



INTEGRATING IoT DEVICES INTO A MOBILE APPLICATION FOR ELDERLY WHO LIVE ALONE

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ABSTRACT

Nowadays, the populations of elderly persons who live alone are increasing worldwide. As we all know, the elderly need more support and need someone to regularly take care of them. The situation become worst for elderly who have health problem that needs to be monitored frequently. Therefore, the main objective of this study is to propose a mobile application known as HomeAlone for helping the elderly manage their daily activities easily and independently. The application is developed on android platform combined with Internet of Things (IoT) sensor devices. The Arduino Uno board will be used as the platform that will connect the sensor devices to the internet. HomeAlone primary concern focuses on the monitoring of the security intruders outside the house and the condition of the main entrance door of the house. The health of the elderly can be monitored using pulse, body temperature and blood pressure sensors. Besides that, the movement of the elderly also can be monitored by using motion sensor which can detect the actual condition of the elderly inside the house. By using this application, the elderly can live more safely and independently and can also relief the worries of the caretakers.

Keywords: Internet of Things, Arduino, sensor devices, elderly apps, mobile app.

INTRODUCTION

In Malaysia, elderly or aging people is defined as those who are 60 years and above based on the definition finalized “World Assembly Ageing 1982” in Vienna [1]. The increasing number of elderly population during the current period of modernization and migration for work among their children has increased the issue of giving adequate support and care for the older people. The aging population is increasing since year 1990 until year 2020 [2]. The rapid aging of the population leads to an increasing number of disabled older people as disability is closely associated with increasing age. With declining fertility and longer life expectancy, Malaysia’s population too is gradually aging. By 2030, Malaysia will be in the category of aging nations with older persons constituting more than 15% of the population [3]. Aging people need more support and help from others due to their poor health and strength to do their daily activities by themselves. However, with modern lifestyle it is rather difficult for their children to take care of them coupled with their own personal life problems. Most working children tend to have great difficulties to provide full care and proper assistance to their aging parents. The situation worsens for elderly who do not have spouse and who are living alone rather than living with their children. This situation had contributed to worrisome feeling among children as the caregivers.

Therefore, the mobile application known as HomeAlone may improve this situation once it is developed. The Internet of Things (IoT) technology shall be integrated into the mobile application. IoT can be described as connecting everyday objects like smart-phones, sensors to the internet where the devices are intelligently linked together enabling new forms of communication between things and people, and between things themselves [4].

This application is developed on Arduino platform. Arduino is based on Atmel AVR (Automatic Voltage Regulator) micro controller which includes Arduino board and IDE (Interface Development Environment) [5]. It can be connected to the computer and USB connections or by using external power. Besides that, this micro controller is able to communicate with android devices which make the monitoring of the elderly status in home is more traceable. This Arduino board can be programmed and connected with sensors like pulse sensor, motion sensor, door sensor and gas sensor. The data or signal that has been captured can be sent to the database and can be stored in android devices. The captured data then can be used to alert and to send notification to the appropriate person such as caretaker and neighbors. The data also can be used by the doctor to analyse the health condition of the elderly.

In order to develop the system a study has been conducted and the objectives of the study are:

1. To study the requirement needed to monitor the health and the security of the elderly.
2. To identify how the IoT can be implemented to help the elderly who lives alone.
3. To implement IoT platform as the tools to monitor and manage the elderly health and their security in the house.

The subsequent section discusses the related work on HomeAlone application. This is followed by the proposed system in section 3. Next, section 4 illustrates the system design and implementation, followed by the discussion in section 5. Finally, section 6 presents the conclusion and future work.



RELATED WORK

HomeAlone can be described as self-management mobile application that is built by following the requirements for the elderly. This system is using IoT technology devices like sensors to monitor the elder's health and their security at home. By using this latest technology, we can develop mobile application that can help the elderly who live alone to do their routine effectively without the help from others. With the introduction of Internet of Things (IoT), the research and implementation of IoT systems are getting more popular. By using these technologies, it increases the quality of life for the elderly and disabled people who might otherwise require caregivers or institutional care [4]. There are a few applications which have been developed to assist the

elderly such as Virtual Cloud Carer and Smart Home System.

Virtual Cloud Carer

There are many applications that have been developed by some developers which is based on Internet of Things technologies. One of the examples is Virtual Cloud Carer which is an application that is focusing more on monitoring elderly health condition in home. The objective of this project is to provide a range of health-oriented goals that can help the elderly to keep active through physical training exercises and also assist the medical staff in the task of monitoring the treatment of these people from homes [6]. Figure-1 shows the system architecture of the Virtual Cloud Carer.

