Multi-level Multi-sensor Based Security System for Intelligent Home

Song-Hiang Chia[1,2], Kuo-Lan Su[3], Sheng-Ven Shiau[1], Ting-Li Chien[2]
1. graduate school Engineering Science and technology, National Yunlin University of Science & Technology
2. Department of Electronic Engineering, Wu-Feng Institute of Technology, Taiwan
3. Department of Electrical Engineering, National Yunlin University of Science & Technology, Taiwan
E-mail: g9610808@yuntech.edu.tw, sukl@yuntech.edu.tw

Abstract: The paper develops a multi-level multi-sensor based security system that has multiple interfaces to be applied in intelligent home. The security system contains four levels. There is passive detection level, active detection level, system supervised level and remote supervised level. The control unit of these passive modules is HOLTEK microchip. Each passive module has two variety interfaces (wireless RF and voice). These modules can use voice to alarm users for event condition, and transmit the real-time status and image signal to the active detection level and system supervised level via wireless RF interface. The active detection level can communicate with other level via wireless RF interface or wireless Internet. The remote supervised level, supervised level and active detection level can communicate with other level via wireless Internet. It can display status of these modules on the monitor. Finally, we present some experimental results using passive and active detection modules on the security system.

Keywords: multi-level multi-sensor**,** HOLTEK microchip, wireless RF interface, wireless Internet

I. 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. How to constructer a safety environment for human life? The most important role is security system. The hardware and software of the security system are complexity, and are not easy to maintain and repair. To increase their development and adaptability, the concept of the module-based security system (MBSS) has been studied in the intelligent building and home. We have developed some module based security modules for the intelligent. How to build up the communication protocol and user interface between the supervised computer and these security modules? It is very importance and difficult for researcher. The interface must be very easy to operate for users.

In the past literatures, many experts research in the security system. 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, and multi-tenant 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 [5, 6].

The paper is organized as follows: section II describes the system structure of the multi-level multi-sensor based intelligent security system for intelligent home, and explains the relation of these levels, and contains devices of each level. The user interface of the intelligent security system is described in Section III. The section present functions of the hand-on controller of the system supervised level. Section IV presents the experimental results using these modules on the AC power detection and intruder detection. The brief concluding comments are described in Section V.

II. SYSTEM ARCHITECTURE

The system architecture of the multi-level multi-sensor based security system is shown in Fig 1. The system contains four levels. There is passive detection level, active detection level, system supervised level and remote supervised level. The passive detection level has wire and wireless security modules, wire and wireless appliance control modules and medical measurement modules. The active detection level has some remote platforms. Such as mobile robots, wheelchair…etc.. The system supervised level has supervised computer, mobile phone, wireless controller and hand-on controller. The communication medium is wireless RF interface and wireless Internet. The remote supervised level may be remote supervised computer, PDA and iPhone. The communication medium is wire/wireless Internet.

We develop the user interface using Visual Basic language for the security system. The system supervised level can control security modules and appliance control modules of the active detection level and passive detection level via wireless RF interface, and supervise the medical measurement modules via wireless RF interface. The remote supervised level can communicate with system supervised level, active detection level and passive detection level via wireless RF interface or wireless Internet. If the wireless Internet is broken, and the communication

interface can use the wireless RF interface. Users can acquire detection results and image signals from system supervised level, active detection level or passive detection level.

In the architecture, there are many security detection modules and appliance control modules in the system. They are independent and autonomous, and can work concurrently. Each module of the security system can transmits the measurement values, parameter values and decision results to the active detection modules and the supervised computer via wireless RF interface (RS232). These modules can speech Chinese on real-time measured data using voice module. Users can reset the critical values of these modules from the user interface of the system supervised level or the remote supervised level via wireless RF interface or wireless Internet.

