International Journal of Scientific and Management Research
Volume 06 Issue 11 (November) 2023
ISSN: 2581-6888
Page: 29-41

Computer Laboratory Automation at a HEI in the Philippines

Erika G. Llabres[1], & Esli Joy N. Fernando[2]
[1]College of Engineering and Architecture, University of La Salette Inc, **Philippines**
[2]College of Engineering and Architecture, University of La Salette Inc, **Philippines**
DOI - http://doi.org/10.37502/IJSMR.2023.61102

Abstract

The study was conducted to design a device which can control appliances through smartphones, the system consisting of a microcontroller and Bluetooth module, the command is received by the Bluetooth which is connected to the microcontroller. The microcontroller receives the command and enables the appliances to turn it on/off.

Descriptive method was used in this study to achieve this design project. Arduino and Bluetooth module were used to address the problem encountered in terms of operation and functionality.

Keywords: App Inventor, Bluetooth, Arduino, Android Application, Automation

1. Introduction

In our modern era, automation has been at its most technological advancements from the manual to electronic automation. It is a big help to discover Wireless technologies that are becoming more popular around the world and the consumers appreciate this wireless lifestyle which gives them relief that tends to grow under their desk. Now with the embedded Bluetooth technology, digital devices form a network in which the appliances and devices can communicate with each other.

In this study, the researchers hope to automate the Computer Engineering Laboratory in the University of La Salette, Inc. The automation system consists of an Arduino microcontroller. The controller can control different appliances in the laboratory automatically in response to the signals coming from the related sensor which is a Bluetooth module.

The aim of this study is to design a device which can control appliances through smart phones. An android application is developed in the smart phone which enables us to control device through Bluetooth. A circuit has been designed where the microcontroller is connected to the relay and Bluetooth device. Once the user switches on/off the appliance through the application developed in the smart phone, the command is received by Bluetooth which is connected to the microcontroller. The microcontroller receives the command and enables the relay which is connected to the appliance to turn it on/off.

2. Background of the Study

After only about a decade, smartphone technology is so successful that people are having trouble imagining a day without them. Besides making phone calls, nearly all smartphones today natively provide directions through GPS, take pictures, play music, and keep track of

appointments and contacts. Through installation of apps, the list of possible smartphone users multiplied by tens of thousands grows longer every day.

All major smartphones in circulation today are equipped with a Bluetooth connection, and this enables the devices to sync up with multiple other devices in the vicinity and exchange data. The technology is also very popular in tablets, laptops, netbooks, headsets for mobile phones, printers, video games consoles, DVD players and TV remotes. There are several other areas where it is implemented as well and it is only a matter of time before technology really encapsulates our daily lives.

In the existing system, the researchers observe that the devices are controlled by manual operation. A person will go near the appliance to switch ON/OFF the device. And also, some professors at the College of Engineering and Architecture that usually uses the laboratory didn't notice open computers upon leaving the room. This might cause some accidents like breakage of the computers and high consumption of electricity.

3. Conceptual Framework

The conceptual framework that was used in the study is the Input-Process-Output Model. A process is seen as a collection of boxes (Processing Elements) linked by inputs and outputs in the IPO model. Based on a set of rules or decision points, information, or material items flow through a succession of tasks or activities. What goes in is the input; the process is what produces the change; and what comes out is the result (Armstrong, 2001).

