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Intelligent home automated system

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ABSTRACT

Home automation system is one of the intelligent systems meant to create new opportunities for industry and business, as well as new experiences for users and consumers. This project is about designing, developing and testing a web-based intelligent home automation system called i-Home. Problems arises from the manually flick switches to control lighting and difficulty in monitoring houses, these activities can be automated. The main users will be residents in any residential area i.e. gated community, terrace housing area, condominium and others. Its function is to ease residents in controlling the lights, fans, air conditioning, the house temperature and monitoring their CCTVs through online. For the hardware component, Raspberry Pi used due to its lower in cost, has a credit card-sized single-board computer that includes a processor, GPU, RAM and MicroSD as the server. Raspberry Pi uses Linux-kernel-based operating system. It also requires PHP, JavaScript, Python and MySQL. The prototype of the system successfully built and performed well in most of the functions of home automation system. Usability and functional testing carried out and both results showed that all functions of the system performed as expected.

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1. INTRODUCTION

Due to the advancement of Internet and technology in current situation, automation and use of internet to control things such as cars, houses, have been the choice of living. In the United States, home automation known as Domotics [1] comprises of different technologies use by households to manage lighting, temperature, entertainment systems and many other house appliances.

Home automation systems are becoming popular with urban living people due to its ease of use where its functionality monitored through desktop, laptop, tablet or smartphone with the help of networking. Another advantage is that owners can protect belongings from theft and fires, promote security, comfort, energy efficiency and convenience. It also helps in reducing the total of cost, time, energy and materials that is used.

Home automation is part of an intelligent system. According to [2] "an intelligent system is a machine with an embedded, internet-connected computer that has the capacity to gather and analyze data and communicate with other systems". Security, connectivity, the ability to adapt to current data, to monitor and manage are essentials for a good intelligent system.

Intelligent systems are creating new opportunities for industry, business, people as consumers and new users. Research and development in this area growing concurrently with the technology especially the internet. Most automation systems, findings by authors [3-7] built to help human labor, time, save energy and to help user especially elder or handicapped persons. Automation of system is not actually about reducing

human labor but more on assisting human to expedite mundane tasks especially in the fast moving world.

Currently, in many housing areas such as apartments, condominiums, landed houses or others, are still using the conventional home system. This system is not an actual system but consists of several switches with connect to bulb or lights, fans, aircond and other basic lightings. In Malaysia, the conventional system is still widely used in rural and urban housing development. Only recently, the need of intelligent systems for housing employed by certain house developers for example Mah Sing Group [8] in Malaysia. These houses are custom design for specific customers. These types of intelligent house system targeted for urban settlement and high-income groups. As a developing country, home automation system in Malaysia are hot stuff and not easily available for low-income group of Malaysian. It is still a new technology application and still in growth mode.

Homeowners or residents are still manually flicking switches on the wall to control lights or fans. Problem arise when they forgot to switch off the lights and fan during the day and left the house for along time, causing wastage of electricity. Once they remember, they will have to go all the way home in order to switch it off. This is time and money consuming in terms of having to go through traffic and tolls.

Another problem is lacking of monitoring system for the CCTC (Closed-circuit Television) installed by homeowners. When they are away from home, they are not be able to look at the CCTV until they come home and replay the tape. While being away from home, they also cannot look at their house through CCTV if emergency happens. They felt worried and insecure of their belonging.

Based on these problems, came an idea of developing a prototype of home automation system called i-Home. This paper describes about the designing, developing and testing of i-Home, which is a system being created to ease residents in controlling the lights, fans and air-conditioning, and monitoring their closed-circuit television (CCTV) as well as the house temperature via online. Many different home automation systems are growing in the market, in this project, comparison of some existing home automation technologies discussed in order to choose which technology to use in the system. Comparison of other popular techniques in home automation, discussed highlighting advantage and drawbacks.

Three local home intelligent systems company selected and studied for this prototype project. The first system, SmartHome [9], a local company in Malaysia provides solution for smart building automation, networking and office automation, among others. Figure 1 is the current website developed by Flexedia Solutions Sdn Bhd, located in Petaling Jaya, Selangor. It has lighting control feature that allows user to control and monitor the light in their home such as switching on or off and controlling the brightness from one or more master control locations. It is fully intergrated with CCTV to raise deterrence and surveillance. The system also reports current temperature and humidity inside the house. However, the system does not have fan and air-condition controller.

