Implementation of a Wireless Communication Technologies based Home Security System

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ABSTRACT
Recently, the demand for home security in the world is intensifying due to the aging population with low birth rate and the significant increase in number of nuclear family with dual working parents. Some enterprises like SECOM, ALSOK, CSP, provide home security services in Japan and many other places. However, most of these services rely on security guards, which is expensive. Besides, some families do not like their homes being under surveillance and monitoring data being kept by a third party. This paper describes a light weighted home security system that exploits the common use of wireless communication technology like mobile phone, Bluetooth communication, wireless sensors, etc. One of the significant advantages is that the monitoring data is kept in a home web server and is shared by family members only. Moreover, the system scale is small and the cost is low, which is more suitable for the smaller scope of a home and a general civilian family.

Keywords- home security system; Bluetooth communication; cell phone; surveillance camera; abnormal detection

1. INTRODUCTION
Home security is a worldwide concerned issue. With the rapid advances of IT /ICT and wireless communication technologies, it becomes possible to develop more sophisticated and convenient home security systems. The most commonly used home security systems are fire alarm, burglar alarm and video surveillance systems. Japan is a relatively secure society but with the increasing aging ratio [1] and the working couple ratio [1], people are starting to realize that more elderly are at home alone and more homes have no one at home, especially during the daytime. On the other hand, as for the working couples, they would like to be aware of the security situation at home, even when they are not at home or at work. Therefore, it is necessary to have a sophisticated system that enables people to keep an eye on their homesecurity and be at ease. Apart from the fire alarm and burglar alarm systems, video surveillance system [2] is another commonly used way of monitoring the situation at home. Some smart home applications may analyze and extract possible abnormal situation. If the system spots a singularity from a set of frames in a recorded video, it sends the specific frames or a short clip of video to people at the remote. There are some competitive home security companies like SECOM [3],ALSOK [4] andCSP [5], they offer the home security system in which various sensors are set at or by the door,windows and some other specific places. The system can detect abnormal occurrences and automatically reports it to the control center of the company. However, some families may not like to use the system due to privacy issues. Moreover, it may be too expensive for a single family to purchase and install such security system although it may be affordable for a whole building or a company.This paper describes a light weighted home security system that exploits commonly used wireless communication technologies like mobile cellphone, Bluetooth communication, wireless sensors, etc. One of the significant advantages is that monitoring data is kept in a home web server and is shared by family members only. Moreover, the system scale is small and the cost is low, which is more suitable for the smaller scope of a home and a general civilian family. In particular, it meets the needs of most Japanese families since Japan is facing the aging and low birth rate problems, and most crime cases fall into the category of burglary due to empty houses, broken windows or unlocked doors. According to the Tokyo Metropolitan Police Department's statistical results in 2005 [1], burglary in the case of empty houses is about 53.4%, burglary by broken windows is about 65.5% for detached houses, and house invasion due to unlocked doors is about 28.1% for apartment houses. It shows that a small scale light weighted system is more preferable than a large scale system provided by a home security company in some aspects such as easier management, privacy concern, and low cost.

2. RELATED WORK AND TECHNOLOGIES
With the development of IT technology, network and automatic control technology, a remote home security monitoring and alarming system becomes more and more practicable today. The home security system (HSS) often utilizes many sensing equipments in the house, such as microphones, cameras, mobile robots or other sensor nodes with different functions. Therefore, there is a variety of HSS system design with different equipments. For example, in [6], the authors used an acoustic intruder detection system for home security. The security system proposed in [7] is composed of two subsystems. They are face recognition module and motion detection module to detect intruders and analyze their facial images. In [8], the authors proposed a home security system based on a sensor network. Their system can track an object based on the alarm events sent from the sensor nodes. The best part of HSS is that both monitoring and control can be done remotely and communicated with wireless network. Bluetooth is a

