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Design a Low Cost Security Robot Applying in Family

Kuo L. Su, Ting L. Chien, Jr H. Guo
Department of Electronic Engineering, Wu-Feng Institute of Techonlogy,
117, Chian-Kuo Rd, Sec 2 Ming-Hsiung, Chia-Yi, Taiwan 621, R.O.C
TEL：+886-5-2269072

sgl0719@ms24.hinet.net cdl@mail.wfc.edu.tw

***Abstract*：**

We design a low cost based security robot system to detect abnormal and dangerous situation and notify us. The transmission interface may be Internet or **GSM(Global System for Mobile)**. The structure of the security robot contains six parts. There are security system, avoid obstacle and driver system, software development system, auto recharging system, remote supervise system and others. First, we structure a mobile robot using aluminum flame. Then, we develop a **multisensor** –based sensor system for the security robot, and we also present the remote mobile security system（RMS）for the security robot system. Finally, we make some experimental scenario to supervise the security robot through the personal computer, and we can get wonderful results for the low cost security robot.

Keywords：GSM, multisensor

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, dangerous environments, hospitals, surgery, entertainment, space exploration, farmland, military, security system, and so on. 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. We believe that robot will play an important role in our daily life in the future, especially security robot.

When people become more and more attach importance to the quality of life, the security and service of our home is important. The security system can identify potential hazards to protect human. A typical intelligent security system consists of intruders, fire, gas, environment sensors and more variety sensors to be installed, such as intelligent building or intelligent robot. Relative to the intelligent building is fixed and passive system; the security robot is an active system. The security robot is more flexible than intelligent building. In the fundamentals, the developed security robot has the following functions to perform such a security service: autonomous navigation, master-slave operated system, supervises through Internet, a remotely operated camera vision system and danger detection and diagnosis system. [1-6]. in the recent, the Internet technology is more and more important. But the cost of the security robot is very expensive, and the weight is very huge. We want to develop a low cost and small weight security robot applying in the family.

In the past literatures, many experts research in the security robot. Some research addressed in developing target-tracking system of security robot [11-12], such as Hisato Kobayashi et al. proposed a method to detect human being by an autonomous mobile guard robot [13]. Yoichi Shimosasa et al. developed Autonomous Guard Robot [10] 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 [8,9]. Moreover, some research addressed in the robot has the capability of fire fighting [7]. There are some products that have been published for security robot. Such as SECON and SOC in Japanese and International Robotics in USA.. The cost of SOC(C4) is about US 100000 dollars, the Chung-Cheng-I price is about US 30000 dollars.

The paper is organized as follows: Section II describes the system the architecture of the low cost security robot. Section III explains the system function of the security robot, and it contains six parts. Section VI presents the experimental results for the remote supervise system of the security robot. Section V presents brief concluding remarks.

II. System Architecture

The security robot is constructed using aluminium frame. The contour of the robot is cylinder. The diameter is 20 cm, and height is 50 cm. Figure 1 shows the hardware configuration of the low cost security robot. The main controller of the security robot is microprocessor. The hardware devices have GSM module, wireless RS232 and sensory circuits, driver system and some hardware devices.

There are six systems in the security robot, including security system, avoid obstacle and driver system, software development system, auto recharging system, remote supervise system and others. Figure 2. is the hierarchy structure of the security robot, and each system includes some subsystem.

There are some functions in every system. For example, the avoid obstacle and driver system contains IR sensory detection function, ultrasonic detection

function and DC motor driver system. The other system has GSM communication function, alarm and display device.

We use microprocessor to control the low cost security robot. There are some questions to be happened. It is very weak on I/O port using microprocessor. So we wanted to extend input and output device to catch the signals of every system. The hardware architecture of the robot is shown in Figure 3. The microprocessor acquires the detection signal from each system through extended I/O device. But the wireless series interface, alarm device and LCD display is not.