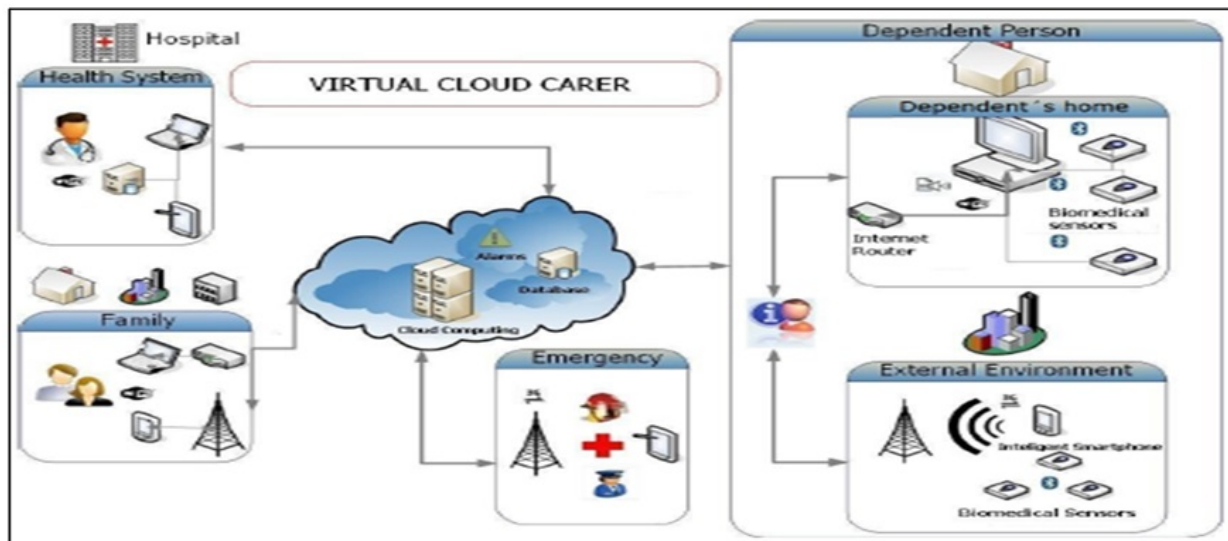


Figure-1. System architecture of the virtual cloud carer.

This project has developed a subsystem for gesture recognition which can detect the elder's movements. The elders with movement disabilities, they can do their physical exercises virtually as the physical recovery process. This project also use mobile device to collect the information from sensors, GPS, accelerometers and the data will be store in cloud. Cloud is used as the platform to store all the elderly's information and use it to give alarm or to alert the elderly's caregivers and their medical personnel. For mobile application they are using android as their operating system.

Smart Home System

With the continuous growth of mobile devices in its popularity and functionality the demand for advanced ubiquitous mobile applications in people's daily lives is continuously increasing. Smart Home App may be developed using the Android app communicating and using the latest technology which is Internet of Things. This system offers powerful means for helping and

supporting special needs of the elderly and people with disabilities, for monitoring the environment and for control [7]. Figure-2 below shows the architecture diagram for the Smart Home System.

This system use Arduino Ethernet for the micro web-server to eliminating the use of PC and the system requires user authentication in order to access the smart home system. When the user enters the correct password, the app will proceed to display the smart home controls page with a message notifying success of login. When the voice activation function is used, the message displayed prompting the user to speak again is shown. There are many systems that the researchers have done based on IoT technology.

HomeAlone is developed based on the ideas of the current research such as the Smart Home System. HomeAlone provides Health Monitoring module which can monitor and record the elderly health. The health record can be collected and generate it to pdf files for reference to the elderly's doctor. Other than that,



HomeAlone application can choose whether they want to alert the caretaker by calling them or just via SMS. However, The Smart Home System uses emails for all alerting purposes. HomeAlone also use email to send the report like health monitoring report and house monitoring report to the caretaker. The difference is between the HomeAlone and Virtual Cloud Carer is that, the Virtual

Cloud Carer system shall be focusing on the elderly with chronic diseases while HomeAlone application is for the elderly who live alone in house.