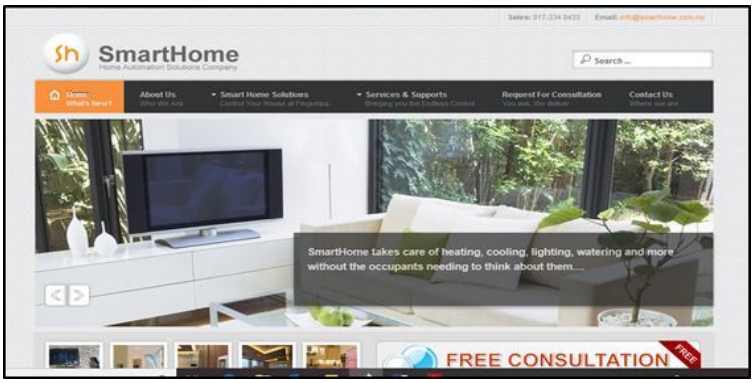


Figure 1. SmartHome : flexedia solution (M) [9]

Bluguard Home Automation system, second selected system, designed to give a smarter and convenience lifestyle by allowing user to control their home appliances such as lighting, air-conditioning and others no matter where they are.

The system, Figure 2, developed by Archton Research Development Sdn. Bhd., located in Puchong, Selangor. Bluguard Smart Home [10] help homeowners incorporate current technology into their homes with the goal of enhancing the quality of home life. The system has built-in standard relay for appliances such as lighting, and built-in standard IR Transmitter for air-conditioning automation. However, the system does not have CCTV and temperature monitoring.

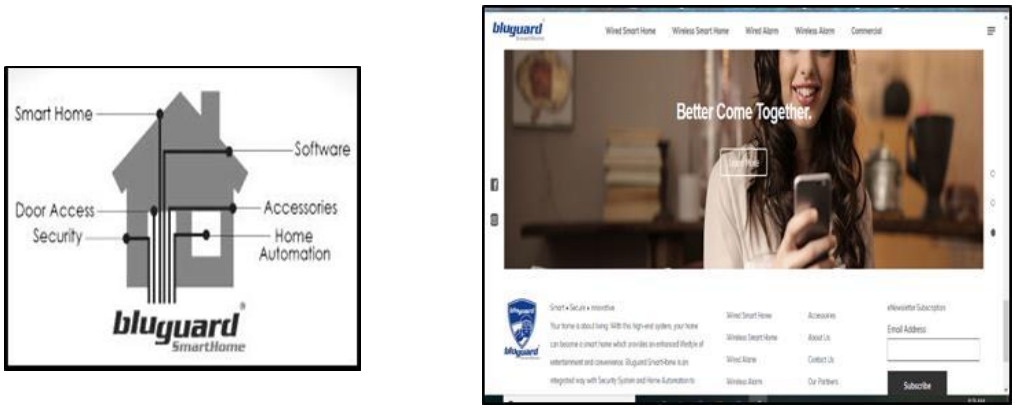


Figure 2. Bluguard smart house system [10]

Millennium II+ the last selected system for review, developed by Emanz Technologies (M) Sdn Bhd., also located in Petaling Jaya, Selangor. The system as shown in Figure 3, offers smart home system [11] via home automation in which owner can remotely monitor and control the lighting, air-condition and temperature regulation. The feature is not only an added advantage for security purpose but also for energy saving. User can also control mood of lighting in the integrated system. However, the system does not have CCTV monitoring feature that can increase the security aspect.

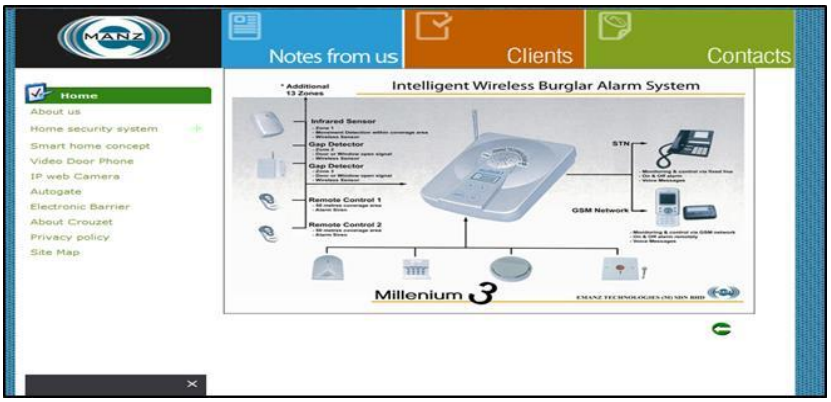


Figure 3. Millennium : emanz technologies website [11]