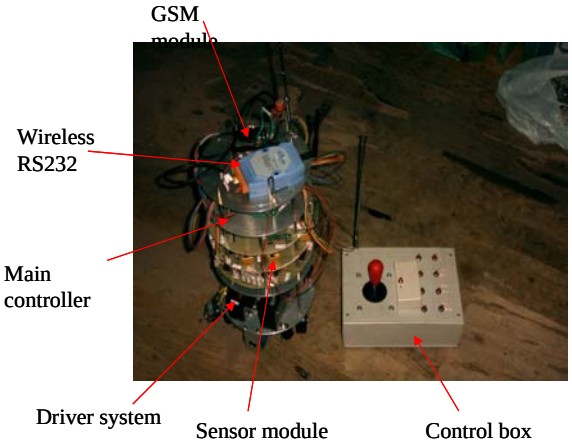

Figure 1. The contour and structure of intelligent security robot.

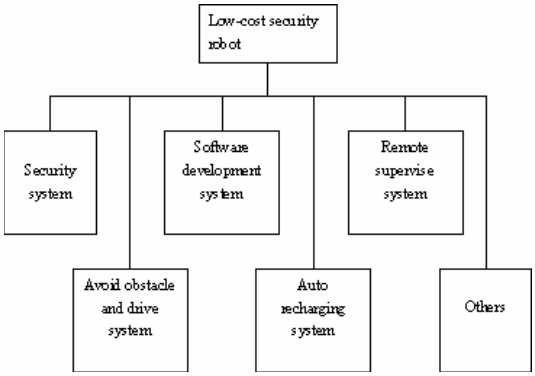

Figure 2. The hierarchy structure of the security robot.

III. System function

1. Security system

The hierarchy structure of security system for the security robot is shown in Figure4. The security system has four variety subsystems. There are fire detection, intruder detection, power detection and environment detection. We employ smoke sensor and flame sensor, for fire detection.

There are two techniques for detection smoke: photo-electric smoke detectors and ionization smoke detection. The principle of ionization smoke detection is that the air cannot conduct electricity (no current flows), when no smoke happens. Otherwise smoke happens, an ionizing radioactive source is brought close to the plates and the air itself is ionized. Flame sensors look for characteristic emissions of either infra-red or ultra-violet light from the flames. We use the ultra-violet sensor (R2868) to detect the flame. It's peak wavelength is 220 *um* and sensing wavelength is 185~260 *um*. We use voting method to detect five conditions. That is to say, smoke sensor and flame sensor detect fire status. We can say fire happening. But smoke sensor or flame sensor detect fire condition for a long time. We can say fire condition, too[14,15].

We use rule-based method to detect intruder. First, we use body sensor, ultrasonic sensor and IR sensor to detect intruder. The detection rule is shown in Figure 6. the environment function contains gas detection, humility detection and luxmeter detection. These analog signals must be converted as digital signals using A/D converter, and transmits these digital signals to main controller through extended I/O card[16].

We use current sensor (LEM55-p) to detect current variety of the power-supply system. The sensor is a current transducer for the electronic measurement of currents, and contains galvanic isolation between the primary (high power) and the secondary (electronic circuits)[17]. For these subsystems, we use some sensors to implement the function. These sensors are listed in table 1.