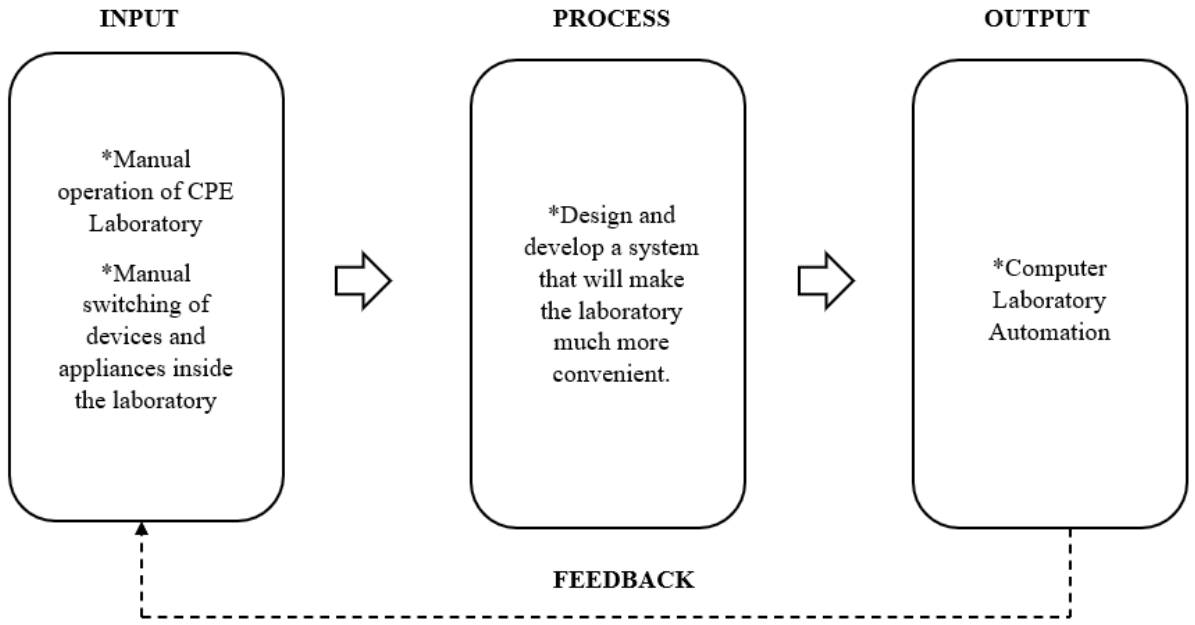

Fig.1: Conceptual Framework

This study is based on the Input-Process-Output. The input includes the manual operation of Computer Engineering Laboratory and manual switching of devices and appliances inside the laboratory. This includes a well-organized procedure for installing the system that is needed for the system to work properly.

The process includes designing and developing a system that will make the laboratory much more convenient.

The output provides the system's outcomes, which show whether the objectives were met.

4. Related Literature

Nadarajah Sriskanthan (2001) entitled "Bluetooth based home automation system" A wireless home network that does not incur additional costs of wiring would be desirable. Bluetooth technology, which emerged in the late 1990s, is an ideal solution for this purpose. This research describes an application of Bluetooth technology in home automation and networking environments. It proposes a network, which contains a remote, mobile host controller and several client modules (home appliances). The client modules communicate with the host controller through Bluetooth devices.

R. Piyare, M. Tazil (2011) entitled "Bluetooth based home automation system using cell phone" This research presents the design and implementation of a low cost but yet flexible and secure cell phone-based home automation system. The design is based on a stand-alone Arduino BT board and the home appliances are connected to the input/ output ports of this board via relays. The communication between the cell phone and the Arduino BT board is wireless. This system is designed to be low cost and scalable, allowing a variety of devices to be controlled with minimum changes to its core. Password protection is being used to only allow authorized users from accessing the appliances at home.

Muhammad Asadullah, Khalil Ullah (2017) entitled "Smart home automation system using Bluetooth technology". In this research a low cost and user-friendly remote-controlled home automation system is presented using Arduino board, Bluetooth module, smartphone, ultrasonic sensor, and moisture sensor. A smartphone application is used in the suggested system which allows the users to control up to 18 devices including home appliances and sensors using Bluetooth technology. Nowadays, most conventional home automation systems are designed for special purposes while the proposed system is a general-purpose home automation system. Which can easily be implemented in existing homes. The suggested system has more features than conventional home automation systems such as an ultrasonic sensor is used for water level detection and soil moisture sensor is use for automatic plant irrigation system.

