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Path Planning of the Multiple Mobile Robot System

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Abstract: We present the path planning techniques on the multiple mobile robot system. The mobile robot has the shape of cylinder and its diameter, height and weight is 8cm, 15cm and 1.5kg. The controller of the mobile robot is MCS-51 chip, and can acquire the detection signals from sensors through I/O pins, and receives the command from the supervised compute via wireless RF interface, and transmits the status of the mobile robots to the supervised computer via wireless RF interface. The mobile robot is module based system, and contains a controller module (including DC motor driver), an obstacle detection module, a voice module, a wireless RF module, an encoder module, and a compass detection module. We proposed the evaluation method to arrange the position of the multiple mobile robot system, and develop path planning interface on the supervised computer for the mobile robot system. In the experimental results, mobile robots can receive the command from the supervised computer, and move the next position according to the proposed method.

Keywords**:** path planning**,** mobile robot, compass

I. INTRODUCTION

With the robotic technologies development with each passing day, robot systems have been widely employed in many applications. Nowadays, robot systems have been applied in factory automation. Recently, more and more research takes interest in the robot which can help people in our daily life, such as service robot, office robot, security robot, and so on. In the future, we believe that robot will play an important role in our daily life.

In the past literatures, many experts research in the mobile robot. Some research addressed in developing target-tracking system of mobile robot [1,2,10], such as Hisato Kobayashi et al. proposed a method to detect human being by an autonomous mobile guard robot [3]. Yoichi Shimosasa et al. developed Autonomous Guard Robot [4] witch integrate the security and service system to an Autonomous Guard Robot, the robot can guide visitors in daytime and patrol in the night. D. A. Ciccimaro developed the autonomous security robot – "*ROBART III*" which equipped with the non-lethal-response weapon [5, 6]. Some researchers study path planning of the mobile robot [11].

The paper considers the problem of the multiple robot system working together. The multiple mobile robot system has more advantages than one single robot system [7]. First, the multiple mobile robots have the potential to finish some tasks faster than a single robot [8]. Furthermore, using several robots introduces redundancy. Multiple mobile robots therefore can be expected to be more fault tolerant than only one robot. Another advantage of multiple mobile robots is due to merging of overlapping information, which can help compensate for sensor uncertainty [9].

The paper is organized as follows: Section II describes the system architecture of the multiple mobile robot system, and explains the functions of the mobile robot. Section III explains the path planning method for the multiple robots on the user interfsce, and how to execute the formation exchange step by step. Section IV presents the experimental results on the formation exchange using the multiple mobile robot system. Section VI presents brief concluding remarks.

II. SYSTEM ARCHITECTURE

The system architecture of the multiple mobile robot system is shown in Fig 1. The system contains a supervised computer, a monitor, a wireless RF interface, remote supervised computer, a color CCD and some mobile robots. The supervised computer can transmits the command to control mobile robots, and receives the status of the mobile robots via wireless RF interface. They contain the orientation and displacement of mobile robots. Each robot is arranged an ID code. The supervised computer can transmits the ID code to the mobile robot, and transmits the orientation and position command to the mobile robot. The mobile robot can move the next position according the command from the supervised computer.

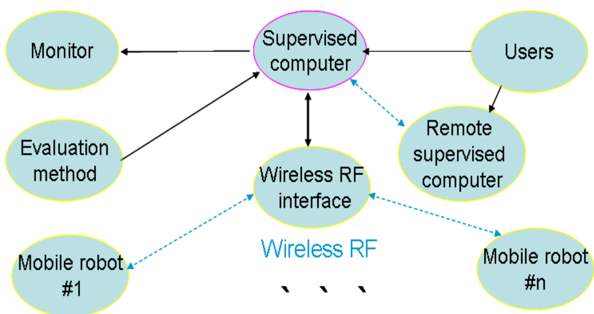


Fig. 1 The architecture of the multiple robot system

The mobile robot has the shape of cylinder, and it's equipped with a microchip (MCS-51) as the main controller, two DC motors, some sensor circuits, a voice driver module, an encoder module, switch input, three Li batteries and a wireless RS232 interface. In the input signals, the encoder module transmits the pulse signal to the controller, and program the displacement of the mobile robot. The reflective IR sensors to detect cross point of the grid plant, and decide the location of the mobile robot. The compass module can calculate the orientation of the mobile robot. The mobile robot can control two DC motors and voice module through I/O pins, and communicate with the supervised computer via wireless RF interface. The core of the RF module is microprocessor (AT89C2051), and communicates with the controller via series interface (RS232). Meanwhile, the mobile robot has four wheels to provide the capability of autonomous mobility. The block diagram of the mobile robot is shown in Fig. 2.