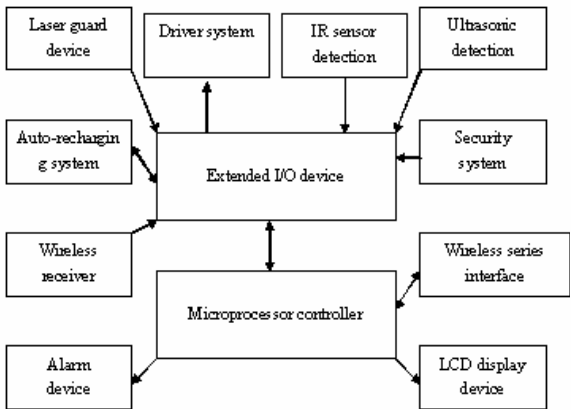

Figure3 The hardware architecture of the robot

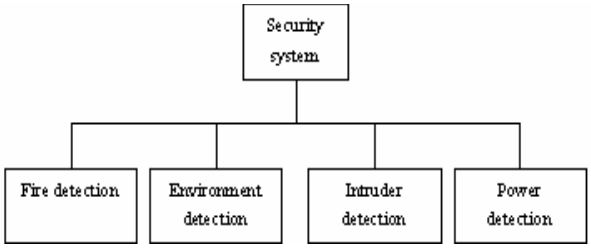

Figure4 The security system architecture

Table 1. Tasks and type of sensors in the security robot

Task	Sensors	Examples
Fire detection	Smoke Sensor	TG135
	Flame Sensor	R2686
Intruder detection	Body Sensor	Body
	IR Sensor	SMC-10R
Avoid obstacle and driver system	Light-operated Proximity Sensor	CDD-40N
	Ultrasonic Sensor	Polaroid 6500
Environment detection	Gas Sensor	TGS 822
	Humidity Sensor	C2 – M3
	Luxmeter Sensor	S1133
Power detection	Current Sensor	CTL6S
	Voltage Sensor	

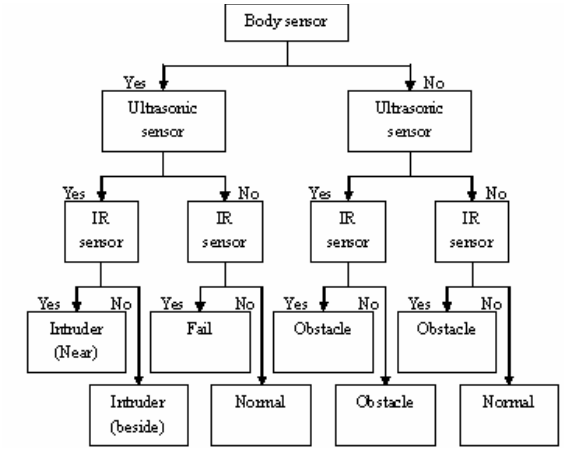

Figure5. The detection rule of the intruder system

2. Remote Supervise System

In the hierarchy of the remote supervise system, it contains communication protocol, data base and user interface. The hardware configuration of the remote supervise system includes a low cost security robot, main controller of the security robot, GSM module and wireless RS232, as show in Figure4.

The main controller of the low cost security robot can get sensory data to detect fire, intruder, gas, etc. It can also control the driver and motor, etc. The main controller of the security robot can interact with personal computer(supervise computer) through wireless RS232. the user can control the security robot using wireless interface, too. The remote user can logo in the personal computer to control the security robot. In order to reduce the Internet time delay, the Web server is usually set up in the local side. Therefore, the main controller of the security robot and the Web sever communicate in the same local area network. Web server can get the sensory data (sensor status, commands, robot status, environment conditions, etc) from robot server through Internet. Web server can also receive client's commands via the Internet and then transmit it to the robot server. The remote user can connect to the Web server or the robot server to get all information by computer or PDA through the Internet.

The user interface of the supervise system on supervise computer is shown in Figure6. The panel can display the sensory status that is detected using variety sensors, and display the state of motor and battery, and display the detection results using sensors from the low cost security robot. The client-side program's function is to order command to the robot and continuously update the sensory data, which receive from the robot supervise computer. The program of the client's user interface be designed by VB.

The security robot communicates with mobile phone using GSM (Global System for Mobile) modular. The GSM modular (WMOD2) was made by Wavecom.. The modular is a seft-contained E-GSM900/GSM1800 (or E-GSM900/GSM1900) dual band module.