Previous researches showed rapid development in automation intelligent system with many developments in prototypes. Countries such as France has good technologies that is the basis of system used in Malaysia.

Many prototype systems with different designs and approaches were developed since the first home automation [12] in 1998. A researcher [13] built a prototype system, which used GSM (Global System Messaging) for android phone users. Author also described that the android platform as powerful tool with open architecture, with many resources and built-in sensors. It does not require programming but make use of the visual design interface. Another author [14] focusing on building of energy efficient home automation system, achieved by using IR sensor and requires C language program. An interesting issue on risk analysis brought up by authors [15], where finding leads to important of including the security and privacy model in the design phase of the system. In other findings [16, 17] most authors built the system with the objective of helping old aged and handicapped people. Authors found that smart home [18] technologies have their advantages and drawbacks based on surveys done in the UK. They reported that respondents positively like the use of this system and their concern are more on autonomy of use and independence of the system.

Author [19] built prototype system, which used intelligent power outlet consists of a ZigBee 2.4GHz interface microcontroller, Radio Frequency Identification reader, a relay and current sensor. The outlet designed to observe low-current loads and governed wirelessly. It features the remote control of the outlet, managing real-time current usage and preventive measures of electrical fires or mishaps.

Latest research findings in this area reported huge development in this application [20, 21] with combination of Internet of Things (IoT) [22-24], (Manuel Suarez-Abela, 2016), which used smartphones making it user-friendly and monitoring done from anywhere, use of voices, Bluetooth technology and many more.

The paper organized as follows: In Section 2, research method used for the prototype development. Section 3, result and analysis for this project presented. Finally, for Section 4 conclusion and the future work.

2. RESEARCH METHOD

There are a few types of home automation system available, which depends on the technologies, [25, 26] used. Another type of automation system is using GSM modem and used of AT command as its mean of communication [26, 27]. Figure 4, shows six types of automation system available currently. Wi-Fi based Home Automation System uses Wi-Fi Technology, Android & Wi-Fi uses direct Wi-Fi that is similar to WLAN 802.11 standard. Zigbee Protocol uses Zigbee wireless technology developed by Zigbee alliance, Cloud Based [28] requires cloud-based knowledge server to store data on HDFS (Hadoop Distributed File System), Raspberry Pi based system [29, 30] which used a credit card sized single microcontroller with Python as the main programming language and Bluetooth Bases [31, 32] system that uses Bluetooth devices.

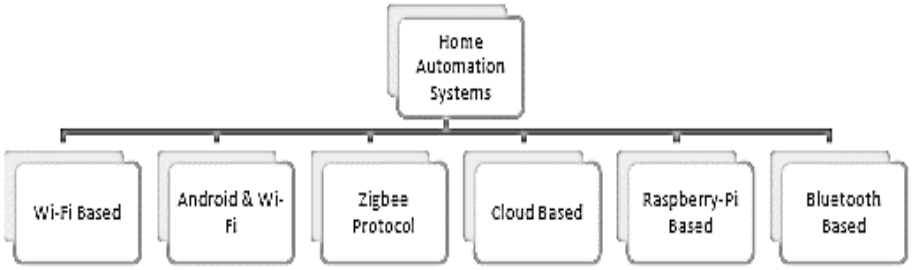


Figure 4. Types of home automation systems [25]

Authors [33-35] reported that a low cost system developed using Arduino UNO and Wi-fi but only available for Android-based phones. Authors [36, 37] used BitVoicer with Zigbee protocol. BitVoicer a software by BitSophia Inc with speech recognition application. Another application based system by author [38] make used of Arduino Mega 2560 microcontroller and IP address with web monitoring system. An author focused on [39] using sensor [40] framework with popular base kit with common purpose for the system

