Develop a Multiple Robot System Applying in Intelligent Home

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Abstract:We develop multiple robot based security system that contains a fire fighting robot, multiple slave robots, security modules and appliance control modules in our daily life. The security system can detect abnormal and dangerous situation and notify us. First, we have been designed a fire fighting robot and some slave robots. These robots can detect fire source, intruder, and gas, and transmits image signal to the supervised computer. The contour of the slave robot is cylinder, and its diameter, height and weight are 8 cm, 16cm and 2kg. The controller of the slave robot is HOLTEK microchip, and detects the environment status using variety sensors. We can control slave robots using wireless RF controller and the supervised computer through RF module. Slave robots can transmit the detection data to the supervised computer using wireless RF module. Finally, we implement the home security system in variety scenario. If fire accident is true, the slave robot can find out fire source using the embedded sensor, and transmits the fire signal to the supervised computer. The supervised computer can control fire fighting robot to fight the fire source using extinguisher or water.

Keywords: Fire fighting robot, multiple slave robots, intelligent building, HOLTEK microchip, wireless RF
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I. INTRODUCTION

Home can provide safety, convenience, and efficiency for people in the 21st century. An intelligent home system is integrated by many function and systems. One of the most important systems is the security system in an intelligent home [1-3]. In generally, the passive security device is fixed on the wall or ceiling. But the method is not flexibility to detect dangerous event. It is not very convenience that uses many security detection modules in the home. In the paper, we develop a multiple robot based home security system that contains a fire fighting robot, some slave robots, a supervised computer and a remote supervised computer. These devices can detect dangerous event at any time. The system can transmits detection data to the user and the remote supervised computer using RF interface and wireless Internet, and transmit detection information to cell phone using GSM modern.

In the past literatures, many researchers have been developed service robot applying in home security system. S uch as Shimosasa et al. developed Autonomous Guard Robot which integrate the security and service system to an Autonomous Guard Robot [4]. The robot can guide visitors in daytime and patrol in the night. Ciccimaro developed the autonomous security robot–"*ROBART III*" which equipped with the non-lethal-response weapon [5]. Moreover, some research addressed in the robot had the capability of fire fighting [6]. There are some products that have been published for security robot. in Taiwan [7].

Many researchers have been studying the problem of multi-robot task allocation for some time. In general, the task allocation problem divides a task into many subtasks, and assigns some robots to each subtask. Gerk ey addresses the multiple robot –multiple task problem (MR-MT) [8] where the object is to assign a robot team to multiple task. So that the systems' efficiency is maximize. This problem is also called the coalition formation. Gerkey and Mataric [9] indicate that despite the existence of various multi-agent coalition algorithms. These algorithms have not been demonstrated in the multi-robot domain. Vig and Julie show that, with certain modifications, coalition formation algorithms provided in the multi-agent domain can be applied to the multi-robot domain [10]. Chen and Li have been proposed a power-efficient path planning protocol named collaborative path planning algorithm (CPPA) for a multi-robot system without global positioning system (GPS) [11].

The paper is organized as follows: Section II describes the system structure of the multiple robot based security system, and presents the function of the slave robot, and the experimental results are implemented in section III. Section IV presents brief concluding comments.

II. SYSTEM ARCHITECTURE

The system architecture of the home security system is shown in Fig 1. The system contains many subsystems. The supervise computer and the fire fighting robot can receive the status of security module and appliance control module using wireless RF interface. In the security module, it uses one-way communication with the supervised computer and the fire fighting robot. But the appliance control module uses two-way communication with the supervised computer and robots. The fire fighting robot and the supervised computer can communicate with GSM modern using RS232 interface, and can communicate with remote supervised computer using wireless Internet. The display panel of remote supervise computer is television. The supervised computer can control slave robots using wireless RS232 interface, and control the fire fighting robot using wireless Internet. In the paper, we are interesting in slave robots and the fire fighting robot.