M. Van Der Werff, X. Gui, W.L. Xu entitled (2005) "A mobile-based home automation system" The home appliances are controlled by the home server, which operates according to the user commands received from the mobile phone via the cellular modem. In our proposed system the home server is built upon an SMS/GPRS (short message service/general packet radio service) mobile cell module and a microcontroller, allowing a user to control and monitor any variables related to the home by using any Java capable cell phone. This paper presents the design and implementation of AT modem driver, text-based command processing software, and power failure resilient output for a microcontroller to facilitate in sending and receiving data via the cell module, together with the design of Java application to enable the cell phone to send commands and receive alerts through the cell module.

Shiu Kumar (2014) entitled "Ubiquitous Smart Home System Using" This research presents a flexible standalone, low-cost smart home system, which is based on the Android app communicating with the micro-web server providing more than the switching functionalities. The Arduino Ethernet is used to eliminate the use of a personal computer (PC) keeping the cost of the overall system to a minimum while voice activation is incorporated for switching

functionalities. Devices such as light switches, power plugs, temperature sensors, humidity sensors, current sensors, intrusion detection sensors, smoke/gas sensors and sirens have been integrated in the system to demonstrate the feasibility and effectiveness of the proposed smart home system. The smart home app is tested, and it is able successfully perform the smart home operations such as switching functionalities, automatic environmental control and intrusion detection, in the latter case where an email is generated and the siren goes on.

Kennedy Bigua (2015) entitled "IoT based Simple Home Automation using Raspberry Pi" There has been an upsurge recently in the industry of smart electronic devices that has considerably eased their interfacing with each other. Controlling each of these devices requires a central control unit; typically, a computer system which was difficult and costly until a few years ago. Now, with the advent of the low cost, easy to deploy and maintain Microcomputers like Raspberry Pi, it has become super easy even for a school student to control high voltage devices without any huge risks involved in the wiring and programming. The system work focuses on the idea of creating and deploying a simple home automation system with minimum cost and simple programming.

The prototype has different components – a Bluetooth chipset, GSM module, toggle switch for rechargeable/non-rechargeable battery, LED indicator, relay, microcontroller, sound alarm, motor, and door lock. The Bluetooth chipset serves as the transceiver, and receiver of the Bluetooth signal between the mobile phone and the device that is responsible for the automation part of the device. The microcontroller processes the resulting inputs and commands gathered from the Bluetooth chipset and triggers the lock to be locked or unlock. The microcontroller also controls the GSM module on sending SMS message upon intruder detection. The toggle switch sets the operation of the battery for rechargeable and non-rechargeable. The LED indicator indicates the power status of the system. The relay switches the door lock to lock and unlocks status by means of digital signal.

Hussaini et al., (2014), designed of a GSM-based biometric access control system. The Fingerprint Scanner automatically scans a finger placed on it and compares it against its template. If a match exists, "Access Granted" is displayed on the LCD and the door is opened, otherwise, "access denied" is displayed. The GSM module is used in the acknowledgement mode to send an Access Request SMS to the Admin Phone (stating the user's unique 3-digit number), waits for the admin to acknowledge the request. IF the admin acknowledges the request, the microcontroller opens the door and displays "access granted". If due to network errors or the admin refuses to reply for some time (30 seconds), the system automatically takes it as an access denied. Generally biometric systems cannot be hacked easily but the system lacks an automated facility in the acknowledgement mode. This system can be enhanced by adding automated security facilities which acknowledge the user instead of admin personnel.

Gyanendra (2010), designs a digital door lock security system using the RFID technology. After receiving the tag information, the reader sends this information to the database for confirmation. If it holds, the information is stored for further operation. The central server queries the database and retrieves corresponding information after receiving the query from the reader. The reader computes timestamp (date, time) after receiving the reply from server and creates a log. Once the tag information is verified, the system generates a control signal through parallel port which controls the opening/ closing of door by means of stepper motor. Creating a log which contains information of the user is another vital security feature to the system, but

it lacks notification and alarming facilities. The system can be improved by adding security feature(s) such as GSM module and buzzer.

