Development of an Elderly Telecare System

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Abstract

In this project, a smart elderly home monitoring system (SEHMS) has been designed and developed. The system consists of three modules which are the telecare system, telehealth system and monitoring system. This paper focuses on the discussion on the development of the telecare system and how it is integrated with the monitoring system to monitor elderly or chronically ill patients. The telecare system consists of two types of devices which are the panic buttons and the presence detectors. The panic buttons can be installed in the strategic area in the house which enables the elderly or individual with disability to call for help when communicating an emergency. Presence detectors are installed under or around the bed to detect the presence of the elderly. The monitoring system behaves as the heart of the overall system. When the telecare devices are triggered, it will send the alarm notification to care giver, social contact and/or emergency respond team via sms, emails or/and phone calls. With the developed system, elderly and chronically ill patients could stay independently in their own home with care facilities and secure in the knowledge that they are being monitored.

Keywords: *Telecare system, Panic Buttons, Present Detector, Elderly Monitoring and Smart Home*

1. Introduction

The elderly or people with disabilities want to remain in their homes even when their health condition has been getting worse [1]. The global population of people over the age of 65 is expected to more than double from 375 million in 1990 to 761 million by 2025" [2]. With this, the telecare service has been widely implemented and used to help one (refers to elderly or individual with disability) to live independently at home. Telecare service refers to the system that could notify the others when help is needed by someone. As the problem of aging and disability are converging, the smart home based health monitoring has become a key research area for ubiquitous and embedded system computing. The idea of this project is to develop an intelligent and versatile home safety environment that could help the elderly and individual with disability live independently in their own home. This paper presents the design and development of a telecare system and how it is integrated with its monitoring system in monitoring the elderly at home. Section 2 introduces the background of the project. Section 3 introduces an overview of SEHMS. Section 4 and 5 discusses the telecare system and monitoring system respectively. Section 6 shows a simple demonstration. Section 7 makes the conclusions of this paper.

2. Background

Telecare refers to the use of communications technology to provide health and social care directly to the user or patient (We refer to the elderly people in our context) [3]. It is a tool used by healthcare professionals to deliver support to user and should be employed to provide a user-centred service that complements but not replace the existing healthcare system [4]. Magrabi *et al.*, developed the Home Telecare System (HTS) which supports information exchange between the hospitals, homes as well as the general practitioner [5-6]. The system facilitates the acquisition, review, analysis and archiving of a longitudinal clinical record which allows the clinician to record clinical measurements such as weight, temperature, lung function, blood pressure, single lead electro-cardiogram and ambulation. The patient is connected to the clinical workstation serially with a personal computer. In addition, the HTS allows the scheduling of questionnaires, medication reminders and the monitoring of an emergency alarm button. A wireless triaxial accelerometer is integrated with an emergency alarm button into the belt worn ambulatory device. When the user clicks the button, the system sends a short text message to the contact person automatically through a monitoring centre. It also provides a voice communications channel with the patient.

There were some successful monitoring systems for elderly people [7-15]. Leijdekkers *et al.*, [12] developed a remote healthcare monitoring system that to care for the elderly and the chronically ill in their homes with care facilities. This remote healthcare monitoring system includes smart phones, wireless sensors, web servers and IP webcams. The authors centered the window based smart phone by integrates all the devices with it. The smart phone acts as a receiver that receives all the data sent by the wireless healthcare sensor and further process the data by sending the data the healthcare server or calls an ambulance during emergency. With the remote healthcare monitoring system, patients are free to move about in their own home and secure in the knowledge that they are being monitored.