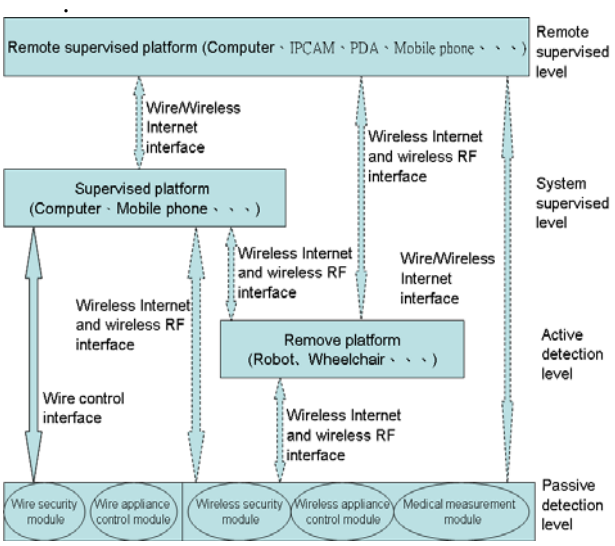

Fig. 1 The system architecture

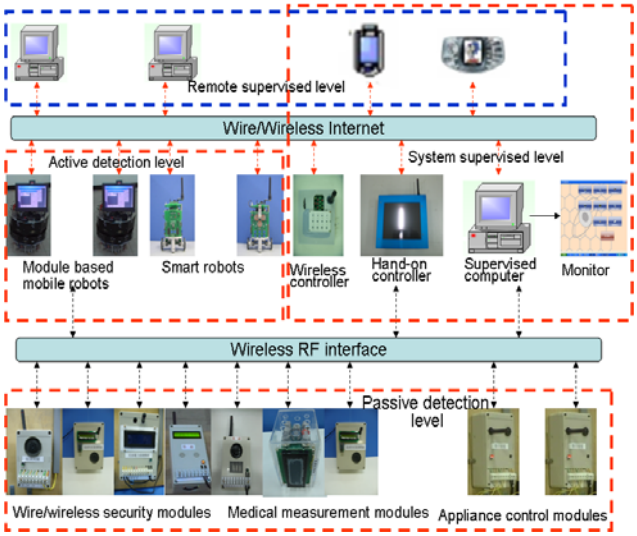

Fig. 2 The prototype of the security system

The controller of these modules is HOLTEK microprocessor. These modules of the passive detection module are classified three types. There are wire/wireless security modules, medical measurement modules and wire/wireless appliance control modules. The active detection level has some remove platform. The main device may be some intelligent mobile robots. We arrange an ID code in each module, and identify the module function by the ID. The prototype of the multi-level multi-sensor based security system is shown in Fig. 2. The security detection modules and appliance control modules of the passive detection level are developed in my laboratory [8]. The mobile robots have been designed in my laboratory, too [9]. In the paper we are interested in communication protocol of these levels for the security system.

III. USER INTERFACE

The user interface of the security system is shown in Fig. 3. The interface has four levels, too. There are wire/wireless passive detection modules and appliance control modules; mobile robot (1) (module based mobile robots), mobile robot (2) (smart robots), GSM interface, remote supervised interface and exit. The interface of the passive detection level is shown in Fig. 4. There are three regions in the supervised interface. This is the graphic supervised monitor for the intelligent security system in the region A. Users can move any modules (passive detection modules and appliance control modules) of the region B to the region using mouse. In the region C, users can program the output response for any security signal input. For example, if the fire condition, we can program alarm, and control appliance module to fight the fire, and control the module based mobile robots or smart robots move to the location. The supervised computer can transmit detection signals to the remote supervised computer and mobile phone via Internet or GSM modern.

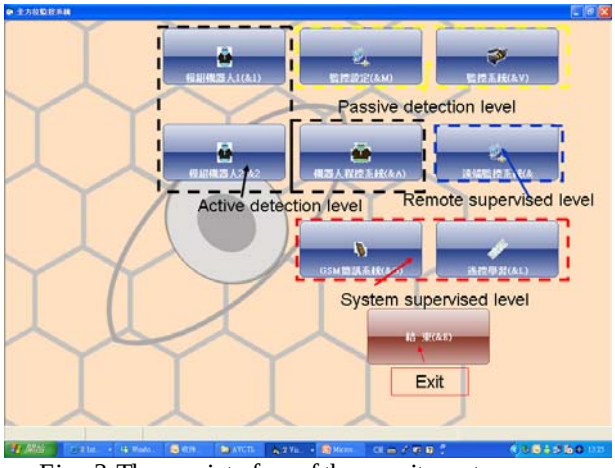

Fig. 3 The user interface of the security system

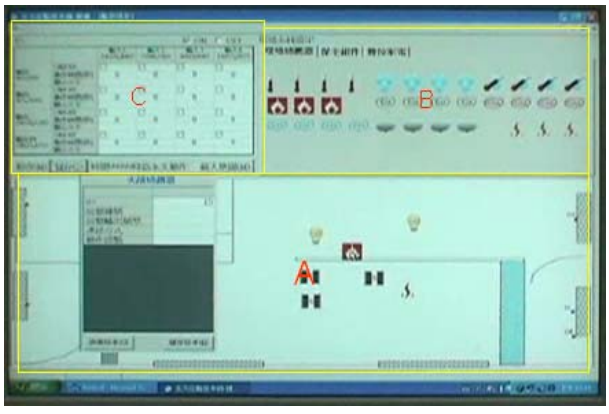

Fig. 4. The interface of the passive detection level

The user interface of the active detection level is shown in Fig. 8. The main role of the interface is mobile robots. The interface can control sixteen mobile robots simultaneously. There are three regions in the supervised interface. The user can program motion trajectory for each mobile robot in the region 1, and can program the motion status for sixteen mobile robots at the same time, and can program 300 motion statuses for each robot. The region 2 can display the status of mobile robots. It contains communication protocol and encoder status. We can know the motion trajectory of the mobile robot. The region 3 has many functions for the mobile robot system. There are loading and storage program file. The user can set the execute cycle for the programmed motion trajectory.