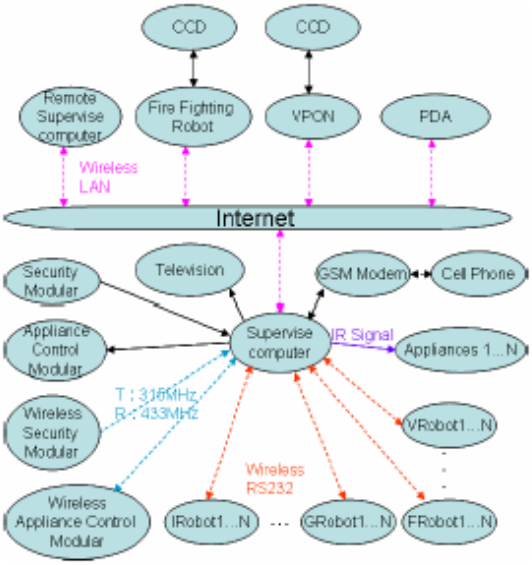


Fig. 1. The overview of the home security system

The fire fighting robot is constructed using aluminium frame. The contour of the fire fighting robot is cylinder. The diameter is 50 cm, and height is about 130 cm. The main controller of the fire fighting robot is industry personal computer (IPC). The hardware devices have display device, extinguisher, CCD, sensors and sensory circuits, driver system, wireless Internet, GSM modem and wireless RF interface. There are six systems in the fire fighting robot, including structure, avoidance obstacle and driver system, software development system, fire detection, remote supervise system and others. Each system includes some subsystem. Each system contains some functions in the fire fighting robot [12].

The slave robot has the shape of cylinder, and its equipped with a microcomputer (HT46R24) as the main controller, two DC motors, some sensors circuits, a colour CCD, a RC servomotor, and wireless RS232 interface. Meanwhile, it has four wheels to provide the capability of autonomous mobility. There are four type slave robots in the security system, such as G-Robot (Gas detection robot), I-Robot (Intruder detection robot), F-Robot (Fire detection robot) and V-Robot (Vision robot). They are shown in Fig. 2.

Fig. 2. The slave robots

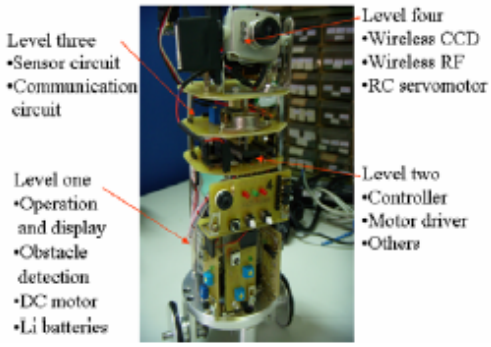


Fig. 3. The structure of the slave robot

The function of the slave robot is shown in Table 1. In the table, the V-robot has only real-time image feedback to the supervised computer and wireless controller on real-time. The others are not only vision feedback but also environment detection feedback (fire, intruder and gas). In the specification, these robots contain wireless RF module (transmit and receive), motion driver, RC servomotor; display LED, wireless CCD and obstacle detection.

The structure of slave robot is shown in Fig. 3. It has four levels in the slave robot. The shape of each level is circle. Each level is embedded some circuits. The power of the slave robot is three Li batteries to be embedded in level one, and connects with parallel arrangement. The level has three obstacle avoidance device using IR sensors. The level two has main controller and two DC motors drivers. The level three has sensor circuits and communication module. The level four of slave robot has RC servomotor and wireless CCD device. The RC servomotor can drive the wireless CCD device according to the user command. The controller of the slave robot is HT46R24. The controller can acquires the detection signal from sensors through I/O pins, and receives the wireless RF signal through wireless RF module and decoder. The controller can transmits the detection result to the remote controller through wireless RF module and encoder, and control the CCD device using RC servomotor.

The circuit block diagram of the slave robot is shown in Fig. 4. The remote controller contains two parts. The upper part is vision and real time status display; ant the bottom part is function key. The main unit of the remote controller is HOLTEK microchip, and can display real time image from each slave robot by the user.