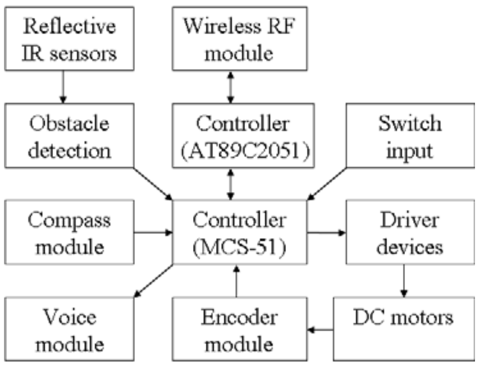


Fig. 2. The block diagram of the mobile robot

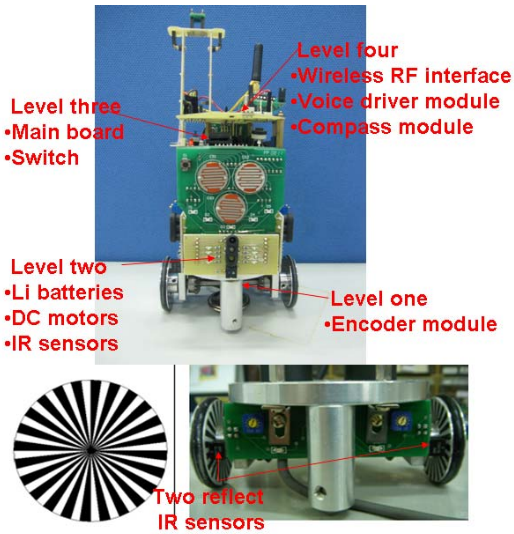


Fig. 3. The structure of the mobile robot

The structure of the mobile robot is shown in Fig. 3. It has some hardware circuits that are classified four levels in the mobile robot. The shape of each level is circle. The bottom of the mobile robot is level one, and the top is level four. The level one of the mobile robot is an encoder module. The module can calculate the displacement of the mobile robot using reflective IR sensors. We use two reflect IR sensors to calculate the pulse signals from the two wheels of the mobile robot. The power of the mobile robot is three Li batteries to be embedded in level two, and connects with parallel arrangement. The level has three obstacle detection circuits using IR sensors, and contains two DC motors to drive the mobile robot. The level three of the mobile robot has main board. The controller of the mobile robot can acquires the detection signal from sensors through I/O pins, and receives the status of the mobile robots via wireless RF interface. The controller of the mobile robot can transmits the detection results to the supervised computer via wireless RF interface. The switch input can turn on the power of the mobile robot, and selects power input to be Li batteries or adapter. The level four contains a wireless RF interface, a compass module and a voice driver module.

The bottom of the mobile robot is encoder module. The module can calculate the moving distance for the mobile robot. We plot the white line and black line on the wheel of the mobile robot, and use two reflect IR sensors to calculate the pulse signals from the two wheels of the mobile robot. We can set the pulse number for per revolution to be P , and the mobile robot move pulse number to be B . We can calculate the displacement D of the mobile robot using the equation

$$D = 4.25 \times \pi \frac{B}{P} \qquad (1)$$

The diameter of the wheel is 4.25 cm.

III. USER INTERFACE

The user interface of the multiple mobile robot system is shown in Fig. 4. The interface has many parts. The label "A" is the communication protocol between the supervised computer and the mobile robots via wireless RF interface. The label "B" set the start position for the mobile robot. The label "C" set the goal position on the grid plate. The label "D" is the command data region by the user. The label "E" can set the information of the mobile robot. The label "F" displays the experimental results (success or failure) for the mobile robot. The label "G" can display the status for the mobile robot on real-time. The label "H" It can display the status of the mobile robot. It contains starting, searching success or failure. The label "I" can display the position on real-time and the final position for the mobile robot. The label "J" can display the orientation on real-time and the final orientation for the mobile robot. The label "K" displays the number of the success and failure for the mobile robot on the test.