The Bluetooth communication link was between two laptops with Bluetooth stack resident on the laptop connected with the Ericsson ROK 101007 Bluetooth module via the Universal Serial Bus (USB). The motion detector was connected to one of the laptops via the serial link (serial cable between the motion detector and the laptop) and the status of the system, connection and detection was monitored directly on computer screen.

This project had more focus on PIR sensor where the distance of detection is configured and monitored in real time. In spite of having Bluetooth technology, the system's drawback is that it is not portable since it uses two laptops. SOREX Wireless Solution GmbH had commercialized their Bluetooth based alarm security system. Their product was very similar to the project being developed but different in approach.

SOREX uses Bluetooth as a key where mobile phone Bluetooth is used to open auto gate and magnetic locked doors. Taking SOREX Wireless Key Basic for example, it uses mobile phone Bluetooth's as access key and registered device can be up to ten phones.

As the user approaches a door, the mobile communicates automatically with the SOREX module. It is up to the user if the door shall open automatically when they approach or push a button as an alternative. The product seems to be more passive since it is a physical key replacement. There also will be an issue on locking function during the electricity blackout. Richard Hoptroff developed an access control system in which each user has a separate password, and a log is kept of time and person accordingly. No custom transmitter is needed but any suitable mobile phone or handhelds would do. Relay is used to provide an isolated switch for opening the electric lock. Relay and electric lock usually require high voltage to operate which make the system require supply from main or socket outlet. During electrical blackouts, the system becomes easily vulnerable, and a user will be trapped until the supply is restored.

Reza Malekian (2015) entitled "Smart Home Automation Security" This paper presents a comprehensive description about different home automation systems and technologies from a security standpoint. The work highlights various security flaws in meaning of the word "intruder" have evolved over time. They examine the challenges in home automation security from the point of view of both the homeowner and security engineer. The work goes on to explain why home automation systems are such attractive targets for an attacker. They point out the role of the user interfaces in security. Various home automation technologies considered in our work include context-aware home automation systems, central controller-based home automation systems, Bluetooth-based home automation systems, Global System for Mobile communications or mobile-based home automation systems, short messaging Service-based home Multi Frequency-Based home automation systems, and Internet-based Home automation systems. The work concludes by explaining future directions home automaton Security research could take.

Eric Paul N. Lucena (2015) entitled "Security on doors and windows with alarming system using GSM" This study aimed to develop a system that can provide security on home through the integration of different security devices. The study sought to determine the following: (a) the features of the security system, (b) efficiency of the security devices used in the system in

terms of its inputs, namely, biometrics fingerprint scanner, human motion sensor and keypad, as well as to determine the response of its output, namely, GSM, intrusion alarm, and LCD. A two-phase method was employed in this study to assess the reliability of the developed system, namely, the experimental development and descriptive method. The implemented system was evaluated, and the system features enumerated were found to be effective. Biometric fingerprint scanner read the fingerprint accurately. Human motion sensor was able to detect human presence. Keypad could activate and deactivate the security system and worked accurately in terms of password recognition. GSM was able to send a text message to the homeowner. Intrusion alarm gave a warning when the sensor detects human presence. LCD displayed the status of the system. Through the integration of various security devices better security assurance can be achieved.

Alexander C. Abad, Jose B. Lazaro, Elmer P. Dadios (2014) entitled "Security System for Remote Farm" The research is all about detection process through Open- Source Computer Vision programming wherein multiple object detection can be applied. Future recommendations for image processing and recognition can be used through Matlab programming technology and Artifical Intelligence Network Technology.

Several different methods have been planned for the combination of the project. Many of them are based on different approaches used in primary research. Some of the methods are useful regarding the project. A lot of them are still in the developmental stage and there are few examples of their application. The researcher would want to adapt some of the study which can help in creating the system. The Related Literature and Studies provide the researchers with ideas and information to improve the study.