More than one method used in information collecting for the success of this project. The methods include searching related literatures, pre-experiences, project focus group, websites and books. Waterfall Model selected for the development of the system. “It is sequential design process, used in software development processes, in which progress is seen as flowing steadily downwards (like a waterfall) through the phases of conception, initiation, analysis, design, construction, testing, production/implementation and maintenance.” [41]. In this model, focus is more on the development of the prototype system. Reasons behind the chosen method are:

a) The model is simple and easy to understand and use. Manageable due to the rigidity of the model where each phase has specific deliverables and a review process.
b) Phases are processed and completed one at a time, which work, well for small projects where the requirements are understood.
c) It also clearly defined each stages and has a well understood milestones
d) Manual tasks are easy to managee using this model.

2.1. Project Scope

a) The scopes of this project are:
b) To design and develop i-Home system to monitor and control home lighting, fan and air-condition, and monitor CCTV and room temperature
c) To develop i-Home web-based system working prototype
d) To conduct testing of the system to ensure that it can monitor and control home lighting, fan and air-condition, CCTV and room temperature

2.2. Component System

Intelligent home automation system comprises of the following:

a) Sensors for measuring or detecting for example temperature, humidity, daylight or motion.
b) Controllers such as PC or a dedicated home automation controller.
c) Actuators for example motorized valves, light switches and motors.
d) Buses for communication: wired or wireless.
e) Interfaces for human-machine and / or machine-to-machine interaction

Hardware used for the prototype system is Raspberry Pi, low cost single-board computer developed in the UK by the Raspberry Pi Foundation with the intention of promoting the teaching of basic computer programming in school. It used to control other hardware. Web camera for CCTV, relay, GPIO Wire connector, Multiple USB hub, TM25 Chip as the temperature sensor, fan as air-conditioner unit and resistor. Software components include motion for running the camera, Notepad++ for coding, WinSCP, Putty for terminal command line, Apache 2 with PHP5 for server, Postfix for Mail server and MySQL as database. Programming language used for this development is PHP (Hypertext PreProcessor) using HTML, MySQL for the database, Apache for PHP and Postfix as mail servers.

2.3. Prototype Development

Figure 5 showed how the development of the prototype done during the process of developing the system. Technical feasibility study carried out in Phase 1, which include identifying software and hardware requirement for the prototype development.

Tools for requirement gathering used are interview and questionnaires. The prototype system architecture and login page shown in Figure 6.