The motion platform of the multiple mobile robot system is shown in Fig. 5. The platform is chessboard based rectangle. The arrangement of the platform is 7 grids on the horizontal direction, and is 9 grids on the vertical direction. The user can set the start position and goal position on the platform. The mobile robot can move on the platform from the start position to the goal position, and transmits the status (displacement and orientation) to the supervised computer via wireless RF interface. The mobile robot measures the displacement and orientation using the encoder module and the compass module. If the moving position of the mobile robot is over the goal position, and we define "failure" on the test. Otherwise the mobile robot moves to the goal position, and we can define "success" on the test. The mobile robot can decide the next orientation using random processing on the test.

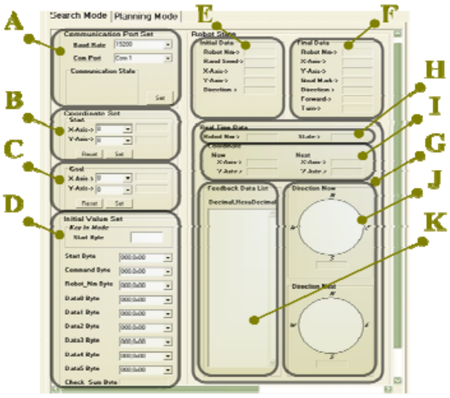


Fig. 4. The user interface of the multiple mobile robot system

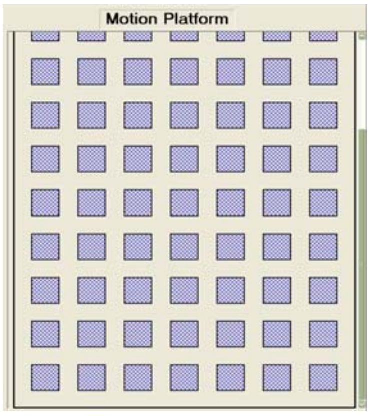
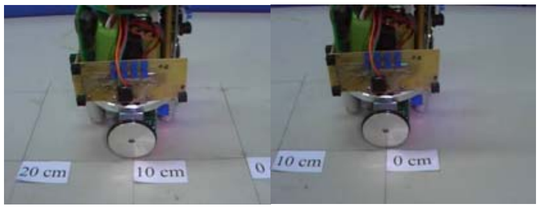


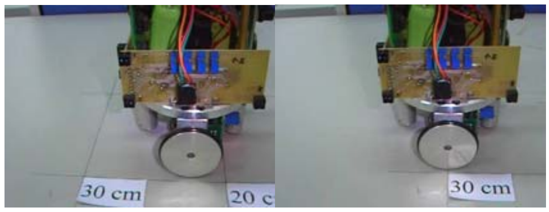
Fig. 5. The interface of the passive detection modules

IV. EXPERIMENTAL RESULT

We must test the accuracy of the mobile robot on the displacement and orientation. The displacement experimental results of the mobile robot is shown in Fig. . The start position of the mobile robot is presented in Fig. 6 (a). We set the displacement of the mobile robot is 10cm. The supervised computer can calculates the pulse number to be about 54, and transmits the command to the mobile robot. The mobile robot receives the pulse number from the encoder module move to the next position on the 54 pulse; the experiment result is shown in Fig. 6 (b). Then we set the displacement to be 30cm. we can compute the pulse number to be 162 according to the equation (1). The mobile robot can move forward on the 162 pulse from the encoder module. The experimental results are shown in Fig. 6 (c) and (d).



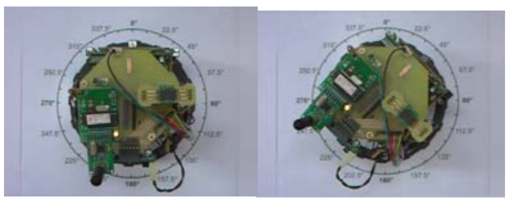
(a) Start position (b) Move to 10cm



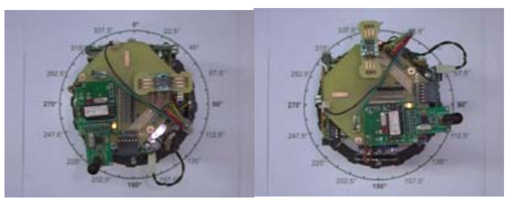
(c) Move to 30cm (continue) (d) Move to 30cm