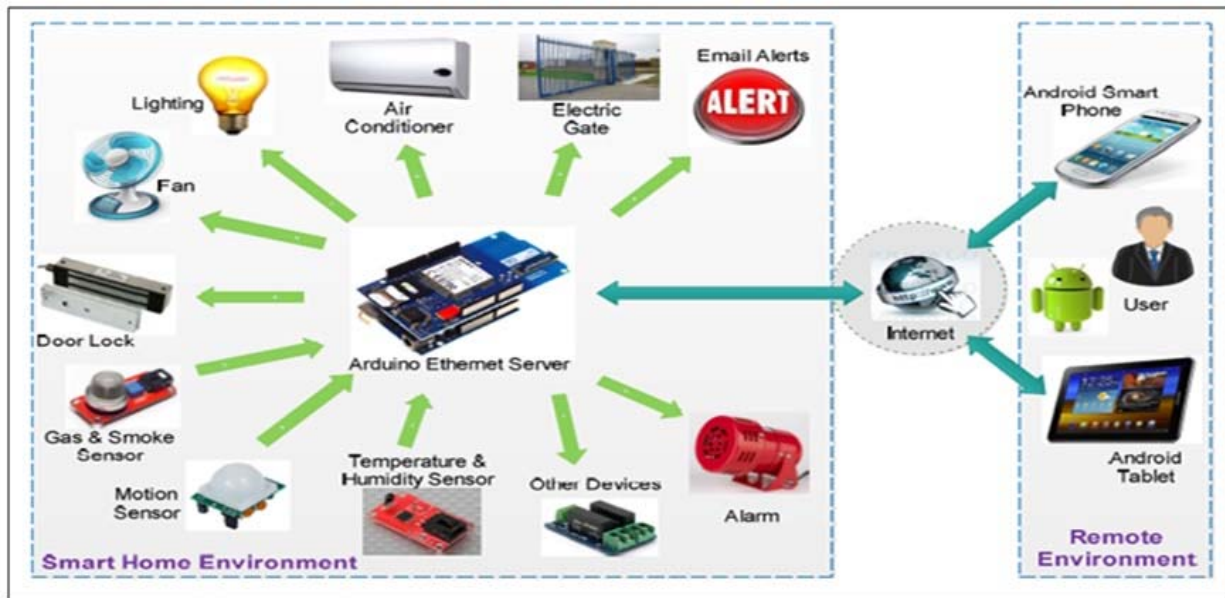


Figure-1. Architecture diagram of Smart Home system.

In order to indicate that HomeAlone system is different compared to existing system, Table-1 shows the features comparison between HomeAlone application and the existing application.

Table-1. Features comparison.

Application	HomeAlone System	Virtual Cloud Carer	Smart Home System
Features			
Focusing on the elderly with live alone	√	x	√
Focusing on the elderly with chronic diseases	x	√	x
Health Monitoring Module	√	x	x
Alerting Purpose (SMS and Call)	√	x	x
Health Report via Email	√	x	x
IoT Technology	√	√	√

PROPOSED SYSTEM

HomeAlone is an application which is built using android application and Internet of Things technology. These systems consist of five modules which are health monitoring, motion detector, gas leakage/smoke detector, door lock detector, and security sensor. The main users for this application are for the elderly people and their caretakers. Other users that may get notification during an emergency are their neighbors and the doctor. HomeAlone is an android application created to help elderly who live alone in their house. The IoT sensors will be integrated with mobile app to make the life of these people more safe and secure. Figure-3 below shows the flow of the HomeAlone application.

Firstly, the caretaker will install the HomeAlone application in the user mobile phone. After the installation, the caretaker can fill up all the information details provided in the application and the user can next start using the application. When the user wants to use the sensors, they need to connect the application with the sensors connected with the Arduino Uno board via Bluetooth. The communication between the Arduino and android can be done via Bluetooth connection. After the connection is successful, the user will start receiving message notifications or dialog messages if a signal is triggered based on some conditions.