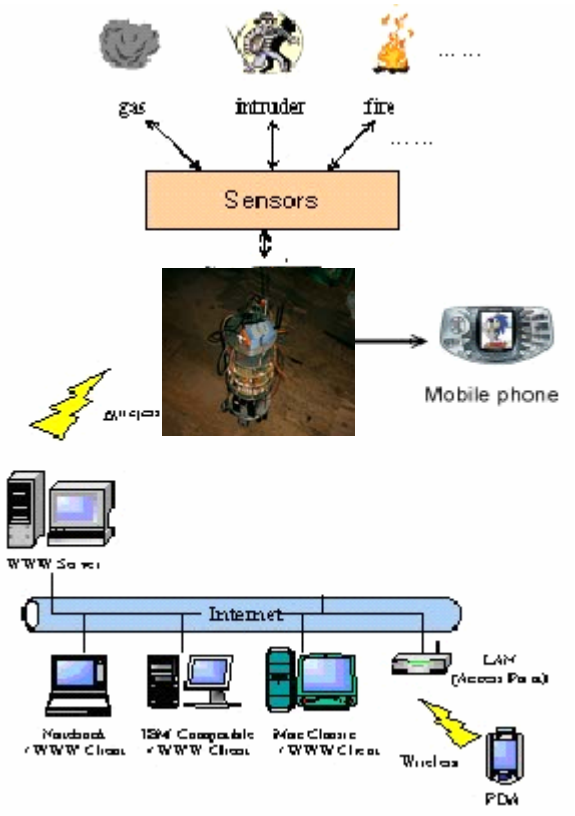

Figure 6. The hardware configuration of the remote surveillance and control architecture.

3. Auto obstacle and motion planning system

The security robot contains eight IR sensors and three ultrasonic sensors to detect obstacle, and can executes motion control, docking, avoid obstacle and following. In this paper, we provide an adequate method to find a simple path to avoid obstacle from the position of robot in this family. The low cost security robot is used in the

family. We can't program the fixed path. It can move in free space, and detects abnormal and dangerous situation to notify us.

The sensor arrangement of mobile robot is shown in Figure 7. We use five IR sensors (I1, I2, I3, I7 and I8) and three ultrasonic sensors (U1, U2 and U3) to detect obstacle. The IR sensor can detects distance from obstacle to be 30 cm. The ultrasonic can detects distance 10m from obstacle. We fuse the advantages of these sensors to increase the precious of the detection obstacle.

The driver system is designed by us. In the low cost part, we use two gear-based DC motor, and use PWM signal to control DC motor. In generally, the DC servomotor is very expensive. We design the cheaper-based encoder device to calculate the displacement of the security robot. The cost of the security robot is about US1400 dollars.

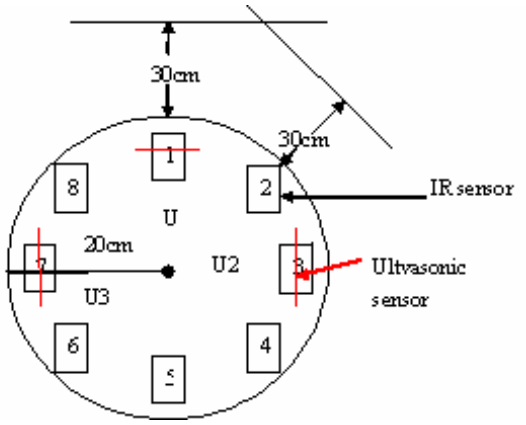

Figure7. the arrangement of IR and ultrasonic sensors

4. Software development system

We develop the software system for the low cost security robot using Visual Basic and assembly language. The assembly language is designed as the main program of the robot. The supervise system uses Visual Basic to program the supervise panel. In the paper, we focus on the main program of the mobile robot. The flow chart of the program is shown in Figure 8.

The main controller of the security robot is microprocessor (89C52). We write the software program using assembly language. Figure 8 is flow chart of the main program. First, we set some initial parameter values, then finish "avoid obstacle subroutine" to control the security robot. Next it catches the sensory data. Finally, it suggests the power is small then the threshold. It is true. The security robot must do auto-recharging behavior. Otherwise, the security robot continue do its task.