Gaddam *et al.*, have developed a smart home monitoring system based on intelligent wireless sensors network which enables elderly who lives at home alone [13-15]. The network is known as SMART component-based Selective Activity Monitoring (S.A.M.) Cognitive Sensors Network that is integrated with various intelligent sensors such as current sensors, bed sensors, panic buttons and water flow sensors and the communication was established via standard RF protocols. The bed monitoring sensors are used to monitor the use of bed and sleeping behaviour of the elderly users. Various types of bed sensors are embedded to the bed with the use wireless technology. If the sleep quality is good, the sensors will provide steady signals. In the other hand, if the elderly is suffering from lack of sleep or shivering/moving continuously during sleep, the sensors will not provide steady signals. Thus, the abnormal condition can be detected. If the person comes out of the bed at night, the time duration for which the bed is not used is also monitored. When there is an abnormal condition detected, the system will sent a notify message to the care giver via Short Message Service (SMS) or text message. In addition, there is an option for the users to use the emergency panic button during emergency. It has the highest priority than the other sensor units. When the emergency button is triggered, the controller reads the status of the unit and sends message (SMS) to the care giver or emergency services immediately.

3. System Overview

The smart elderly home monitoring system (SEHMS) is divided into three different modules which are the monitoring system, telehealth System and telecare System. Figure 1 shows the block diagram for the overall system architecture. The red single open arrow dotted lines represent the data transmission line to the monitoring system (personal computer). The blue single open arrow dotted lines represent the data transmission line from the monitoring system. The double arrow lines represent parent and child relation within the modules. The yellow dotted line boxes indicate the respective connection method used between the terminals.

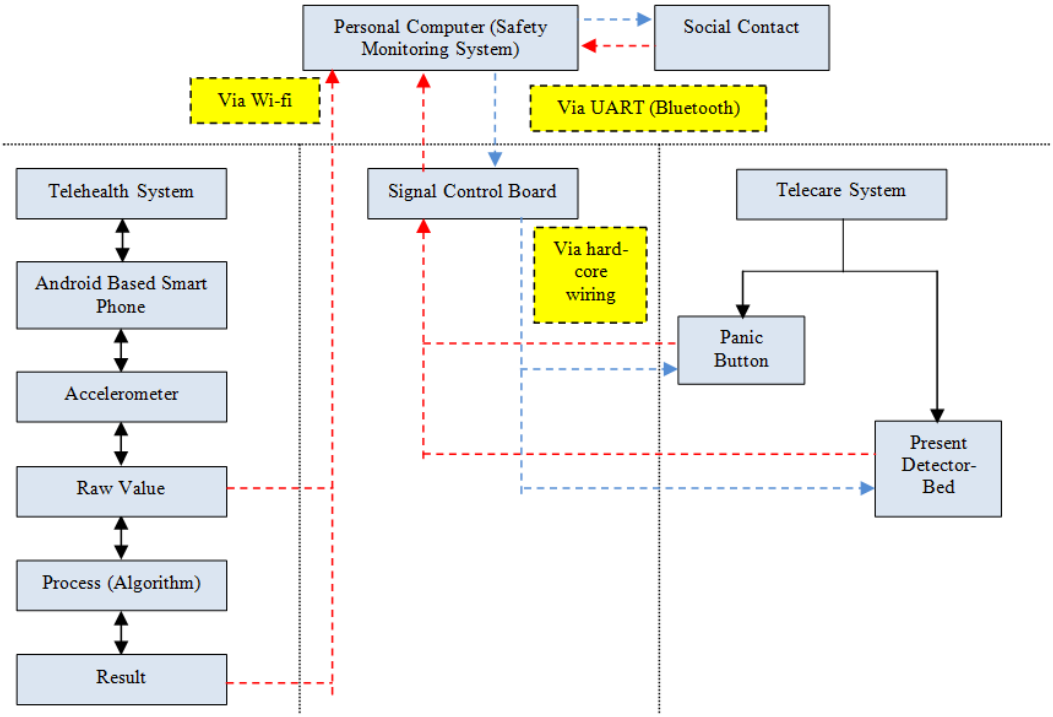

Figure 1. Overall Architecture Block Diagram of SEHMS

4. Telecare System

4.1. Panic Buttons

The purposes of the panic buttons are to enable the elderly or individual with disability to call for help when it is needed. The elderly and chronically ill patients may be attacked by diseases or falls that could paralyzed the elderly (or chronically ill patients). In such situation, they can seek for help by activate one the panic buttons. The panic buttons can be installed in the strategic area in the house, for example, in the toilet, beside the bed, beside the sofa, dining table, along the staircase and etc. The emergency alarm could be activated by switch on one of the panic button. If the panic button was switched on accidentally, the emergency alarm could be cancelled by switching off the panic button.

