fig. 5(b). The mobile robot can be programmed the motion trajectory according to the Fig 5(a). Then we make a test using the mobile robot. First the mobile robot stops at the start point, and move to the goal point according to the proposed method. It can acquire the position axis and orientation angle using the laser positioning system, and modify the orientation using the equation (1). Then it can move to the next intersection. The mobile robot turn left, and modifies the error angle. The mobile robot can face to the next intersection. Finally it can move to the goal point. The experimental results are shown in Fig. 6.

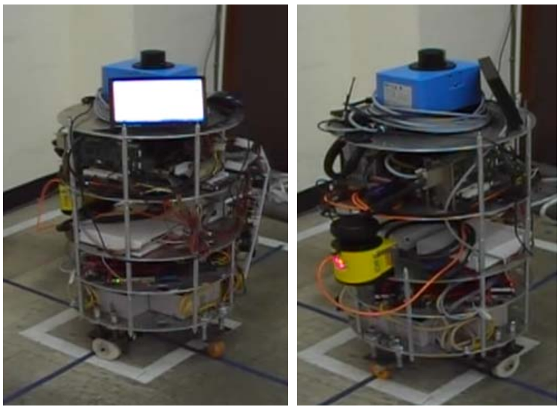
Next we place four obstacles in the motion trajectory of the mobile robot. The mobile robot can measure the distance from the obstacle using laser range finder. The distance is small than the threshold, the mobile robot can turn left about $\pi / 4$, and walk following the obstacle to the next position. The experimental scenario is shown in Fig. 7.



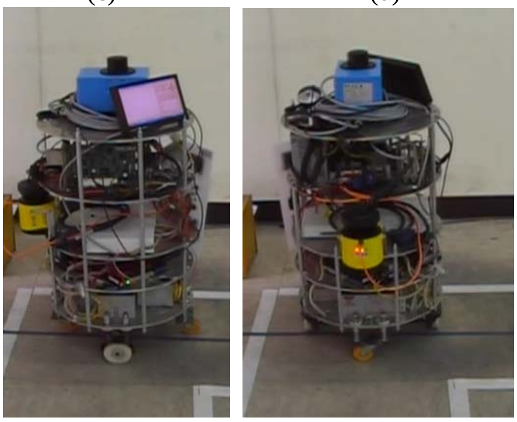
(a) (b)
Fig. 5 The user interface of the supervised system



(a) (b)

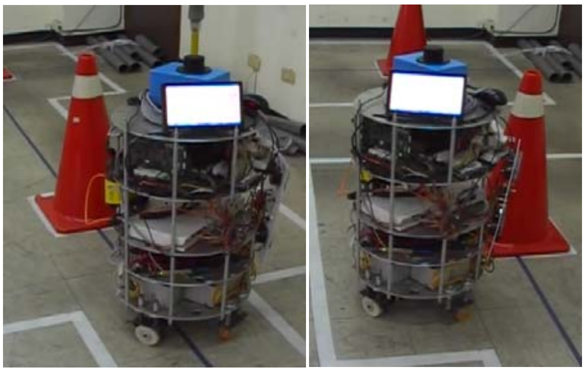


(c) (d)



(e) (f)

Fig. 6 The motion trajectory experiment



(a) (b)

Fig. 7 The avoidance obstacle experiment

6. CONCLUSION

We design an intelligent mobile robot for perfect life on home automation, and present a motion trajectory problem of the four-wheeled mobile robot using laser range finder and laser positioning device. The mobile robot has six system, including structure, avoidance obstacle and driver system, software development system, detection module system, remote supervise system and others. The motion trajectory of the mobile robot is programmed using kinematic method. The major advantage of the proposed method is that the motion trajectory of mobile robot is easily programming, and can be used in obstacle avoidance system. The main controller can establish the control command to the NI motion control card, and control the mobile robot move along the programmed trajectory. Then we use the mobile robot applying in the security system of the home automation.

ACKNOWLEDGMENT

This work was supported by the project "Design of the platform for intelligent Robot" under Ministry of Education of Taiwan, R. O. C. (97-E-03-064).

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