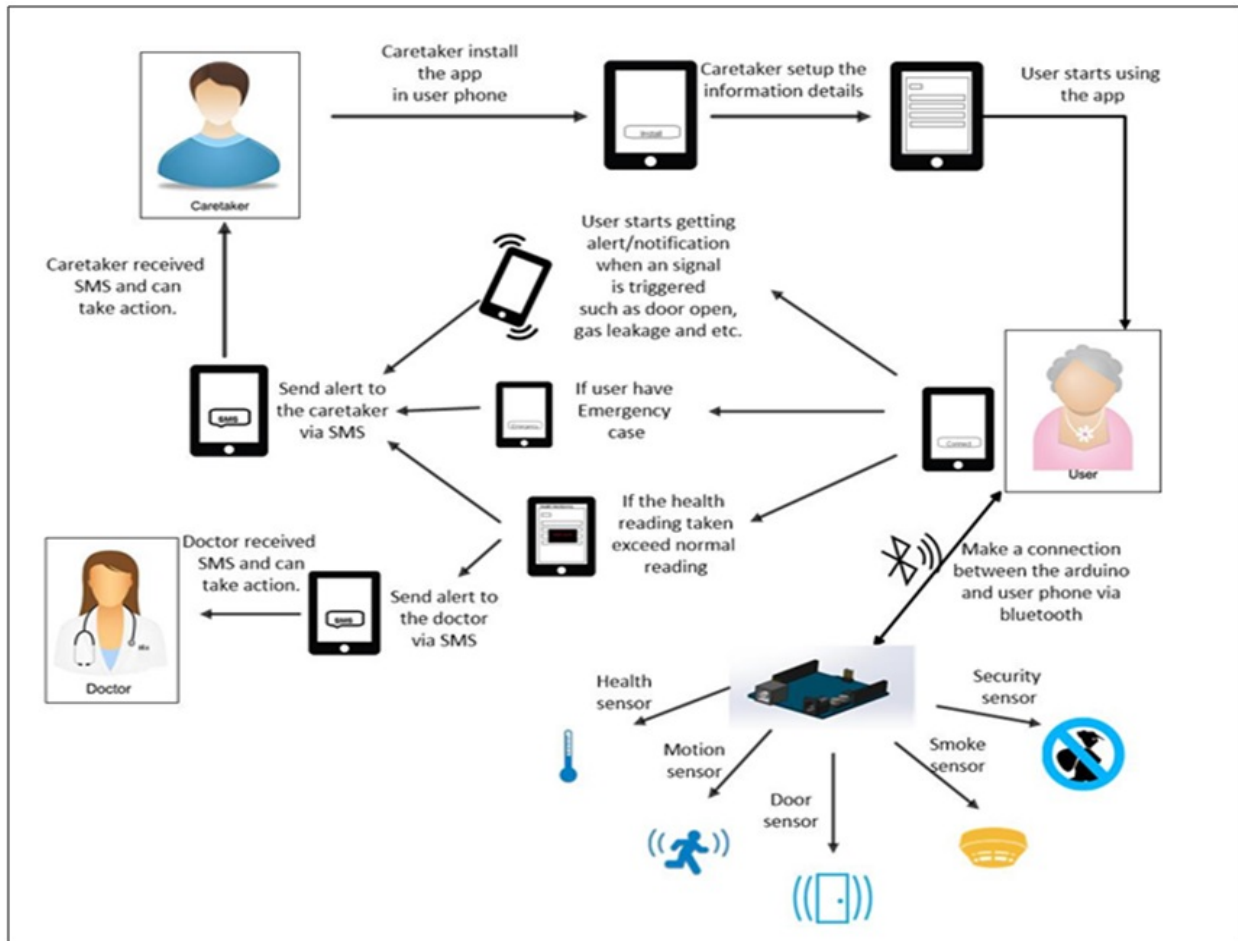


Figure-3. Flow of the HomeAlone application.

Health Monitoring Module

Health monitoring module is used to monitor the health condition of the elder people every day to make sure they are in a good condition otherwise action can be taken if their health is not good. For elderly's health, if the data taken using the sensor exceeds the normal reading, then an alert notification will be send to the caretaker and doctor via SMS so that they can start taking action. Figure-4 shows the flow of health monitoring module. This flowchart shows the flows of the health monitoring module which the user can record their data using sensors and save the data in the database. There are three types of health monitoring data usually taken which are pulse, body temperature and blood pressure. The user needs to connect to the smartphone with Bluetooth module in the Arduino Uno to receive the health reading from the sensor and save the data received. The health record also can be generated into the pdf format if the user wants to refer it to their doctor.

The lightweight reasoning engine is integrated to the mobile app to reason on raw sensor measurement for further processing that can turn into actionable intelligence [8].

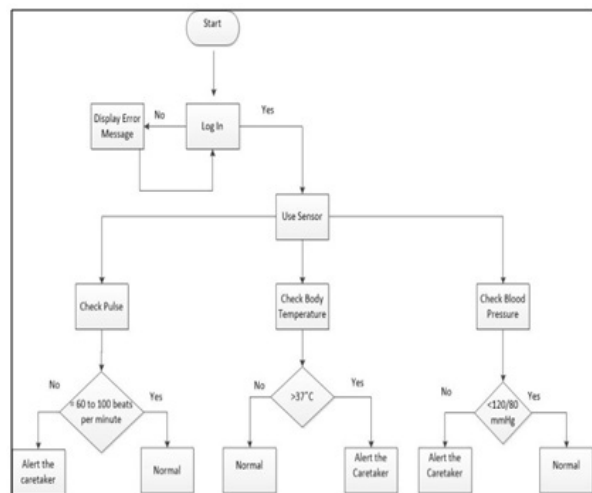


Figure-4. Flowchart for health monitoring module.

There are three conditions of the sensor measurements that can be recognized in the system which are normal, warning or critical. When the reading of their health data is bad, they will receive a warning notification and an alert



message will be sent to their caretaker via SMS. The status is determined by using the rule based reasoning. The algorithm used to determine the status of the elderly health is shown below.

Rule Based Reasoning

```

BEGIN (data measured of parameter 1)
CHECK parameter 1
IF (n data measure is in the range of the threshold)
THEN the system will return the status as normal
ELSE IF (data measure is in +/- n threshold value)
THEN the system will alert the elderly and ask
whether want to send alert to the caretaker
IF (elderly click on the yes button)
THEN the system will send alert notification to
the caretaker
ELSE the system will dismiss
ELSE the system will send alert notification to the
caretaker for further action.
END IF
END
  
```

The threshold usually varies for every people because the threshold value normally depends on some specific things such as their age, health condition, and etc. This range can be set up differently for each user.