Fig. 6. The displacement of the mobile robot

The orientation experimental results of the mobile robot are shown in Fig. 7. The start position of the mobile robot is presented in Fig. 7 (a). We set the orientation of the mobile robot is 45^0. The supervised computer can calculates the pulse number to be about 21 on the two driver wheel, and transmits the command to the mobile robot. The mobile robot receives the pulse number from the encoder module move to the next position on the 21 pulse; the right driver wheel is forward, and the left driver wheel is forward. The experiment result is shown in Fig. 7 (b). Then we set the orientation to be 270^0. The mobile robot can turn left 90^0 according to the command from the supervised computer. We can compute the pulse number to be 42 according to the equation (1). The mobile robot can move forward on the 42 pulse from the encoder module, and the left wheel can move backward 42 pulse. The experimental results are shown in Fig. 7 (c) and (d).



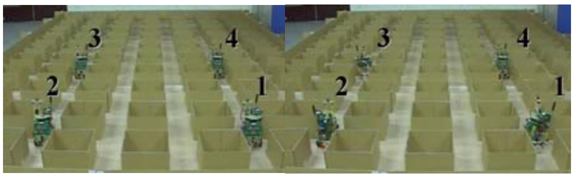
(a) Start position (b)Turn right 45^0



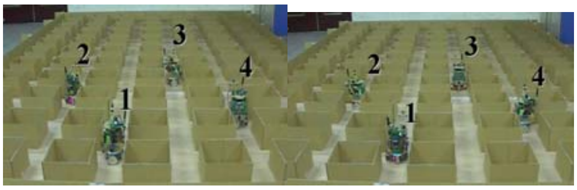
(c) Start position (d) Turn left 90^0

Fig. 7. The orientation of the mobile robot

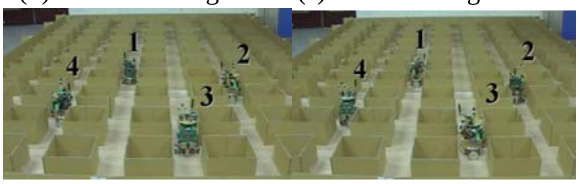
We implement the formation change using the multiple mobile robot system. In the experiment results, we use four mobile robots to arrange on the four directions of the rectangle. The experimental scenario is shown in Fig 8 (a). The supervised computer orders the command to the four mobile robots. The robot #1 turns left, and moves one grid. The robot #2 turns right about, and move three grids. The robot #3 turns left, and moves two grids. The robot #4 turns left, and moves two grids. The experimental results are shown in Fig. 8 (b) and (c). Next the four robots turn right to move four grids (Fig 8 (d) and (e)). Next the four robots turn left, and move one grid (Fig. 8 (f) and (g)). Finally the robot #1 and #2 turn right, and the robot #3 turn left. The experimental results are shown in Fig. 8 (h). The programming processing is minimum displacement on the test by the four mobile robots.



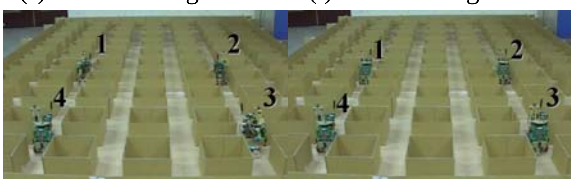
(a)Start position (b) First arrangement



(c)Second arrangement (d) Third arrangement



(e) Forth arrangement (f) Fifth arrangement



(g) Sixth arrangement (h) Final arrangement

Fig. 8. Formation change for multiple mobile robots

V. CONCLUSION

We have developed the path planning of the multiple mobile robot system. The system contains a supervised computer, a monitor, a wireless RF interface, remote supervised computer, a experimental plate and four mobile robots. The mobile robot has the shape of cylinder and its diameter, height and weight is 8cm, 15cm and 1.5kg, and executes the path planning using two interfaces. One is wireless RF interface, and the other is voice interface. The supervised computer can control multiple mobile robots, and receive the status of the multiple mobile robots via wireless RF interface. Users can program the motion trajectories on the supervised computer. The paper has been presented formation change using four mobile robots. In the future, we want to develop more applications of the multiple mobile robot system.

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