5. Data Gathering Procedure

The researcher identified the appropriate data gathering procedure in conducting the research to wit:

1. The researcher gathers information through books, internet and studies conducted by other individuals and researchers.
2. A letter was presented seeking for approval to conduct the proposed project.
3. Evaluation/survey forms were made via Google Form and floated online to the respondents after the demonstration. The collected data as well, were treated statistically to answer the specific questions posted and presented in the chapter.

6. Statistical Treatment of Data

To ensure that the data which were gathered would yield to simplified but valid numerical information, categorical and quantitative data, the following statistical treatment was utilized for each of the questions that the study sought to answer.

The researcher uses a standard questionnaire to assess the performance of the system. The questionnaire will be distributed to the respondents. The evaluation instrument is based on the characteristics and sub-characteristics provided by ISO/IEC 9126.

ISO 9126 is one of the evaluation standards that has been acknowledged internationally in evaluating software from the software engineering perspective. ISO/IEC 9126 suggests only five software metrics such as Excellent, Very Good, Good, Fair, and Poor.

Table 1: Numerical Scale

Respondents	Frequency
4.51 to 5.00	Excellent
3.51 to 4.50	Very Good
2.51 to 3.5	Good
1.51 to 2.5	Fair
1.00 to 1.50	Poor

Weighted mean method was used in computing and interpreting the result. The formula of computing and interpreting of data is as follows:

Rating = (E*5) +(VG*4)+(G*3)+(F*2)+(P*1) / Respondent

Where:

E = the total number of respondents who answered Excellent
VG = the total number of respondents who answered Very Good
G = the total number of respondents who answered Good
F = the total number of respondents who answered Fair
P = the total number of respondents who answered Poor
7. Software Development Methodology

7.1 Development Approach

Systems design is the process or art of defining the architecture, components, modules, interfaces, and data for a system to satisfy specified requirements. One could see it as the application of systems theory to product development.

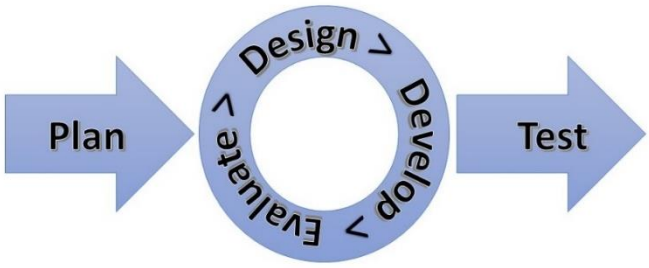

Fig. 2: Illustration of RAD Model

Researchers used RAD since it is an incremental software development process model that emphasizes an extremely short development cycle. The RAD model can be adapted to a system which rapid development is achieved by using component-based construction.

Plan. The researchers discussed and brainstormed ideas which help them to plan and design the system.

Design. After planning, researchers come up designing the structures and framework of the system which will solve the identified problems.

Develop. After designing, researchers constructed the framework (hardware and software) and applied the design that is being made for the system.

Evaluate. Researchers evaluated in the process for it will be the basis of the improvement of the system.

Test. The final procedure for the system process. Researchers generated the system to the devices to know how it will be effective to the specified users.

7.2 Software Development Tools

The data being described below are information of the hardware, software and program specifications needed for the development of the system. The list of specifications is those being used by the proponent personally in developing the different modules of the system.

1. Windows 7 Professional OS or higher
2. Arduino Software IDE
3. MIT App Inventor

7.3 Programming Environment

Fig. 3: Illustration of Blocks Programming

Blocks Programming. Block-based coding or block based-programming is coding within a programming language where instructions are mainly represented as blocks. It has a pallet of commands to choose from, making memorizing commands unneeded, and therefore easy for beginners to start coding.

The Arduino Integrated Development Environment - or Arduino Software (IDE). contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino and Genuino hardware to upload programs and communicate with them. The Arduino IDE employs the program avrdude to convert the executable code into the Arduino board by a loader program in the board's firmware.

App Inventor for Android. Is an open-source web application originally provided by Google, and now maintained by Massachusetts Institute of Technology (MIT). It allows newcomers to computer programming to create software applications for the Android operating system (OS). It uses a graphical interface, very similar to Scratch and the StarLogo TNG user interface, which allows users to drag-and-drop visual objects to create an application that can run on Android devices.