Motion Detector Module

Motion detection is the process of detecting a change in motion in the surroundings relative to an object [9]. HomeAlone application use motion detector to detect the movement of the elder people who live alone in their house. This is to make sure that the elderly is still moving and to detect immediately if anything happens to them such as suddenly fainting or collapsed. The flowchart for the motion detector is shown in Figure-5.

Figure-5 shows the flows on how the PIR motion sensor detects the movement of the older people in the house. For example, when the elderly goes to the restroom, the motion sensor will start to save the time it detect a motion. Then within the given time, for instance in 30 minutes, if the elderly did not come out from the restroom, the elderly smart phone will vibrate. A voice notification will start to remind and then a dialog notification will be pop up asking about their condition. If the elderly did not respond within several minutes, the pop up window will dismiss and sending an alert to the caretaker and neighbour asking them to check on the elderly. However, if the elderly respond is okay, then the system will ignore and shall not send the alert notification.

Door Detector Module

Door detector is used to make sure the door in the elderly people house is always properly closed for their safety. If the door is not close then the application will give out notification in the elderly devices to remind them to close the door.

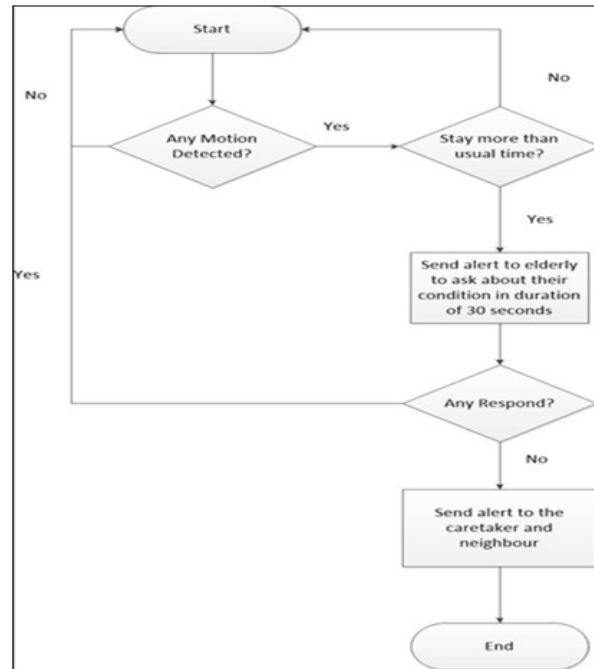


Figure-5. The flowchart for motion detector module.

The elderly smart phone will vibrate and a voice notification will start to remind the elderly to close the door. Door magnetic switch will be used for this module. The sensor is a reed switch encased in an ABS plastic shell. Only one of the sensors will be connected to the Arduino board, the other half just a magnet. When the magnet is less than 13mm (0.5") away, the reed switch is stated as closed [10].

Gas Detector Module

Most elderly tend to be very forgetful, for example they forgot to turnOff the cooking stove after cooking activities. Gas sensor can be used to detect any gas leakage in the elder people house. The gas sensor is triggered and gives alert to the elderly and the caretaker. The sensor used in this module is MQ-4 gas sensor. This sensor can detect if there is any gas presence in the elderly's house. This sensor has a high sensitivity and fast response time [11]. The elderly will get a warning if there is a gas leakage inside the house and will be asking whether they want to give emergency alert to their caretaker or not. This is because the gas sensor is too sensitive and it may detect any small gas emission and may not be so dangerous for the elderly.

Security Sensor Module

Security module is built to detect any motion outside of the elder people house. This module is to avoid if there is an intruder outside of the elderly's house and can take a safe action if such situation happens. This module uses PIR motion sensor like in the motion detector module. When the person moves around within a sensor range which is 7 meters, a signal will be triggered [12]. A



dialog message will be pop-up in the elderly smart phone to ask whether they want to make an emergency alert or not. The elderly can choose whether they want to make a call or just sending a message to their caretaker. All the motion detected by the sensor will be save in the database and the record can be generated as a report to be viewed by the caretaker.