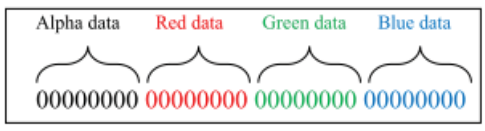
proprietary wireless technology standard for exchanging data over short distances from fixed and mobile devices. It has been advocated by mainly five Home Security Systemcompanies around theworld: Ericsson, IBM, Intel, Nokiaand Toshiba. Using this technology, we can connect laptop, PDA, mobile phone, etc, and exchange voice and data information to each device without using a cable. The differences between IrDA and Bluetooth are IrDA uses infrared technology, Bluetooth uses 2.45GHz short-range radio frequency band freely and provides communication to each device over obstacles within 10 meters range [9]. This technology is also used in game controllers, such as in Sony Play Station 3(PS3). In this system, a PS3 game controller is used as the substitution of sensing window or door's locked and unlocked states.Although Bluetooth is the most popular technology currently in the field of short range wireless communication,new standards such as UVB, NFC, and ZigBee are ready to enter the field.

3. HOME SECURITY SYSTEM DESIGN

This home security system is designed with the emphases on using devices that are light weighted and easy to use by anyone for instantaneous check of windows and doors. Moreover, the system is implemented with the aim that anyone, anywhere, anytime can conveniently check and grasp the situation of his/her home.The system is composed of a home computer, a number of Web Cameras, a number of sensors, and cell phones for or it is raining and a window is or some windows are open, of course, it is necessary to send an email. If there is no abnormality but a door is open, it is necessary to send an email. Otherwise, there is no need to send email. In Java API, there is a class, GmailSender, which provides the email sendingfunction. Thissystem used the method, send(String,String,String,String,String), defined in this class.

4. COMPARISON OF TWO IMAGES

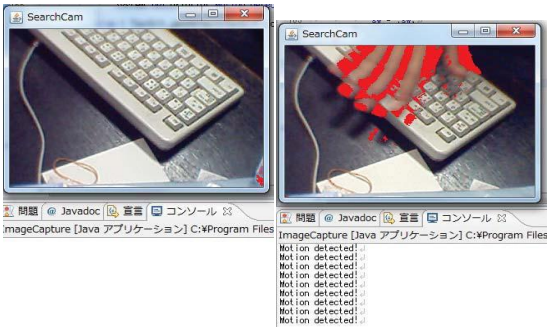
In the process of detecting abnormal situation at home, a comparison of two frame images is one of the important steps. In this system, a sequence of frame images is captured from a recorded video file at a defined interval. The system continuously makes comparison of every pair of frame images, i.e., the previous frame image and the current frame image. The image comparison algorithm takes two images, stores pixel values of the two images into two arrays, and compares each pair of pixels with the same index. As we know, each pixel is represented by 3 colors, i.e., red (R), green (G), and blue (B). In Java, it is coded in a 32-bits color data.



The 32-bits data is separated into 4 sets of 8-bits data and each 8-bits data is converted into an integer value. The color value of a pixel is calculated by averaging the integer values of red color data, green color data, and bluecolor data as given below.

intcolor = ((int)red+(int)green+(int)blue)/3;

If we note the previous frame image as image1 and the current frame image as image2, then the comparison of two pixel color value becomes to compare image1_pixel[i] and image2_pixe1[i]. If their value difference is over a tolerance, they are regarded as different pixels. If the percentage of the different pixels over the total number of pixels is greater than 1.5%, the two images are regarded as different images and an abnormality may have occurred. As an example, below are two images taken from a Web camera.



(a) (b)

Figure 1. An example of the motion detection by SearchCam()

Once a person puts his hand on the keyboard, the function, SearchCam.check() can detect the motion and output a conclusion. In order to easily show the color value differences of some pixels before or at the time one's hand is put on the keyboard, the latter in Figure 7(b) is marked in red color. Of course, when the hand is not moving any more, SearchCam.check() detects no any motion object and concludes the situation is not abnormal.