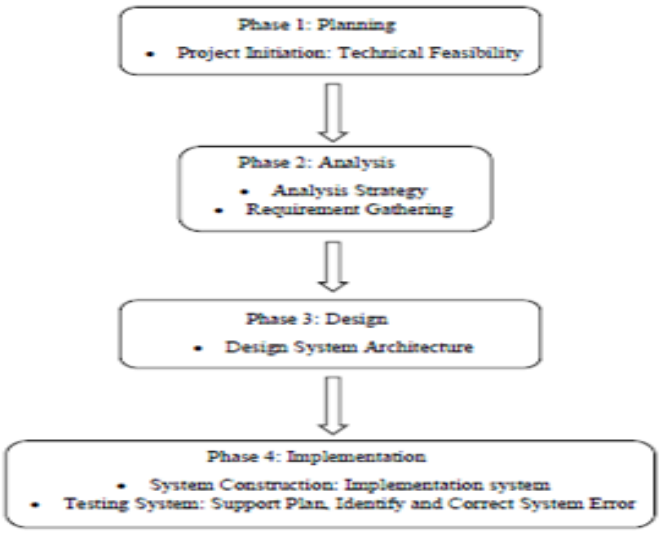


Figure 5. i-Home Prototype development

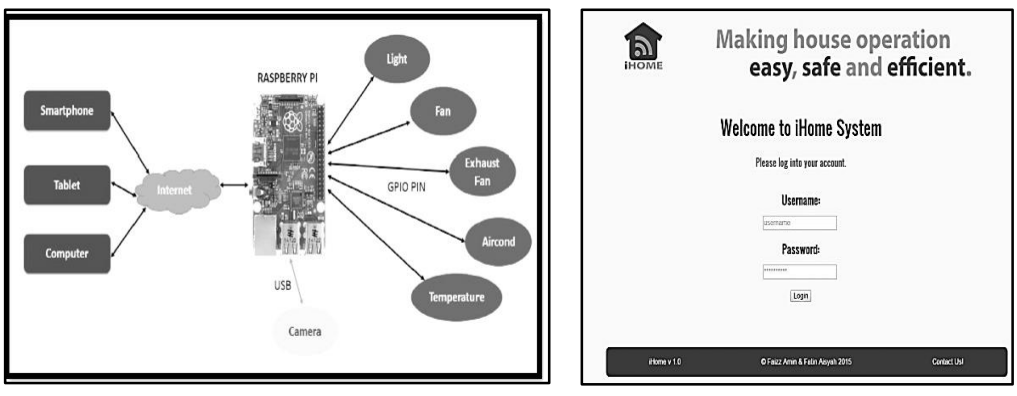


Figure 6. i-Home architecture and login page

Figure 7 until Figure 9 showed the graphic user interface of the prototype web-based system.

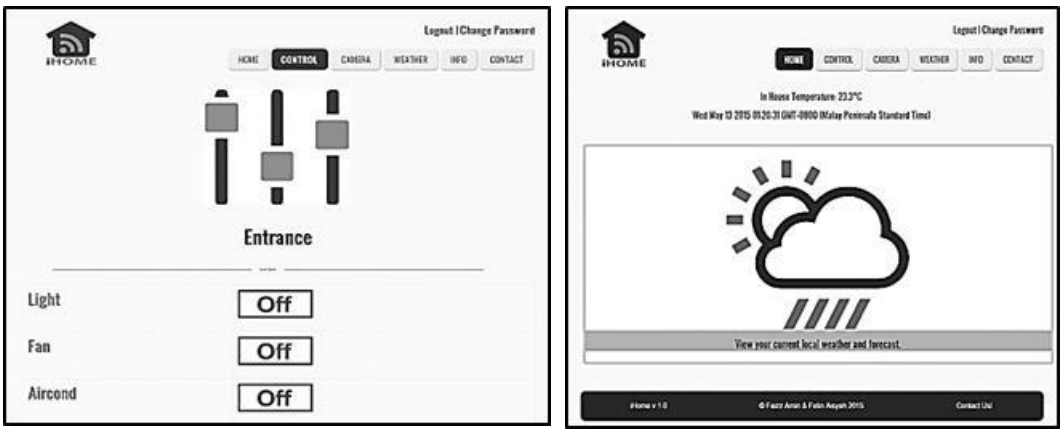
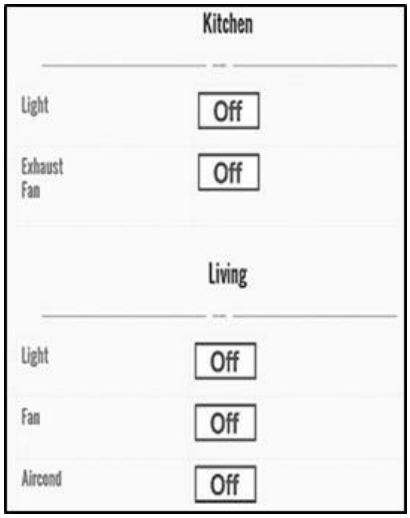


Figure 7. Switches and announcement pages



Test Case	TC01	Test Case Name	Log in
System	i-Home	Subsystem	User
Designed by	Fatin Aisyah Yasmin	Design Date	30th March 2015
Executed by	Muhammad Faizz Amin	Execution Date	13th April 2015
TC01			
Test Data	Title : User Log into the system Input Button Value : Log In		
Pre - Condition	User must be registered into the system		

Step	Action	Expected System Response	Pass / Fail
1.	User must fill in the username and password form and logs in to the system using the 'Log In' button.	User will be successfully logged in to the system if username and password is correct and 'Home' page is displayed afterwards. Error message will be displayed if username or password is incorrect.	PASS

Post - Condition	User successfully login and will be directed to the homepage.