SYSTEM DESIGN AND IMPLEMENTATION

Architecture Diagram of the proposed system

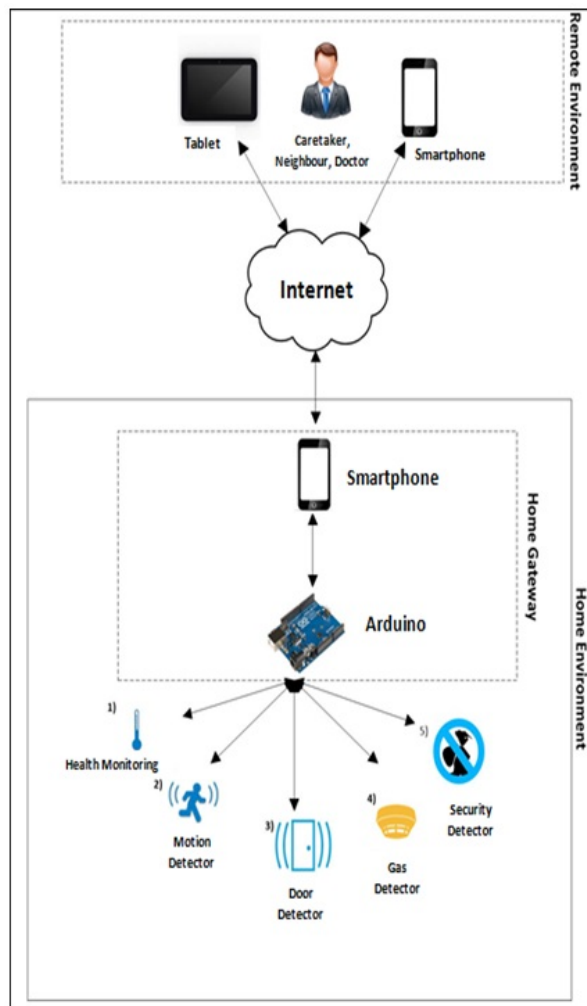


Figure-6. HomeAlone's architecture diagram.

Figure-6 shows the architecture diagram for HomeAlone application. From the figure above, we can see that HomeAlone consists of three layers which are remote environment, home environment and home gateway. Remote Environment represents only authorized users such as caretaker and neighbour that can access the system using their Smart phone application. Home environment consists of Home gateway and hardware interface

modules. The mobile phones will be used to manage, control and monitor system components.

The sensors will be connected directly to the Arduino board and the results taken by the sensors will be send to the mobile phone using Bluetooth connection. The report for health, motion and security data will be send to their caretaker via email. The modules for this project mainly comprises of health monitoring, motion detector, door detector, gas detector, and security sensor.

User Interface Design

HomeAlone user interface is on everything that the user can see and interact with. HomeAlone use several UI modules provided in android properties to build its user interfaces like the menus, dialogs and notifications. The user interfaces involved in the HomeAlone will be explained in detail throughout this chapter.

Figure-7(a) shows the main menu of the HomeAlone II application. Figure-7(b) shows the types of health that is monitored in HomeAlone II application. The user can enter the health monitoring page and choose type of health data they want to measure such as pulse, body temperature, and blood pressure. The user will measure the data using the sensor and save the data into the database for record.

When motion sensor detects a movement/motion of the elderly, the interface will change the status as shown in Figure- 8 below. Figure-8(a) shows the dialog message when the elderly remain too long in the toilet, the dialog message will pop up in the elderly device to ask about their condition. Figure-8 (b) shows the interface when the user click at the emergency button, then the application will show a pop-up window for confirmation. This is to make sure that the user has not clicked it unintentionally.

Health monitoring data and motion detection is recorded in the mobile database.. This data can be email to caretaker or the elderly who can bring this recorded data when they do the medical checkup with the doctor. Figure 9 shows an example of house security monitoring record. This data is recorded when some event is triggered. The database stores the information about the gas leakage, motion of the elderly and if there is any possible intruder detected. This data can be referred by the forensic team if something happen to the elderly. The report also can be sent to caretaker via email as shown on Figure-10. After the elderly clicks at the generate PDF button, the PDF report will be generated and automatically send the report to the caretaker.

The same goes on house monitoring report as shown in Figure-9. This report is for the caretaker to monitor his/her parent in the house when they are not around. This report also can be used as reference if something bad occurs to the elderly person. This record is for emergency cases whereby the elderly suddenly death, the forensic team can see this report. They can check the last movement detected and whether there was an alert message during that time. Other than that, when there is a gas leakage detected, it also can be the reason for the cause of death.



From this report, it may be useful that the rate of sudden death can be decreased.

Figure-10 shows the example of health report that will be sent to the caretaker. This report is generated after the elderly/caretaker click at the generate pdf button in the Health Monitoring page. This report can be brought when

the elderly want to see their doctor for check-up or for any health monitoring purposes. The doctor can also request the caretaker to send this report to her/him if they want to see the health condition of the elderly.