4.2. Presence Detectors– Bed

Presence detectors are installed under or around the bed to detect the presence of the elderly (or chronically ill patients). The system indicates the status of the elderly (or chronically ill patients) whether they away from the bed. Elderly (or chronically ill) might wake up in the middle of the night for a toilet trip, to drink a cup of water or etc. They often walk in the dark which will lead to a high possibility of fall occur. Thus, if the they away from the bed in the middle of the night and do not return within a certain period, the system will activate the emergency alarm to inform the social contact, care giver or emergency respond team to have an investigation.

4.3. Hardware

The panic button as shown in Figure 2 is made up by a green led, HK4101F-DC5V-SDG relay, a switch, and a resistor. The usage of the relay is to control the working sequence of LEDs (indicator and ceiling light) and buzzer based on the signal received from signal control board. The presence detector is made by a micro switch (as shown in Figure 3) and multiple of the switches are placed under the bed to detect the presence of any person who lay on the bed.

Figure 2. Panic

Figure 3. Micro

Figure 4 shows the assembled signal control board that manipulates the signal between the monitoring system and telecare devices. The circuit board was developed based on the schematic diagram as shown in Figure 5 which had been modeled, simulated and tested by using Proteus software. SK40C was used as the development board in this project. It offers an easy-to-start solution for PIC microcontroller user. In addition, this board provides the power supply for the telecare devices. The microcontroller used in this project was PIC 18F 4520 from MicroChip Inc as shown in Figure 6. PIC 18F 4520 has a large number of I/O (input/output) ports (36 ports) and it allows more switches to be added to the signal control board. Furthermore, it is sufficient to perform the signal controlling task that is required by the SEHMS. Figure 7 shows the JY – MCU Arduino Bluetooth wireless serial port module that is used to transfer the data from the signal control board to the monitoring system via Bluetooth transmission.