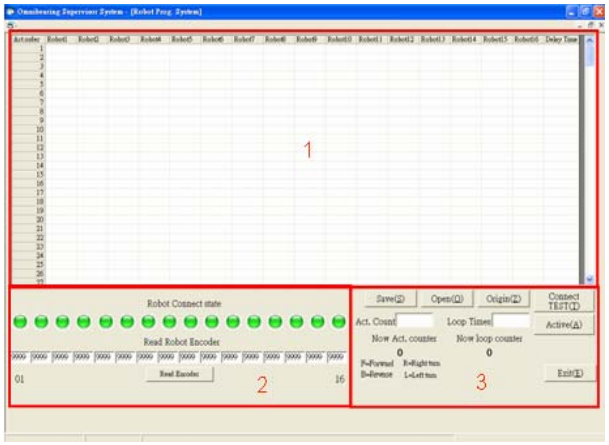

Fig. 5 The user interface of the active detection level

We design the hand-on controller using embedded system. The controller has a touch screen, a main board, a voice module, a wireless RF module and some devices. Users can touch the screen, and roll the screen to select the function on the hand-on controller. The controller can control security modules, appliance control modules and mobile robots on the passive detection level and the active detection level. The prototype of the hand-on controller is shown in Fig. 6. The hand-on controller can hang up the wall, too.

Fig. 6. The user interface of the hand-on controller

In the AC power security detection module, we use redundant management method to estimate the exact values on current and voltage for the security system [7]. The value of the measured parameter is obtained by the following equation at that sample time k, and the estimated value is

$$\hat{x}(k) = \frac{\sum_{i=1}^{l} m_i(k) I_i(k_i)}{\sum_{i=1}^{l} I_i(K)} \tag{1}$$

Where I_i is a weighted value for the each measurement value m_i at the given sample time k. So we can define Ii is

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

$$f[*] = \begin{cases} 1, & if \quad * \quad is \quad true \\ 0, & if \quad * \quad is \quad false \end{cases} \tag{3}$$

The b_i is a threshold value for each measurement value m_i, and m_j is another measurement value.

IV. EXPERIMENTAL RESULT

In the passive detection modules, we use AC power detection module to detect power variety of the home. The power detection module can measure the exact current value using the proposed method, and display on the LCD panel to users, and transmit the detection results to the system supervised level (supervised computer and mobile phone) and the active detection level (mobile robots) via the wireless RF interface. The experimental results are shown in Fig. 7 (a).

(a)

(b)

Fig. 7 The experimental result for AC power detection module

The user can reset the critical power value (1600mA) of the AC power detection module on the user interface, and the initial

critical value is 3000mA. The supervised computer of the system supervised level can transmit the reset power value to the module via wireless RF interface. Users can execute the function the on the remote client via wireless Internet. The experimental result is shown in Fig. 7 (b). Then we see the new critical value to display on the interface of the supervised computer.

Multi-level multi-sensor based security system can use passive detection modules and active detection modules to detect environment of the intelligent home. The dangerous event happens on the security system. The security modules of the passive detection level can transmits the signals to the active detection level and system supervised level. The active detection modules (mobile robots) can move to the event position to do double check, and deal with the event. The system supervised level can control the appliance control modules to deal with the dangerous event (fight the fire source), and transmits the status to the remote supervised level via wireless Internet.

Mobile robots of the active detection level can move autonomous according to environment using ultrasonic detection module and IR detection module (Fig. 8 (a)). Users can supervise mobile robots for forward, backward, turn right, turn left and stop using wireless controller, hand-on controller or supervised computer via wireless RF interface or wireless Internet. The security module finds out the intruder from the door. Mobile robots can receive the detection signal from passive detection modules via wireless RF interface, and move to the event location (Fig. 8 (b) and (c)). It can transmit the image signal and the real-time detection results to the supervised computer and the remote supervised computer. The user can control CCD device to catch the face of the intruder via wireless RF interface. The experimental result is shown in Fig. 8 (d).

(a) (b)

(c) (d)

Fig. 8. Intruder experimental result using mobile robots

V. CONCLUSION

We have presented a a multi-level multi-sensor based security system that has multiple interfaces to be applied in intelligent home. The security system contains four levels. There is passive detection level, active detection level, system supervised level and remote supervised level. The controller of these modules is HOLTEK microchip. We want to develop multisensor fusion algorithms to enhance the detection results through these detection modules. In the AC power security detection module, we use redundant management method to estimates a exact power detection value for the security system. These security detection modules and appliance control modules can transmit signals to the system supervised level and action detection level. In the paper, we use the intruder event to implement the function of the multi-level multi-sensor based security system for intelligent home. The experimental results are very nice on the system. In the future, we want to increase some security detection modules, and extend the function of the user interface to present the perfect life for human.

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