Develop a Module Based Security System for Intelligent Home

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Abstract: The security detection system of intelligent building, home is important, to human life. An unlucky event was often caused by the negligence of humans. We have developed a module based security system for home automation. The structure of the security system contains many modules. Each module has two variety interfaces (wireless RF and speech). There are active and passive modules in the security system. The active security module is smart robot. We have designed many types' smart robots for the security system. The passive security modules contain fire security module, intruder security module, environment security module, gas security module, AC power security module and appliance control module. In the security module, we use multisensor fusion algorithms to decide an exact output. In these modules, we use two-wire communication method through wireless RF interface, and use voice alarm for event condition, and transmit the real-time status to the supervised computer. In the smart robot system, we have designed many types smart robot for the security system. We have designed a general user interface (GUI) for the intelligent security system. The user interface can supervise these modules and smart robots using wireless RF device, and remote supervised using wireless Internet and cell phone, too.
Keywords: home automation, wireless RF, general user interface.

1. INTRODUCTION

Intelligent buildings and home can provide safety, convenience and welfare for human living in the 21st century, and allow effective management of resource with minimum life-time costs at the same time. The most important role of the intelligent home is security system. In the security system, redundant and complementally information results can enhance system reliability and certainty of intelligent home using multisensor fusion method. In generally, the price of the intelligent home system is very expensive. We want to develop a cheap and flexibility system for the intelligent, and he system is very easy operation and convenience for the user.

Wang and So [1] presented the history of development of building automation system (BAS). The structure of features of a modern BAS was introduced and future trends of BAS are discussed. Azegami and Fujiyoshi [2] described a systematic approach to intelligent building design. Kujuro and Yasuda [3] discussed the systems evolution in intelligent building. The quality of building services can be enhanced by updated information processing and communications functions of building automation systems. Finley et al. [4] presented a survey of intelligent building and reviews issues such as system perspective, subsystem services, multi-tenant building. Flax [5] discussed components and cost benefits of the intelligent building. Chung and Fu expect to set up the standard of appliances and communication protocols, and propose a complete system architecture with integrate control kernel to construct an intelligent building system [6, 7].

The paper is organized as follows: section II describes the system structure of the security system for intelligent home. Section III explains detection methods and algorithms for these detection modules of the security system. Section IV describes the user interface of the intelligent home. Section V presents the experimental results using these modules for the home security system. The brief concluding comments are described in Section VI.

2. SYSTEM ARCHITECTURE

The system architecture of the intelligent home security system is shown in Fig 1. The system contains many subsystems. The supervise computer and the intelligent mobile robot can receive the status of security modules and appliance control modules using wireless RS232 interface. The security modules and the appliance control module use two-way communication with the supervised computer and smart robots. The intelligent mobile 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 the supervise computer is television. We develop the user interface using Visual Basic language for the intelligent security system. The

supervised computer can control smart robots using wireless RF interface, and control the intelligent mobile robot using wireless Internet. The user can acquire image signals from intelligent mobile robot, supervised computer and IPCAM through Internet. The supervised computer can acquire image signals from smart robots and CCD through wireless RF interface. In the paper, we are interesting in security modules, appliance control module, smart robots, and user interface.

In the architecture, there are many modules in the system, and it's equipped with a microcomputer (HT46R24) as the controller. These modules are independent and autonomous, and can work concurrently, each module can transmits the sensory data, parameter values and detection results to the mobile robot and the supervised computer through wireless series interface (RS232), and transmits detection results to PDA and 3G mobile phone using GSM module, too. These modules can speech Chinese on real-time measured data using voice module. We develop a general user interface for the home security system. The security system 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.