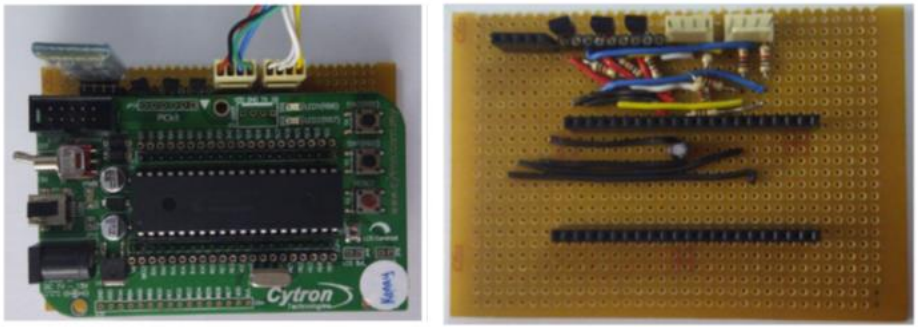

Figure 4. The Signal Control Board

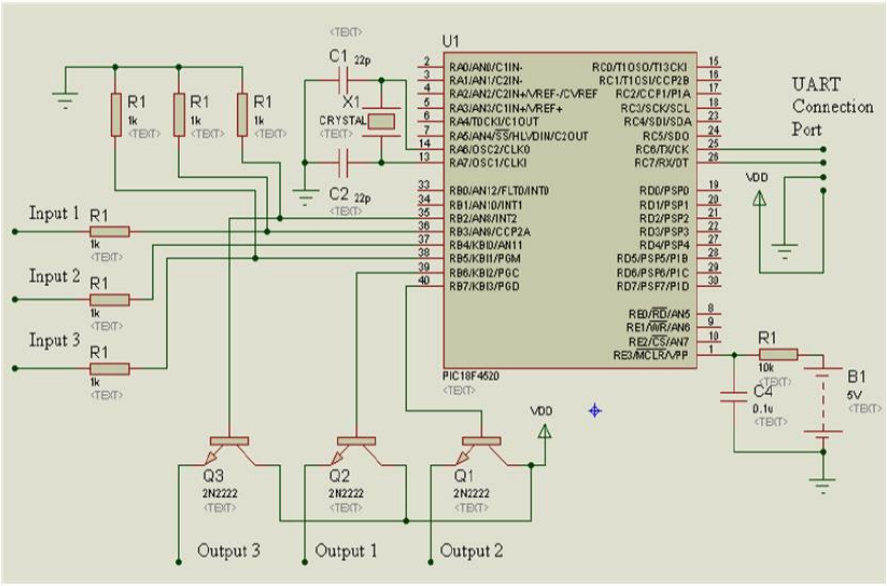

Figure 5. The Schematic Diagram for the Signal Control Board

Figure 6. PIC 18F 4520

Figure 7. JY – MCU Arduino Bluetooth Wireless Serial Port Module

4.4. Software

The program code in the microprocessor (PIC 18F 4520) was developed by using MPLAB. MPLAB enables user to choose either assembly code or C programming for code writing. It turns the code into hex form before deploying it into the microprocessor. During the operation, the microprocessor takes the input signals from

all the telecare devices and process the signals based on the programmed codes before sending back to the respective telecare devices.

4.4.1. Panic Button: Figure 8 shows the process flow for the panic button. The microprocessor continuously updates the status of all the telecare devices to the monitoring system even though there isn't any change of the telecare devices. One can request for help by activating the Panic Button. Under the normal condition, the LED indicator of the Panic Button should be in green. If the LED indicator flashes in red and green, it indicates the monitoring system is sending a "help request". In the other hand, if the indicator turns red, it indicates the "help request" has been sent to the contact person (emergency respond team, social contacts, relatives, and *etc*.).

Once the Panic Button activated, the signal control board will receive a triggering signal from the Panic Button. After that, the signal control board will send an output signal (a blinking command) to the respective Panic Button's indicator, and update the monitoring system about the "help requested". After the "help request" has been sent successfully, the signal control board will receive a notification from the monitoring system. Then, it will send an output signal ("emergency" signal) to the Panic Button to turn the indicator in red. One can turn of the "help request" with switching off the Panic Button. After the signal control board received the signal "normal" from the Panic Button, it will update to the monitoring system with sending a signal "normal" to the Panic Button to turn the indicator in green.

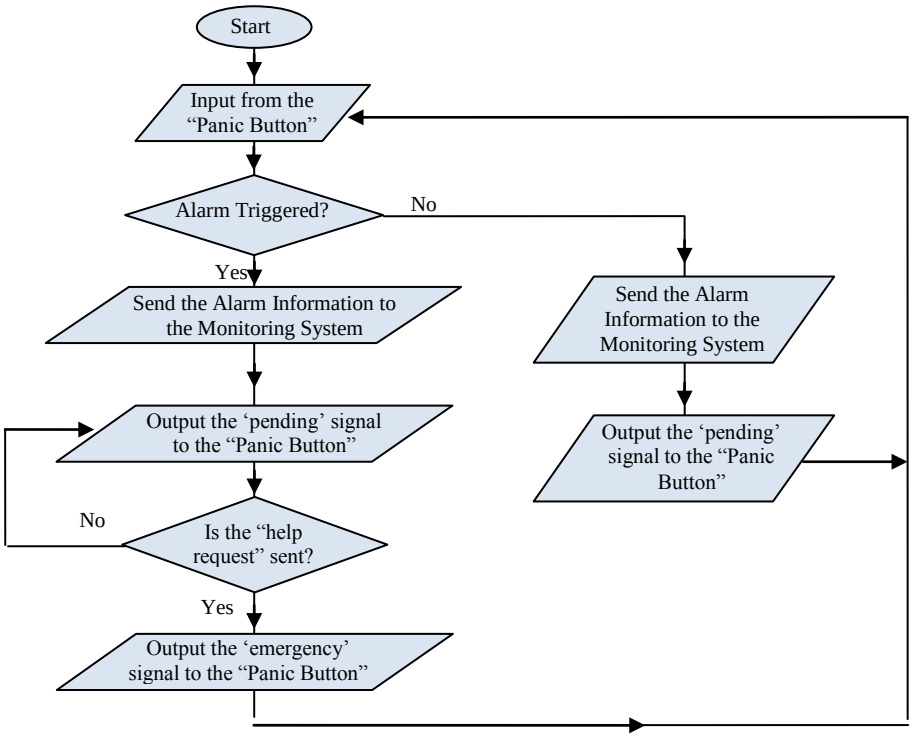

Figure 8. The Process Flow of the Panic Button

4.4.2. Bed Presence Detector: The bed presence detector can be switched on or off manually or automatically by presetting the time period to the system. During the activated state, the signal control board will indicate if there is a person lay on the bed.