8. System Design

8.1 Conceptual Design

The researchers used System Development Life Cycle (SDLC) as framework for the development of automation system for CPE Laboratory. SDLC is the process of building, deploying, using, and updating the system. Traditional SDLC is composed of five phases illustrated in figure below.

Fig. 4: Illustration of System Development Life Cycle

Phases of SDLC:

Planning. In this stage, the researchers identified the scope of the proposed system and ensured that the proposed system is feasible.

Analysis. In this stage, the researchers documented and carefully understood the laboratory needs and the processing requirement of the proposed system.

Design. To design the solution system based on the requirements defined and decisions made during analysis.

Implementation. To build, test, and install a reliable information system with trained users ready to benefit as expected from the use of the system.

Support. To keep the system running productively, both initially and during the many years of the system's lifetime.

8.2 Logical Design

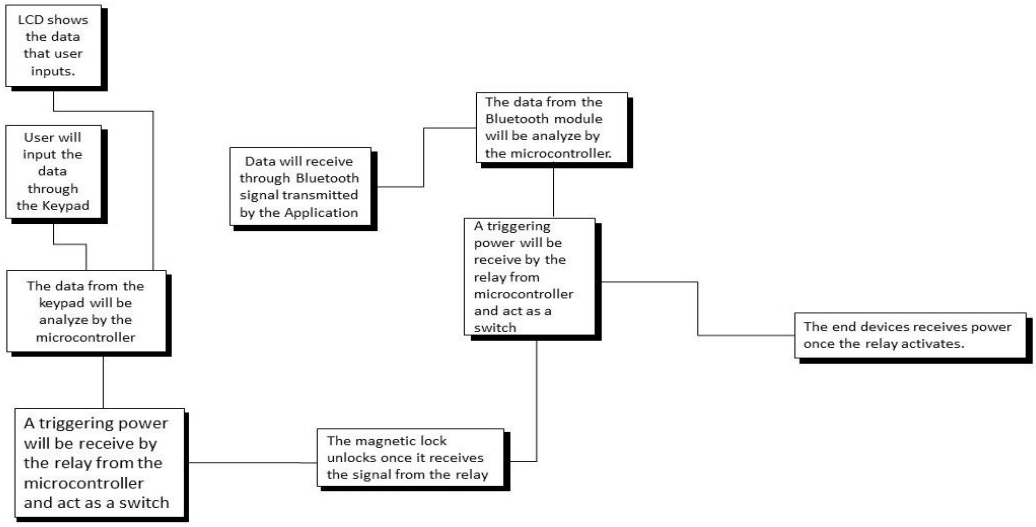

Fig. 5: Logical Diagram

The figure above shows how the data flows logically. The LCD shows the data that user inputs which is connected to the Arduino Uno Microcontroller. The 4X4 Matrix Keypad also connected to the microcontroller. The user must input the correct password so that the relay will activate unlocking the Magnetic Lock connected to relay from the microcontroller. The other connection is for the Mobile Application. The Bluetooth module connected from the Arduino Mega Microcontroller receives signal from the user's device having Bluetooth capability. The other relay will receive the input power from the Arduino Mega controlled by the application that will trigger the switch sustaining the power of end devices (light, electric fan, printer, outlet for the computers).

8.3 Hardware Infrastructure Setup

Infrastructure is the foundation or framework that supports a system or organization. The figure below shows the connection of components which connected to end devices.