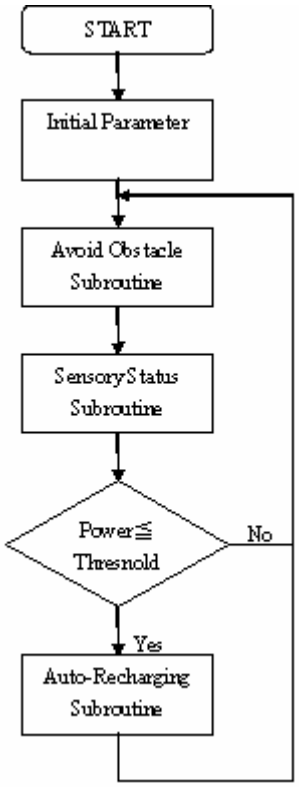

Figure 8. The software flow chart for the low cost security robot

5. Auto-recharging system

The robot always monitors its power capacity. When the power is lower than threshold value, the recharging behaviour of the mobile robot is necessary. We program the auto-recharging behaviour as follows.

In the first step, the mobile robot can detects the laser line using laser detection device (shown in Figure9). The laser detection device combines sixteen photo resistors. When the laser light photo resistors, the signal of the laser detection device change, and send the variety signal to the main controller through the extended I/O device. The mobile robot can moves the front view to the laser light of the charging station.

The mobile robot touches charging station. The signal of the limit switch that is embedded on the charging station can control the laser light to be off. The control box auto-recharging station can detects the charging current, and protects the charging current to be overload, and notify the mobile robot have been finished the charging status. The charging flow chart is shown in Figure 10.

We want to overcome an error angle for the docking behavior. We design the new docking station (Figure 11), and implement a slider bar in the X-axis (left-right motion) on the docking station. And then a pilot on the docking station will slide into the concave in the security robot. After the robot leave the docking station, Compress springs on a slider bar are used to bring a

pilot to center.

