Home automation monitoring system based on Internet-of-Things application

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Abstract. The design of a smart green environment of home automation for appliances monitoring systems is developed based on an IoT(Internet of Things) application. The smart home concept represents a motivating platform for innovation of information technology services to produce more operative house devices and system that can improve the standard of life. This project aims at controlling home appliances via Smartphone using Wi-Fi as a communication protocol and the Raspberry Pi as a server system. The user here can move directly with the system through a web-based interface over the net. The designed system not solely monitors the sensor data but also actuates a process according to the need. Therefore, globally accessible automation of electronic appliances is created attainable with the utilization of a Raspberry Pi micro-controller board, a web affiliation and relay switches in a user-friendly way for the users to regulate home electronic appliances with high flexibility and security.

1. Introduction

The topic of the Internet of Things (IoT) and smart home are the most active areas in research today. The smart home concept represents a motivating platform for innovation of information technology services to produce more operative house devices and system that can improve the standard of life. The system is proposed to create a smart environment by switching ON and OFF the target devices by Wi-Fi. Conventional switches at our home right now also introduces difficulties to the elders and disable people as switches are placed or located in several different places while these group of people may not move freely. The system is designed to improve home security using the smartphone by increasing home efficiency through the internet.

The remainder of this paper is organized as follows. Section 2 discusses the related works. This is followed by the Methodology in Section 3. The Experimental Result and Conclusion are discussed in Section 4 and 5, respectively.
2. Related works
The designed system of home security is designed to improve protection using the smartphone by increasing home efficiency through the internet. One of the most advantages by using Raspberry Pi is stated by [1] is that the devices can be controlled in any of the operating systems in mobiles for both windows and android. The control of various appliances by means of General Purpose Input Output (GPIO) in another laptop can be monitoring of the devices by using IoTs.

There have been several studies in the literature reporting application of servo motor in controlling the electrical appliances [2-4]. There are two mechanical functions described of the fan; firstly is the DC motor which has the responsibility to provide main rotation and its speed, and secondly is the servo motor which has a responsibility to make the swing move for directional steering.

Previous research in [5,6] has shown that the proposed system can control the electrical appliances remotely. It stated that the Raspberry Pi could be controlled from any distant place with the help of weaved cloud service. Webiopi is the framework used to interface the Raspberry Pi with user input and which was installed and updated. Raspberry Pi micro-controller board is used to control the switches of appliances through the internet. A website has been created using weaved services for acquiring user input. In another study, [7] proposes a Raspberry Pi based home automation system through the web server and smartphones. This model uses a simple, user-friendly interface for the access of the Raspberry Pi. However, using Raspberry Pi for controlling each component needs many Raspberry Pi modules. According to an investigation by [8], there are several design challenges and considerations involved while developing the proposed home automation system, many of which are determined by user needs. One of them is environmental consideration. Home automation technology is more considered into its sustainability, and its convenience which integrating new and existing technology together will reduce energy consumption and the carbon footprint at home. The proposed home automation system was done by [9,10] can reduce the number of wastage from the lithium-ion battery in individual remote that could harm the environment. The implementations of simple changes that not only help the earth but will also add convenience to the home and saves cost. Furthermore, the system can be used to accommodate people with special needs including elderly, disabilities and chronic illness.

An earlier study by [11,12] developed the application of smart home by integrating IoT with a web server and cloud computing by focused on the Arduino platform, Zigbee technology and Cloud services. This approach demonstrated the feasibility and efficacy of a smart home. However, the number of studies [13-17] show that significant differences do exist, contradictory in terms of its approach.

3. Methodology
The project consists of 3 main components which are Home Interface, Raspberry Pi and Web Interface (via HomeAssist apps). The signal will alert the user, and the user can monitor the condition of electrical appliances at home through the apps either by a PC or a smartphone as shown in following Figure 1.

![Figure 1. Block diagram of the proposed system.](image-url)
3.1. Schematic diagram of virtual circuit

The designed circuit of hardware part is simulated by using computer software ‘Multisim’ to build the virtual circuit. The Virtual circuit is a test run on the software and error is detected and solved. Whenever an error occurred during the hardware simulation, troubleshooting is done to detect the problems occurred and solved it. Next, when the circuit runs well in the hardware simulation, the circuit is then ready to be transferred to the stripboard. All the components are soldered properly on the stripboard. Testing is conducted again to make sure all the connection of components are in good condition and run as designed. The prototype is designed and built after the circuit is completed. All the circuit is installed on the prototype and then test run. All circuit is made to ensure run as designed, and any error that occurred during the process has to be solved until it works properly. The virtual circuit consists of several electronic components such as Raspberry Pi 3, NPN BC337 Transistors, LED, 9V and 6V battery, 12V DC fan, diode, 2 units of 1 kiloΩ, resistors, 5 units of 4.7 kiloΩ resistors and the electromagnet. This is shown in Figure 2.

![Figure 2. Wiring diagram of virtual circuit.](image)

Raspberry Pi 3 is used as the central controlling device. The LED’s are used as a source of light for this project. As soon as a person enters the room, the ultrasonic sensor detects the human presence the brightness of the room is dependent on the level of light intensity that falls upon it. Also, the lights can be controlled remotely from anywhere in the world using the relay. All the components communicate with each other using the wireless protocol. Wi-Fi is used for communicating with the devices.