Figure 8. Switches page and ample of test

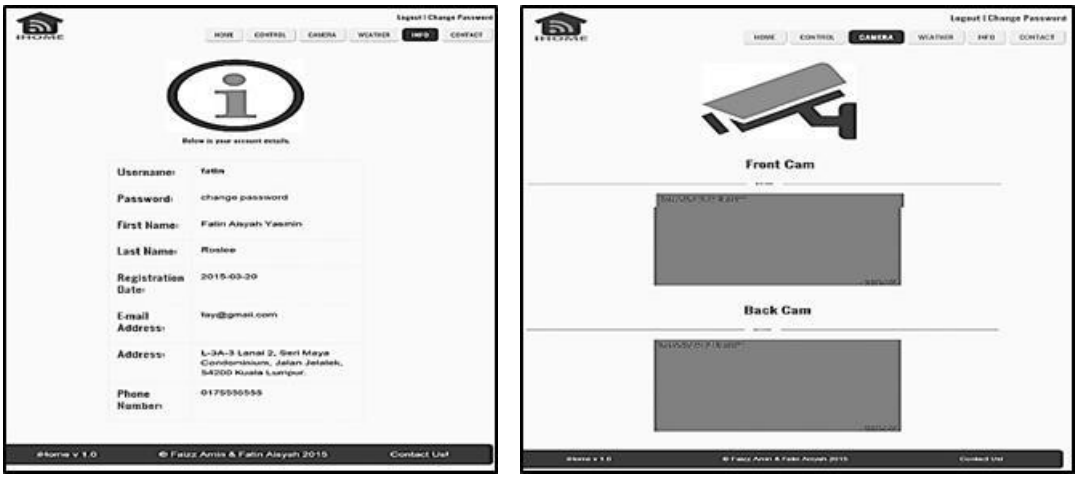


Figure 9. Information and CCTV pages

3. RESULTS AND ANALYSIS

To test the system usability scale, a survey of questionnaire was conducted. Selected users were asked to use the system and provide feedback.

Another method used is test case documentation. In this test, a set of conditions under which a tester will determine whether an application, software system or one of its features is working as it was supposed to [42].

A test case is usually a single step, or occasionally a sequence of steps, to test the correct functionality of the system. Additional information that may be included are test case ID, description, order of execution number, related requirements, depth, category, pass or fail and remarks. Under special circumstances, there could be a need to run the test, produce results, and then a team of experts would evaluate if the results can be considered as a pass-chapters.

Figure 10 showed the sample of questions asked to selected users. In this case, respondents are staff and student of UniKL MIIT. Figure 11 is the finished prototype system with house model. The system function with the desired features and work perfectly.