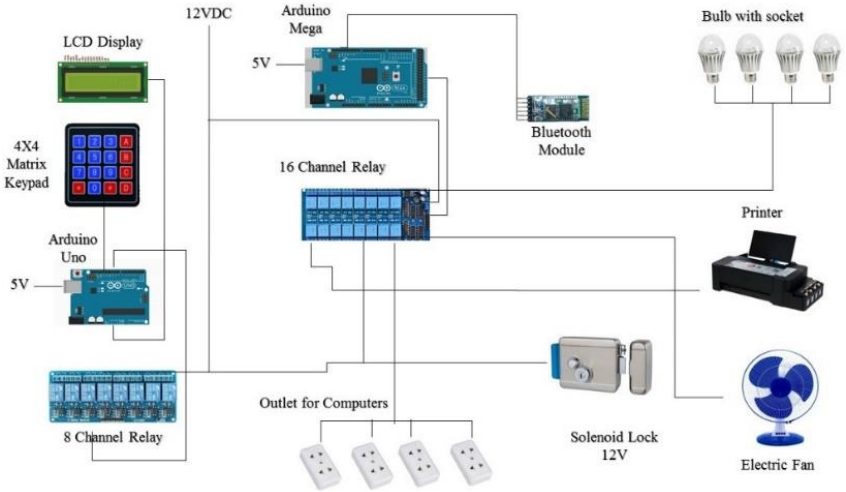

Fig. 6: Hardware Infrastructure Setup

9. Results and Discussion

Table 2: Functionality of the System

Functionality	SCORE	REMARKS
1. Functions required for the system are tested (Suitability)	3.75	Very Good
2. Functional accuracy is provided (Accurateness)	3.75	Very Good
3. Functions met specifications (Compliance)	3.25	Good
4. Easy of connecting with other systems is provided (Interoperability)	3.75	Very Good
5. Substantial security is provided (Security)	4	Very Good
TOTAL	3.7	Very Good

Table 2 shows the weighted mean of the functionality of the system. The "Functions met specifications" got the lowest score while "Substantial security is provided" got the highest. The total score was 3.7 having a remark of "Very Good".

Table 3: Reliability of the System

Reliability	SCORE	REMARKS
1. Software includes no bug: (Maturity)	3.25	Good
2. A certain level is maintained even when trouble occurs in hardware. (Fault Tolerance)	3.5	Good
3. Normal operations are restored readily, when a failure occurs in hardware. (Recoverability)	4	Very Good
TOTAL	3.58	Very Good

Table 3 shows the weighted mean of the reliability of the system. The "Software includes no bug" got the lowest score while "Normal operations are restored readily, when a failure occurs in hardware" got the highest. The total score was 3.58 having a remark of "Very Good".

Table 4: Usability of the System

Usability	SCORE	REMARKS
1. Easy to operate (Understandability)	3	Good
2. Easy to remember (Learn Ability)	3.25	Good
3. Allows easy operation management (Operability)	3.5	Good
TOTAL	3.25	Good

Table 4 shows the weighted mean of the usability of the system. The "Easy to remember" got the lowest score while "Allows easy operation" got the highest. The total score was 3.25 having a remark of "Good".

Table 5: Efficiency of the System

Efficiency	Excellent	Very Good
1. Provides good response and high throughput (Time Behavior)	3.25	Good
2. Allows effective use of system resources (Resource Behavior)	3.5	Good
TOTAL	3.38	Good

Table 5 shows the weighted mean of the efficiency of the system. The "Provides good response and high throughput" got the lowest score while "Allows effective use of system resources" got the highest. The total score was 3.38 having a remark of "Good".

Table 6: Maintainability of the system

Maintainability	SCORE	REMARKS
1. Allows easy analysis of design documents and programs when a bug is found in both hardware and software (Analyze ability)	3.5	Good
2. Allows easy expansion and modification of the system (Changeability)	3.25	Good
3. Modification of the system does not affect others (Stability)	4	Very Good
4. Laborious tests are not required after a modification is made (Testability)	3.5	Good
TOTAL	3.56	Very Good

Table 6 shows the weighted mean of the maintainability of the system. The "Allow easy expansion and modification of the system" got the lowest score while "Modification of the system does not affect the others" got the highest. The total score was 3.56 having a remark of "Very Good".