5. IMPLEMENTATION

This system is implemented in Java. In this implementation, the main devices used are a Web camera, a cell phone, a note PC, a number of ID sensors, and a Bluetooth embedded Sony PS3 wireless game controller. Actually, it is idea to use a lock for a door and a hook for a window and the lock and hook with wireless sensors are controllable via the bluetooth wireless communication with PC. However, such lock and hook are very rare on the market. Instead, we use thebluetooth embedded Sony PS3 game controller as the sensor attached to the lock or hook for a door or window in this system.

Sony PS3 wireless controller (sixaxis): there are two electrodes. In default, they are disconnected but become connected when the circle button is pressed

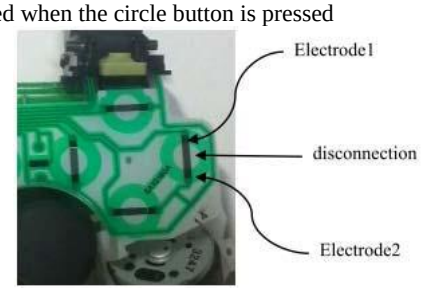


Figure2.ThePS3wirelesscontroller

The lock used in this system is a crescent lock as given in Figure 9(b). The idea is to connect the electrode1 and electrode2 in a PS3 wireless controller to the two ends of a lock with two wires in red and in black as

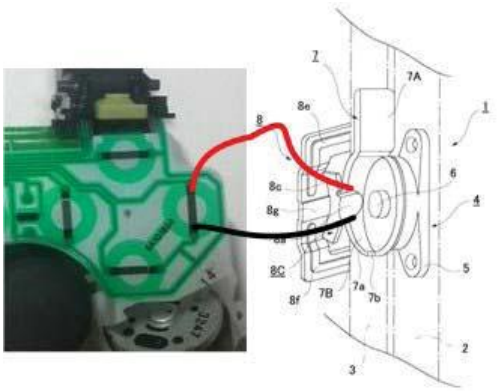


Figure3.ThePS3wirelesscontrollerwithalockviawires

When the lock is hooked, the two wires are connected, it means two electrodes are connected, which is equivalent to the button in the PS3 wireless controller is pressed. Via the bluetooth communication, the controller signal is sent to the home computer through Bluetooth dongle. Using JoyToKey software, the game controller signal can be converted into the keyboard signal. Via the interface, KeyListener, the system can catch events from the KeyListener and analyse the lock situation, and then act accordingly.

The system is run for a number of simulated situations: Figure 10 (a) and (b) just present two system implementation scenarios: friendly interface and uses the popular cell phone as the terminal, which makes it easy for anyone to use at anytime in anywhere. Since it is a small scale of system, it is easy to use and maintain. Furtherrmore, the recorded data is kept in its home computer system, and the family privacy problem can be solved.As for our future work, we would like to improve the system so that one can operate his/her cell phone to control the door locks or window hooks at home if it is raining or is about to rain. Instead of using Sony game controller, the system should use controllable window hook and door lock.

6. ACKNOWLEDGMENTS

We would like to express our gratitude to Huang Laboratory's research team for their valuable support. In particular, Ms.ShiqinYang, Mr. Ahmad SofianShminan, and Mr. Toshihiro Tamura who gave great help in writing up this paper.presents the situation in which a window is unlocked and a window is open but someone (a child) is at home presents the situation in which no one is at home and a window is open. Of course, with information received from the cell phone, a use may act accordingly. For example, in the situation 1, if it is raining, the user may ask the child to close the window. In the situation 2, if it is raining or is going to rain, the user may need to go back or ask his/her neighbor or friend nearby to close the window.

7. CONCLUSION AND FUTURE WORK

This paper presents the design and the implementation of a light weighted home security system in which cell phones, surveillance cameras, and other common wireless sensor devices are used. It is a practical implemented system in which the motion detection algorithm is described and how to PS3 wireless controller for sensing a door or window's lock state is explained. Moreover, the system has a user-

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