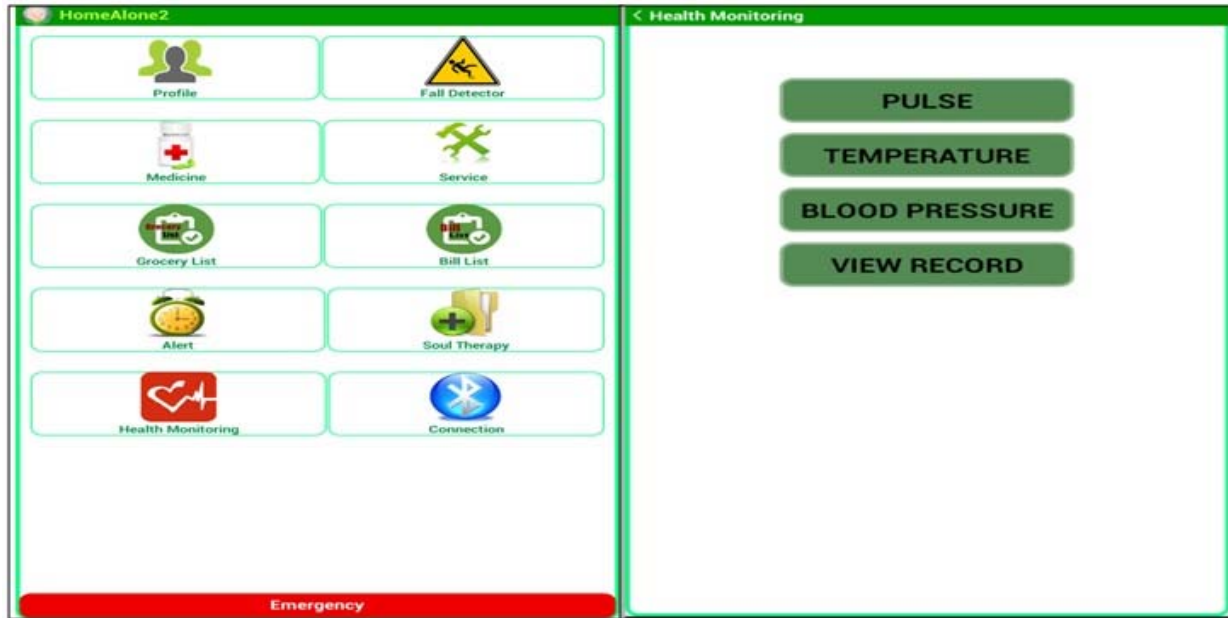


Figure-7. (a) Main menu (b) Health monitoring.

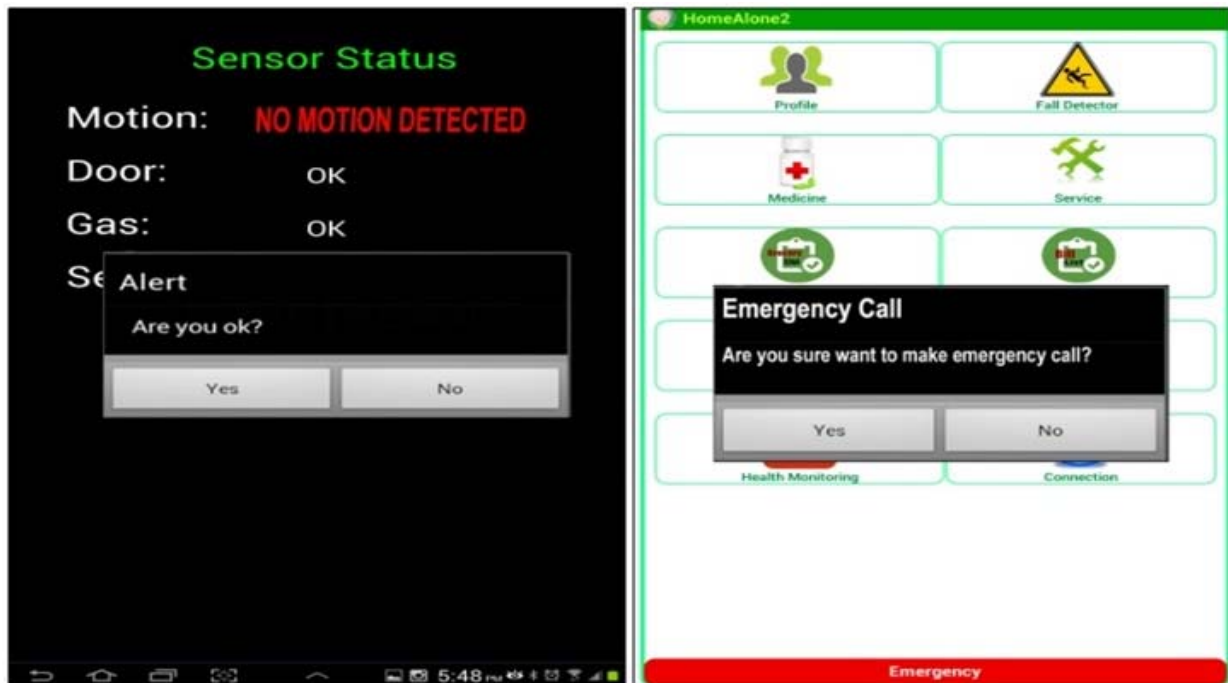


Figure-8. (a) Motion sensor is triggered (b) Notification alert.