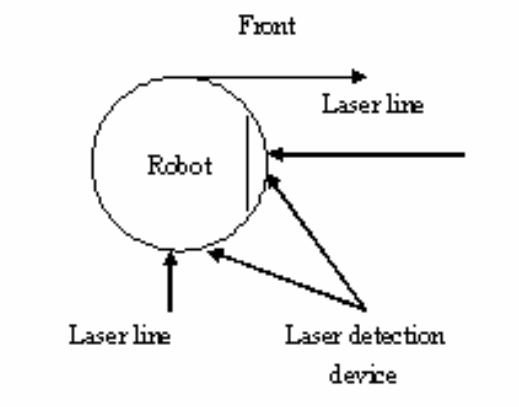

Figure 9. the auto-recharging method for LCSR-I

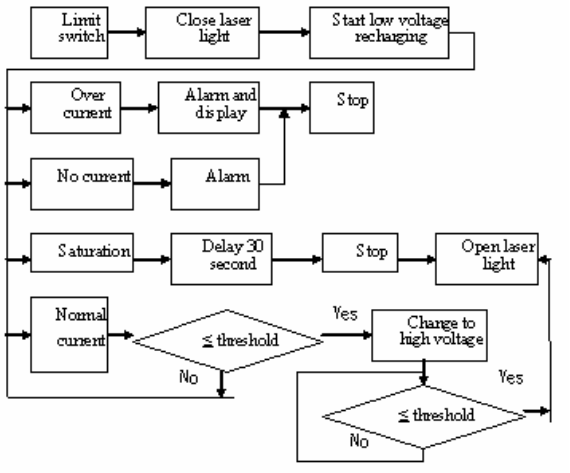

Figure10. The auto-recharging flow chart

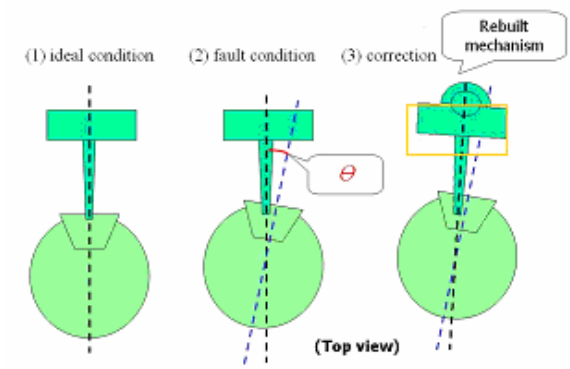

Figure 11. an error angle **θ** in the docking situation

6. Other system

In the other system of the low cost security robot, it contains auto-dialling, alarm, dangerous display, power schedule and robot structure. The dangerous display can displays abnormal point.

IV. Experimental Results

The security robot can move orientation autonomous according to environment state using ultrasonic sensors and IR sensors. We can supervise the low cost security robot for walking forward, walking backward, and rotation, turn right and turn left through the wireless series interface. We can order command to the security robot executes function from supervise computer. The control software is programmed using Visual Basic. In the supervise computer, the computer monitor display panel is shown in Figure 12. We click the walking forward. The command must be transmitted to main controller of the security robot through wireless interface, and the wireless box can control the security robot walking forward using motion control unit.

In the sensor detection experimental results, we control the security to move the fire source. The fire sensors detect the fire condition. The security robot must be alarm quickly, and transmits the signal to supervise computer through wireless series interface, and send the fire signal to the mobile phone using GSM module. In the intruder detection, the experimental results are the same as fire detection.

Finally, we make the auto-recharging experimental. The security robot detects the power to be low. It can find the laser line , and follow the laser line move to the recharging station. In the Figure 13, the laser line is guarding the security robot to the recharging station.

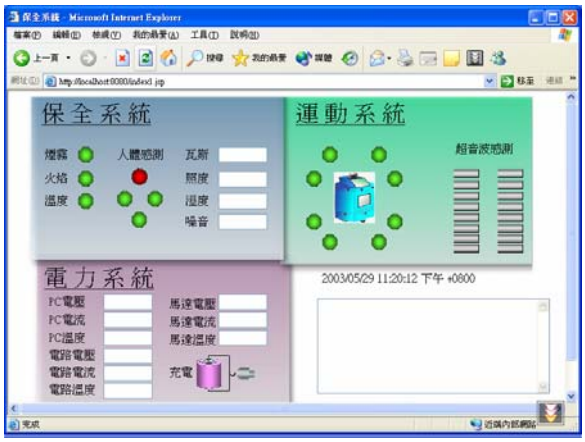

Figure 12. The web interface of the supervise system on server-side.

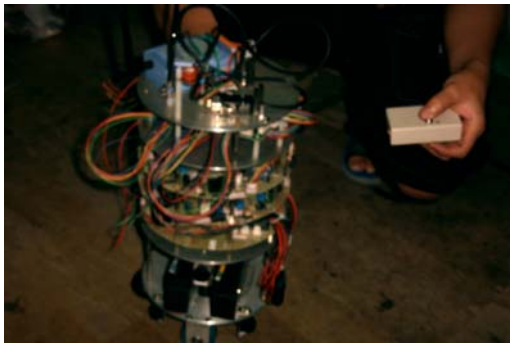

Figure 13. Tthe security is guarding by laser line

V. Conclusion

We have presented a multisensor based real time monitoring system that is applied in intelligent security robot, and design a low cost and smart security robot. The main controller of the low cost security robot is microprocessor. We program assembly language to control the mobile robot using sensor data, and design the wireless supervises system using Visual Basic from series interface. In the experimental results, the user control the mobile robot through the wireless, and can control the mobile robot using wireless control box. The mobile robot detects the dangerous status, and transmits the sensor signal to the user (supervise computer or mobile phone) through the wireless. When the power is lack, the mobile robot can find out the auto-recharging station using laser detection device. In the future, we want to modify the Internet function, and increase the detection device, and use multisensor fusion algorithm in the low cost security robot system.

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