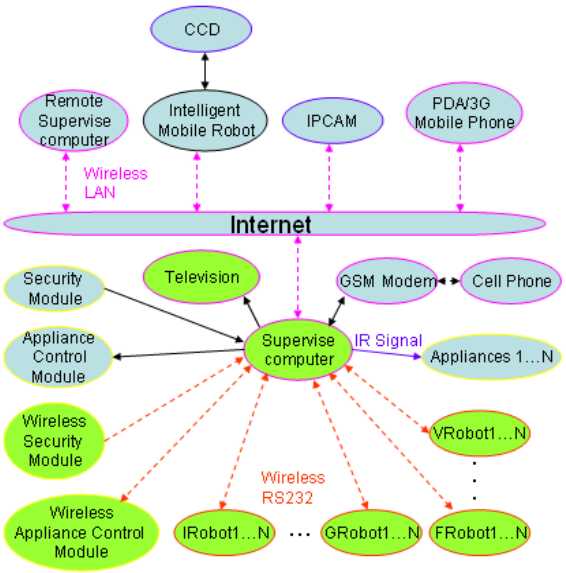

Fig. 1 The overview of the home security system

3. DETECTION MODULES

We develop some intelligent security detection modules for home automation system based on the multi-models fusion architecture. They contain active and passive security modules in the security system. We design some smart robots that are embedded detection devices to detect environment status in the active security modules. In the passive security system, there are fire security module, intruder security module, environment security module, power security module and gas security module. These modules can detect surrounding of the intelligent home using sensors and wireless RF interface. We list sensory type of these security modules in Table I.

Table I. Sensors of security system

Module	Sensors
Fire security module	Three flame sensors,
Intruder security module	Touch sensor, magnetic sensor, IR sensor and body sensor.
Environment security module	humidity sensor, illumination sensor and temperature sensor
Power security module	Four current sensors.
Gas security module	CO sensor, smoke sensor, gas sensor and alcohol sensor
Smart robot	Flame sensor, gas sensor and body sensor

- **Fire security module**

In the fire detection module, we use three flame sensors to detect fire source, and use the weighted average method to decide event. We set the same weight value for these sensors. The prototype of the fire detection module is shown in Fig. 2. The decision rule is according to equation (1) and (2). Then we set a threshold for the fire security module. The average value $\bar{x}$ is over than threshold, and we can say to be fire event. Otherwise we can say no fire condition. The ith measurements value of n sensors is presented x_i, and the weight must be satisfied $0 \le \omega_i \le 1$ is

$$\bar{x} = \sum_{i=1}^{n} \omega_i x_i \qquad (1)$$

$$\sum_{i=1}^{n} \omega_i = 1 \qquad (2)$$

- **AC Power security module**

We proposed a power detection and diagnosis method using four current measured values in the AC power security module, and use a multilevel multisensor fusion method to decide the exact power of the intelligent home. The redundant management method is developed for the power security module. The proposed method is not only to detect power value, but also to diagnose

sensory status [8]. We can find the estimate value of the measured parameter is obtained by the following equation at that sample time.

$$\hat{x} = \frac{\sum_{i=1}^{l} m_i I_i}{\sum_{i=1}^{l-j} I_i} \tag{3}$$

$$Ii = \sum_{j=1}^{l} f\left[\left|m_i - m_j\right| \le \left(b_i + b_j\right)\right] \quad i = 1,2,\cdots l \tag{4}$$

$$f[*] = \begin{cases} 0, & if \quad * \quad is \quad true \\ 1, & if \quad * \quad is \quad false \end{cases} \tag{5}$$

m_i and m_j are measured values of the ith and jth sensors, and I_i is the indicator function of the ith sensor.