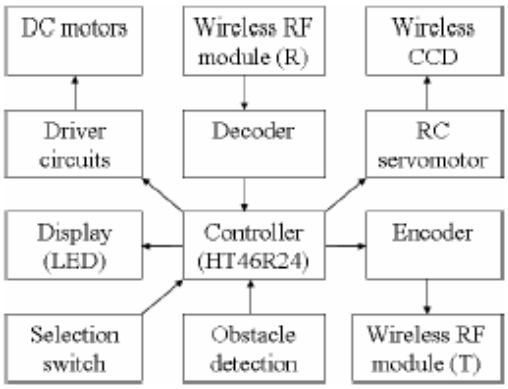


Fig. 4. The circuit block diagram of the slave robot.

The user interface of the supervised system is shown in Fig. 5 for the multiple robot system. There are three regions in the supervised panel. This is the motion programming for each robot in the region 1. The user can program the motion step for sixteen robots, and can program 300 motion steps for each robot. The region 2 can display the status of mobile robots. It contains communication status and encoder status. The region 3 has many functions for the multiple robot system. There are loading and storage program file. The user can set the execute cycle for the programmed motion trajectory.

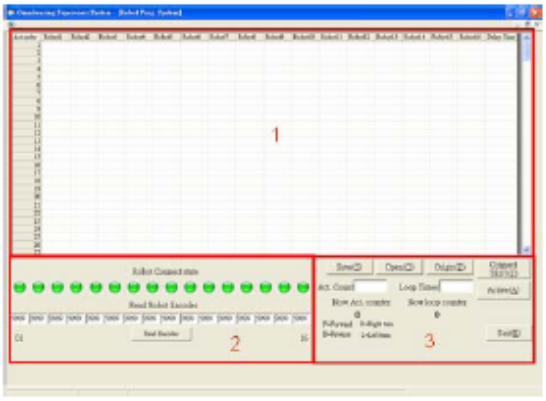


Fig. 5. The user interface of the supervised system

III. EXPERIMENTAL RESULTS

The slave robot can move autonomous according to environment using IR sensors. The user can supervise the slave robot for forward, backward, turn right, turn left and stop through wireless RF interface. The slave robot can transmit the real-time image to the remote controller. The experimental result of slave robot is shown in Fig. 6. The user cans remote control the slave robot forward (a) and turns right (b). The user can control RC servomotor to drive CCD device using wireless controller, and transmit the real-time image to the controller. The experimental result is shown in Fig. 7. The user can control the rotation angle of the CCD device.

(a)move forward (b)turn right

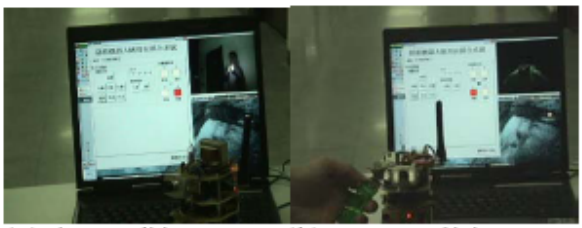
Fig. 6. The user control the slave robot using wireless RF controller

(a)The angle is 0° (b)The angle is 30°

Fig. 7. The user control CCD using wireless controller

In the sensor detection experiment, the slave robot can move autonomous in free space. The slave robot detects dangerous event, and can transmits the event signal to the wireless controller. The F-Robot can detect the fire source, and transmits the intruder signal to the wireless controller. The I-Robot and G-Robot can detect intruder and gas, and transmit these event signals to the wireless controller. The experimental results are shown in Fig. 8. These detection signals can transmit to the supervised computer using wireless RS232 interface by slave robot. The experimental result is shown in Fig. 9. The monitor displays a fire status (red LED) from F-Robot to be shown in Fig. 9(a). Fig. 9(b) presents the gas condition (red LED).

(a)F-Robot detect fire (b)Transmit to controller
Fig. 8. The fire detection experimental result



(a)Fire condition (b)Gas condition
Fig. 9. Transmit signal to the supervised computer

IV. CONCLUSION

We have presented a multiple robot based home security system. The security system contains many subsystems. The slave robot have G-Robot, I-Robot, F-Robot and V-Robot. These slave robots can detect environment status, and transmit the event signal and real-time image to the wireless RF controller and the supervised computer. The user can control these slave robots through wireless RF interface by the wireless controller and the supervised computer, and remote supervise these device through wireless Internet.

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