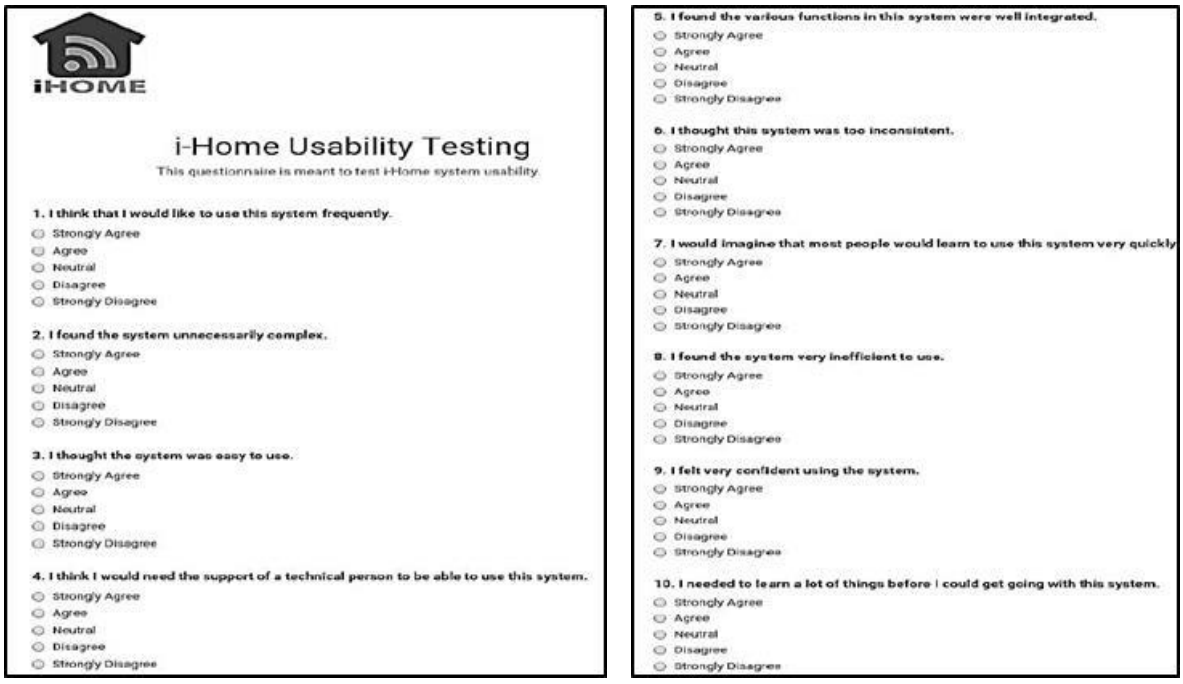


Figure 10. Testing questionnaires

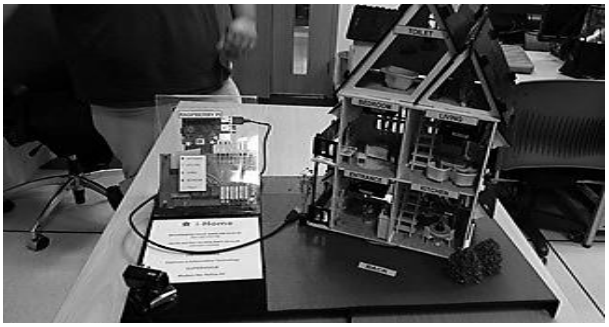


Figure 11. Prototype system with house model

3.1. Existing System Comparison

In comparison, Table 1, showed the comparison among the three systems with the proposed prototype system, i-Home. i-Home system incorporated the features as stated in the table.

Table 1 Comparison between i-Home and Three Systems

System Features	SmartHome	Millennium II+	Bluguard Home Automation	i-Home
Online Monitoring	√	√	√	√
Integrated	√	√	√	√
Light Control	√	√	√	√
Fan Control		√		√
Air-condition Control		√	√	√
CCTV Monitoring	√			√
Temperature Monitoring	√	√		√

3.2. Questionnaire

The result, Figure 12, presented that most respondents 90% strongly agree most people will learn the system quickly and felt confident on the system. 75% agreed that they will use the sytem frequently and 77% also agreed that the system is easy to use. 88% disagree that the system is unefficient to use. They also disagree that they need to learn many things before they can get the system going, with 50% finding.

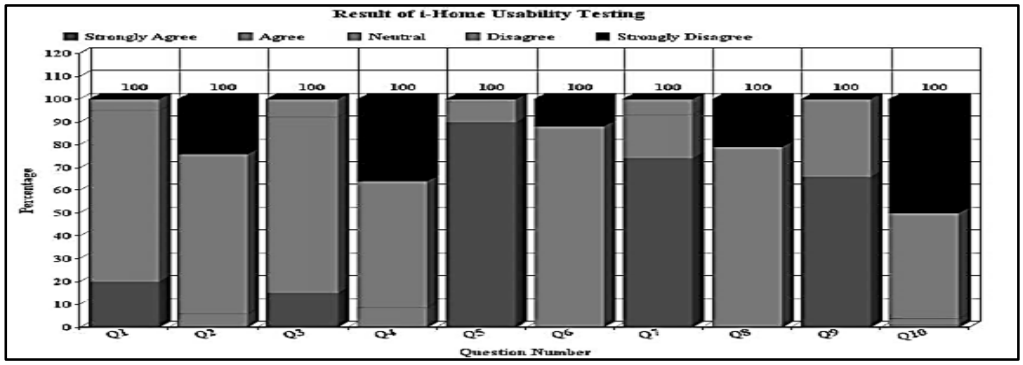


Figure 12. Questionnaire chart

4. CONCLUSION

This prototype features function as expected, where all functions of the prototype worked well for users to monitor and control lights, fans, and air conditioning, and monitor CCTV as well as temperature. All in all, this project gives students the opportunity to experience what may be expected from them once they join the industry. In Malaysia, intelligent home automation system has a bright future and making its way progressively to capture the house buyers and housing market interests. The prototype run and work as expected and won a GOLD medal award in 2015 for URCE Final Year Project Competition, organized by UniKL MICET, Melaka.

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