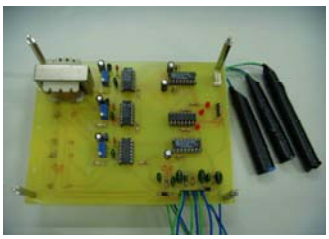

Fig. 2 The prototype of the fire detection module

- **Smart robots**

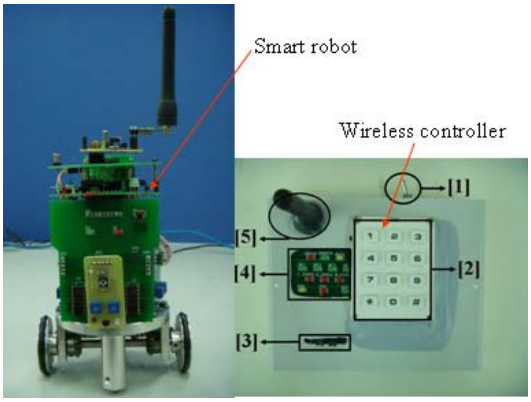

Fig. 3 The smart robots and remote controller

The smart robot has four levels to be embedded hardware devices. The smart robot has the shape of cylinder and its diameter, height and weight is 8cm, 15cm and 2kg. They are shown in Fig. 3. The power of the smart robot is three Li batteries, and connects with parallel arrangement. It has three IR sensors to avoid obstacle. The controller of the smart robot is HT46R24, and can acquire the detection signal from sensors through I/O pins, and receives the command from the supervised computer and remote controller through wireless RF interface. The controller of the smart robot can transmits the detection result to the remote controller and the supervised computer through wireless RF interface.

4. USER INTERFACE

The user interface of the intelligent security system is shown in Fig. 4. There are four regions in the supervised interface. This is the graphic supervised monitor for the intelligent security system in the region 1. The user can program the status of security modules and appliance control modules, and receive the status from these modules by wireless RF interface. The user can move any module (security module and appliance control module) of the region 2 to the region using mouse.

The region 2 can display the arrangement of these security modules and appliance control modules. It can display the real-time measured values of these security modules, and the user can set the threshold value by the supervised computer, and transmit the set value to the module using wireless RF interface. In the region 3, the user can program the output response for any security signal input. For example, if the intruder event happened, we can program alarm, and hazard, and control the appliance module, and transmit the status to the user by the remote supervised computer, PDA or 3G mobile phone through Internet or GSM modern in the region. The user can program the status of each floor of the building in the region 4.

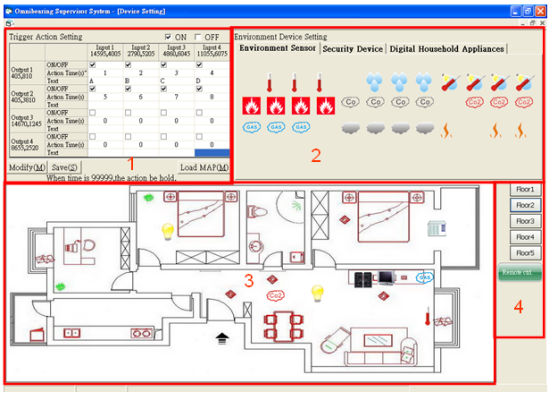

Fig. 4 The user interface of the supervised system

5. EXPERINMENTAL RESULTS

In the intruder security module, we use magnetic sensor to detect the intruder. The intruder detection module can transmit the decision results to the supervised computer and the remote supervised computer (or mobile phone) through the wireless RF

interface and Internet (or GSM modern). The experimental results are shown in Fig. 5. The user put off the magnetic sensor from the intruder detection (from Fig. 5(a) to (b)). The module can transmit the signal to the supervised computer, and the supervised computer can transmits the intruder status to the user using GSM modern to be shown in Fig 5(c). The module can speak "intruder" use Chinese language. There are many experimental results in the reference.

The smart robot can move autonomous according to environment using IR sensors. The user can supervise the smart robot for forward, backward, turn right, turn left and stop through wireless RF interface. The smart robot can receive the detection signal from the security module through wireless RF interface, and move to the event place. It can transmit the image signal and the real-time data to the supervised computer and remote controller. The user can control CCD device to catch the event using wireless RF interface. The experimental result is shown in Fig. 6

(a) (b) (c)

Fig. 5 The experimental result for intruder detection

Fig. 6 The fire detection experimental result

6. CONCLUSION

We have presented an intelligent security system applying in the intelligent home. The security system contains active security module (smart robot) and passive security module. These security modules have two interfaces, one is wireless RF interface, and the other is voice interface. It can speak Chinese language according to the environment status. The security system contains five detection modules, one application control modules and smart robots. The detection methods of these modules have weighted average method, statistical method and redundancy management method. These smart 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 smart robots through wireless RF interface by the wireless controller and the supervised computer, and supervise these devices using remote supervised computer, PDA and 3G mobile phone.

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