If the microprocessor encounters nothing, it will send an output signal "normal" back to the bed presence detector. Under the normal condition, the indicator of the bed presence detector should be in green.

Once the bed presence detector detected a person left the bed, it will send the information to the signal control board and the microprocessor will start the counter. The counter will count for 15 minutes (this is a preset value by the user and can be changed accordingly). If the microprocessor found the person left the bed after 15 min (the bed presence detector can't detect any person for 15 min), it will inform the monitoring system to send a "help request" to the contact person (emergency respond team, social contacts of the user, relative, and *etc*.) to have a look on the user. In addition, the microcontroller will also sound the buzzer and light up the ceiling light to notify others about the incident occurs. If the person goes back to the bed within 15 minutes after leaving the bed for a toilet trip or to have a glass of water and e*tc*., the condition in the microprocessor will be reset back to the "normal" state.

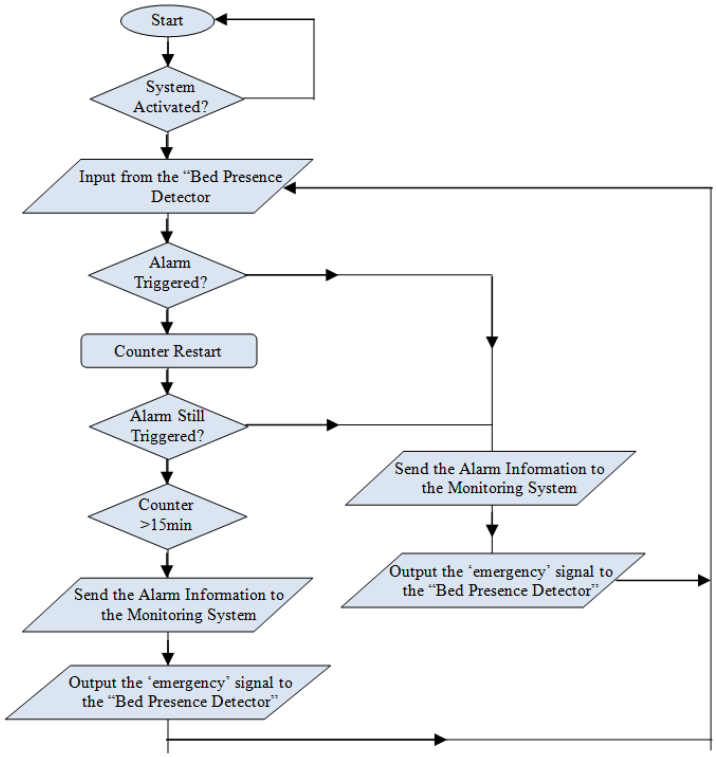

Figure 9. The Process Flow of the Bed Presence Detector

5. The Monitoring System

The monitoring system behaves as the heart of the overall system. It creates an environment that enables the elderly and individual with disability to live independently in their own home. With this system, elderly and chronically ill patients could stay independently in their own home with care facilities and secure in the knowledge that they are being monitored. The monitoring system is developed on a personal computer which is integrated with other modules. Once triggered, the monitoring system will send the information of the alarm (information such as what cause the emergency alarm, where the

alarm occur and when is the alarm triggered) with the alarm notification to care giver, social contact and/or emergency respond team via sms, emails or/and phone calls. This will increace the chances the elderly (or chronically ill) to be to rescued after an accident happened. The authorized social contact, care giver and/or emergency respond team can further access to the monitoring system for more information. In addition, the monitoring system can also answer the call automatically after the emergency alarm has started.