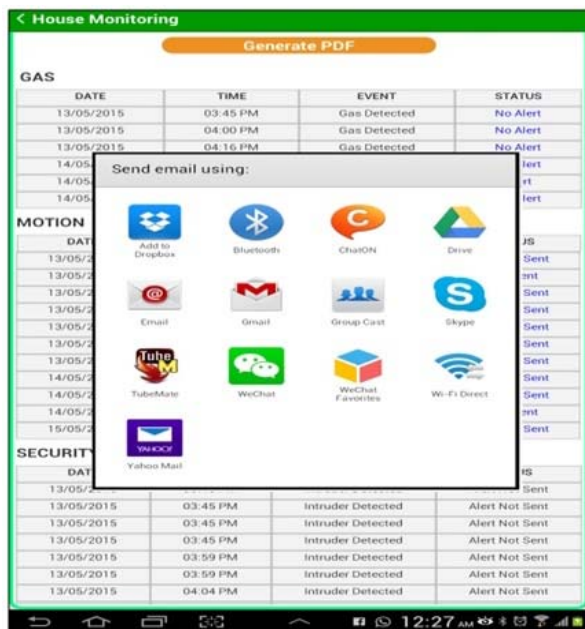


Figure-9. Screenshot of home security report.

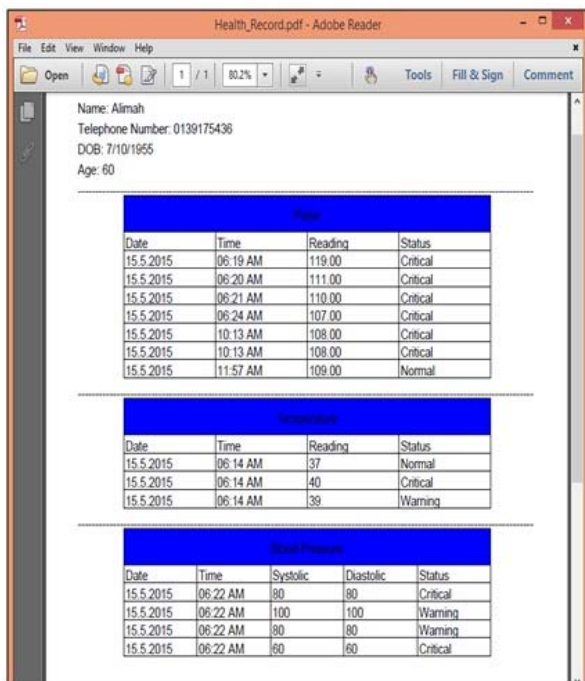


Figure-10. Health report.

DISCUSSIONS

One of the advantages of HomeAlone application is that it is an apps developed for elderly who live alone in the house using the mobile apps and sensor devices. HomeAlone application also record the important data such as the movement of the elder house in the house, gas leakage record or if there is any detection of potential

intruder outside the elder people house. It will record the time and date when the cases occur and whether there is an alert notification sent to the caretaker and neighbor. The data also can be stored and printed in the pdf format for future used. If at all something happens to the elderly like sudden death or collapse in the house. The evidence of the situation can be traced by referring to the data that have been captured. For example, in the case of sudden death, the last motion recorded can be referred to know exactly about their last movement detected and on the health record. This can be compared to each record to find out the cause and the time of death for the forensic purposes.

The main objectives of the HomeAlone application are the security and to monitor the health condition of the elder people. All the IoT functionalities are successfully integrated into an Android application on smartphones or tablets. This is the major contribution of this study since IoT can be deployed on any Android devices.

CONCLUSIONS AND FUTURE WORK

HomeAlone application had met the objectives and fulfills the requirement of the elderly. For example, the app allows the elderly to take their health reading and give alert notification if the reading of the data taken is abnormal. Other than that, the security of the elderly too can be more secure with the use of the sensors that can easily alert the elderly, caretaker and neighbour if something goes wrong like gas leakage or intruder detected happen. The elderly also can use the emergency button located at the main page if they experience any emergency and want to alert their caretaker.

HomeAlone application is designed with a user-friendly and simple interface to ensure that the elderly understand and easy for them to use the application. Other than that, by using the IoT technology sensors, its makes the movement of the elderly in the house to be more secured and can be easily monitored by their caretaker. Lastly, the app also can enhance and reduce the current problems facing by the elderly who live alone in the house.

In the future, HomeAlone can use variety of sensors meeting the requirements for the elderly. For example, in the current security detection module, it only use PIR motion sensor which can detect if there is a motion detected outside the house. In the future, maybe it can be improved with the use of camera which can detect the face of the possible intruder detected outside the house by integrating image processing technique. This can avoid false motion because the elderly can immediately see the face of that person detecting it as an intruder.

HomeAlone is a mobile app equipped with functions that may assist the elderly who live independently and reduce worrisome of caregiver. The app had been developed by integrating IoT technologies according to the needs and requirements of the elderly. With a good design and better functions of a smart phone, elderly people will have the opportunity to enjoy a better



life, live independently longer, happier and maintain healthy. In addition, this app will bring happiness and calming in the state of mind of the children as the caregiver.

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