Table 7: Portability of the system

Portability	Excellent	Very Good
1. Provides flexible requirement (Adaptability)	3.5	Good
2. Providing easy installation work (Install ability)	3	Good
3. Complying with porting specification (Conformance)	3.5	Good
4. Easily allows replacement of parts and components (Replace Ability)	3.75	Good
TOTAL	3.44	Good

Table 7 shows the weighted mean of the functionality of the system. The "Providing easy installation work" got the lowest score while "Allows easily replacement of parts and components" got the highest. The total score was 3.44 having a remark of "Good".

10. Conclusion

Summary of findings

This study "Automation of CPE Laboratory" is beneficial to the user in controlling appliances and securing the laboratory. The researchers used survey and evaluation to test the effectivity of the proposed system.

The findings of the study revealed the following:

1. The proposed system is providing substantial. The overall mean was 3.7 having a remark of "Very Good" in terms of functionality.
2. The proposed system has normal operations restored when a failure occurs. The overall mean was 3.58 having a remark of "Very Good" in terms of reliability.
3. The proposed system allows easy operation to the users in control and operation. The overall mean was 3.25 having a remark of "Good" in terms of usability.
4. The proposed system allows effective use of system resources. The overall mean was 3.38 having a remark of "Good" in terms of efficiency.

5. The proposed system can be modified without affecting the other components. The overall mean was 3.56 having a remark of "Very Good" in terms of maintainability.
6. The proposed system easily allows replacement of parts and components. The overall mean was 3.44 having a remark of "Good" in terms of portability.

The researchers conclude the following based on the data obtained from the respondents: first, the proposed system is an important help for professors and laboratory administrators in terms of bringing convenience in controlling the devices and equipment inside the laboratory. Next, guarding the laboratory in a modernized manner could stop unauthorized persons from entering, potentially reducing risk and accidents inside the laboratory. Lastly, reduce the time spent checking the power status of the students' computers.

11. Recommendation

According to the study's findings, the researchers recommend the following. First, it must have backup power in the event of a power outage. Next, a sensor must be installed to detect the professors. Then, improve the application's GUI and create an app for iOS users. Finally, add more system features.

Acknowledgements

The researchers would like to thank Mr. Luigi Lambinicio, Mr. Djson Julio, Ms. Kate Lyndel Pascual, and Ms. Jeanvill Milla for their help and assistance in fulfilling the researcher's system.

References

1) Abuan, D. D., Abad, A. C., Lazaro Jr, J. B., & Dadios, E. P. (2014). Security systems for remote farm. Journal of Automation and Control Engineering Vol, 2(2).
2) Asadullah, M., & Ullah, K. (2017, April). Smart home automation system using Bluetooth technology. In 2017 International Conference on Innovations in Electrical Engineering and Computational Technologies (ICIEECT) (pp. 1-6). IEEE.
3) Castillo, C. M., Lucena, E. P. N., Bentulan, M. A., Felipe, C. G., & Buog, E. J. (2013). Security on Doors and Windows with Alarm System using GSM. PULSAR, 2(1), 1-1.
4) Chandra, B. R., Kaustubh, K. H., Reddy, T. S., & Goud, K. J. Solenoid Based Home Security System Using RFID.
5) Hussaini, H., Adamu, M. Z., Ajagun, A. S., Ijemaru, G. K., & Oresanya, B. O. (2014). Design of a GSM-based biometric access control system.
6) Jajodia, A., & Das, S. (2017). IoT based Simple Home Automation using Raspberry Pi. International Journal of Engineering Trends and Technology, 53(3), 124-125.
7) Kumar, S. (2014). Ubiquitous smart home system using android application. arXiv preprint arXiv:1402.2114.
8) Piyare, R., & Tazil, M. (2011, June). Bluetooth based home automation system using cell phone. In 2011 IEEE 15th International Symposium on Consumer Electronics (ISCE) (pp. 192-195). IEEE.
9) Sriskanthan, N., Tan, F., & Karande, A. (2002). Bluetooth based home automation system. Microprocessors and microsystems, 26(6), 281-289.
10) Van Der Werff, M., Gui, X., & Xu, W. L. (2005). A mobile-based home automation system.