5.1. The System Flow and Development

A personal computer equipped with Bluetooth and Wi-Fi connections is used as the platform for the monitoring system. Visual Studio is used to develop the monitoring system as well as the GUI that monitor the status of all the telecare devices. Figure 10 shows the program flow for the monitoring system. Basically, there are two main tasks performed by the monitoring system which are (a) update the status of all the telecare devices, (b) and to call for help if it is needed.

It is important to establish server/client communications which enables the telecare devices (clients) to be connected to the monitoring system (server) via Wi-Fi. The developed program based on Figure 10 enables the monitoring system to receive the data from the telecare devices via TCP/IP. It has been designed in such a way that the IP address of the server ("ServerIP2" from the code above) and the port number ("Port2" from the code above) can be easily changed by selecting the preferable IP address and port number. The personal computer sees the Bluetooth module as a serial port. Thus one can read the data received via Bluetooth in Visual Studio by adding a serial port listener. One must ensure the correct serial port number and baud rate are selected in order to capture the data sent by the Bluetooth module by monitoring system. The functionally of a background worker enables the visual studio to run multiple tasks simultaneously. The developed code enable repeating loop between the function *e.g.*, separation and create graphs which are run parallel with the other program.

The developed program has the capability further analyze the raw data received, and separate the string received into single character based on the condition and pass the processed data to the other functions. As the system keep update the status of the devices, it means the diagrams are also been refreshed is term of milliseconds even though there is no change on the signal received. This will make the program unable to handle the refresh rate and make the program hang. To overcome this problem, a comparison function is developed where the graphical indicator will not be refreshed until there is a change on the signal received from the respective device.

Zed Gpraph is a tool that able one to performs graph plotting on various platform (Visual Basic, Visual Studio and *etc.*). The author uses the Zed Graph to perform dynamic real time graph potting on the monitoring system. To enable the monitoring system to send the "help request" via email automatically whenever there is an emergency alarm triggered, the Simple Mail Transfer Protocol (SMTP) is used. SMTP enables one to send mail automatically by just few steps of setting. The author uses a registered hotmail account to send the mail to the contact person. Different account provider has different server host and server port. The respective server host and server port could be easily found by perform a simple Google search.

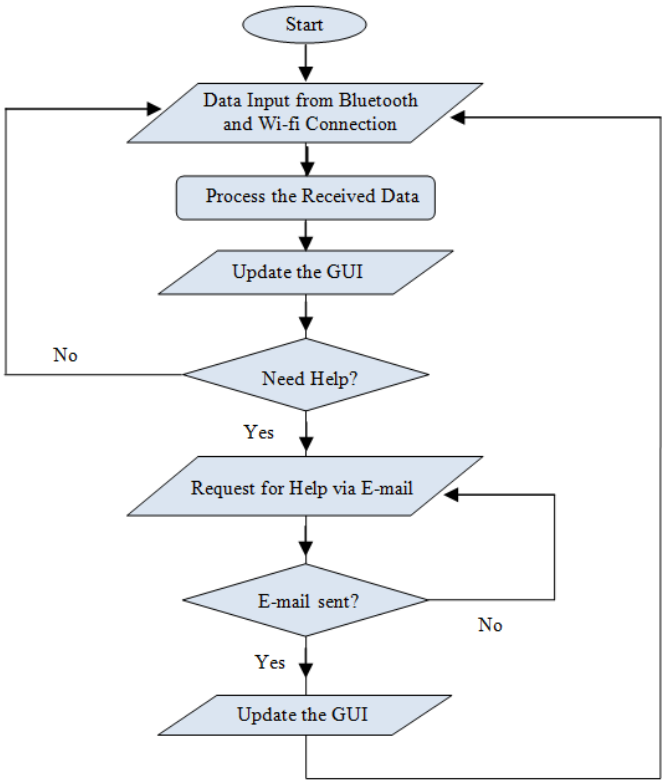

Figure 10. The Process Flow for the Monitoring System

6. System Demonstration

If a user has triggered the panic button in the bathroom, the monitoring system will notify the "help requested" then update the GUI (as shown in Figure11a) and send the help request to person whom concern via e-mail. If the e-mail was sent successfully, the monitoring will update it GUI by changing the status "Calling for Rescue" to "Rescue Called" as shown in Figure 11b. Figure 12 shows the e-mail of 'help request' received by the contact person.

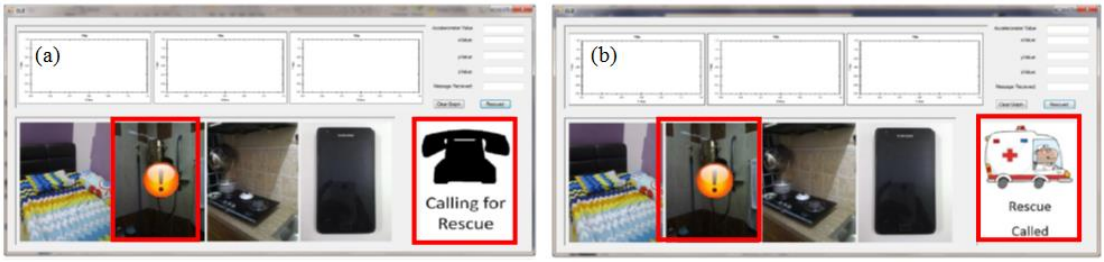

Figure 11. GUI of Monitoring System (a) Help Requested in Bathroom (b) Help Request Sent

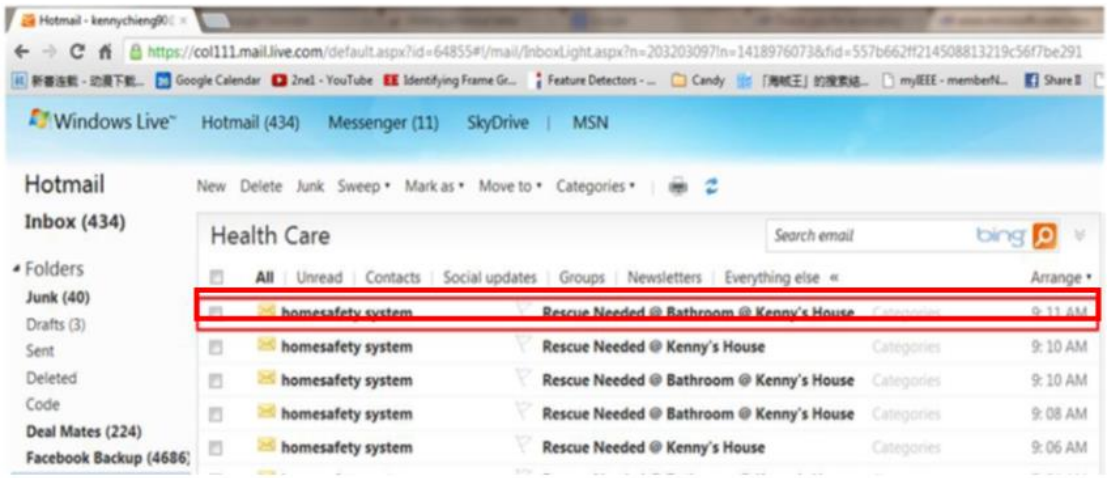

Figure 12. Help Request E-mail Received

7. Conclusions

A telecare system has been designed and developed. It consists of two types of devices which are the panic buttons and the presence detectors (bed). The panic buttons can be installed in the strategic area in the house which enables the elderly or individual with disability to call for help during emergency. Presence detectors are installed under or around the bed to detect the presence of the elderly (or chronically ill patients), which can determine whether they have away from the bed. The monitoring system behaves as the heart of the overall system and it was developed on a personal computer. Once triggered, the monitoring system will send the alarm notification to care giver, social contact and/or emergency respond team via sms, emails or/and phone calls. This will increace the chances the elderly (or chronically ill) to be to rescued after an accident happened. The authorized social contact, care giver and/or emergency respond team can further access to the monitoring system for more information. In addition, the monitoring system can also answer the call automatically after the emergency alarm has started. With the developed system, elderly and chronically ill patients could stay independently in their own home with care facilities and secure in the knowledge that they are being monitored.

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