In the circuit of the electromagnetic door, a Raspberry Pi 3 with GPIO pin 25 is used as an input signal to control the current flow. Next, the GPIO pin 25 is connected to a relay switch which driven by a BC337 NPN transistor. Besides, a green LED light, and 9V battery is connected to the normal open (NO) port of the relay switch while an electromagnet is connected to the normal closed (NC) port of the relay switch. Four 1.5V batteries are connected in series with the electromagnet to supply voltage to the electromagnet.

As for the fan circuit, a relay switch is connected to Raspberry Pi GPIO pin 20 as an input signal to control the current flow. A diode is connected in the relay circuit to allow the current flow in one direction only. A DC12V fan is connected to a 9V battery in series and connected to normal opened port of the relay switch.
For the circuit of the lighting system, Raspberry Pi GPIO pin 22 and 27 are used as input switches to open the LED lights. Next, GPIO pin 22 is connected in series with a 4.7 kiloΩ resistor and a blue LED light. While the white LED light is connected in series with a 4.7 kiloΩ resistor and GPIO pin 27, the LED lights will turn on by trigger the GPIO pins.

For the circuit of the rice cooker, GPIO pin 5 of Raspberry Pi is used as an input signal to circuit. The GPIO pin 5 is connected to a 4.7 kiloΩ resistor and red LED light which represents ‘cook’ in the rice cooker. GPIO pin 6 of raspberry pi is connected to 4.7 kiloΩ resistors and green LED light which represents the ‘keep warm’ condition in the rice cooker.

The circuit is controlled by the tiny computer, which is Raspberry Pi 3. In order to run the tiny computer, the circuit needed to be programmed. To do the programming, first set up the Raspberry Pi. Then, the coding that controls the circuit is generated. When the coding works, it will be implemented into the Raspberry Pi 3. In order to let the user able to access the whole system, the Raspberry Pi 3 is then linked to the open-source home automation platform. At last, the port configured for forwarding, so that home assistant platform can be used outside with other devices when connected to the internet.

3.2. **Flowchart of constructing hardware and software**

![Figure 3. Flowchart in constructing hardware circuit](image)

![Figure 4. Flowchart of programming software](image)
Figure 3 shows the flowchart of completing the hardware part of this project. While Figure 4 shows the steps to program the circuit of the project.

3.3. HomeAssist apps through mobile or personal computer (PC)
This smart home system consists of three main parts which are the electronic circuit, the prototype of the house and the home assistant. The other two presented in previous Part A and B. The home assistant is an open source for home automation platform running on Python 3. This interface tracked and automatically controlled all devices without storing any of the data in the cloud of the house. This will allow the user to control the project using an open-source home automation platform. For this purpose, the user interface can be used on https://raspberry.pi.mshome.net:8123 or https://192.168.8.100:8123.

4. Experimental result

4.1. Construct virtual circuit
The circuit built in this smart home basically categorized into five parts that represent five house devices, which are electromagnetic door, rice cooker, fan, CCTV and lighting system. The project is used for controlling house devices by using a smartphone or computer connected with the internet. Every circuit has a different operation for the project to function according to their specification. Correct operation is essential to ensure this project to success.

Multisim is computer software that simulates the virtual circuit. By using the software, one can figure out the connection of the circuit and the components required in order to redesign the circuit. After the simulation, the designed circuit is transferred to the breadboard to test the circuit practically. The circuit is connected with Raspberry Pi 3 to test its functionality. Figure 5 depicts the image of the simulation using Multisim software.

![Circuit simulation using Multisim](image-url)
Figure 6 illustrates transferred circuit on breadboard and stripboard accordingly.

![Figure 6. (a) Circuit on breadboard, (b) Circuit on stripboard](image)

4.2. *Hardware part*

Figure 7 shows the developing of an electronic circuit that runs the home automation process. While both Figure 8 and Figure 9 are the prototypes of the house. The prototype of the house was made up from the mounting board.

![Figure 7. Fully-developed Circuit](image)

Figure 8. Outer view prototype

Figure 9. Inner view prototype
4.3. Programming home automation applications

The home assistant is an open source for home automation platform running on Python 3. This interface track and automatic control of all devices without storing any of the data in the cloud of the house.

Firstly, Python-pip and python-dev were installed. Raspberry pi should always update with the command ‘sudo apt-get update’. Next, the folder in Raspberry Pi can be seen on a laptop. After that, home assistant software is installed. A file is created and configured in order to run the home assistant service. After configuration to run the service, ‘daemon’ was reloaded and home assistant service was enabled in the system, and this interface is shown in Figure 10(a) where the user needs to log in with the correct password. While Figure 10(b) display the applications of Home Assistant for the Smart Home system. This app enables the user to control the electrical appliances over the net.

![Image](image-url)

**Figure 10.** (a) Log in password needed of Home Assistant apps, (b) User interface of Smart Home System

5. Conclusion and future enhancement

For this project, the smart home automation appliances monitoring system (IoT-based) is produced. This project is considered successful because it achieved the main objective. A design for a home automation system is recommended using the Raspberry Pi 3 board, web-based interface over the cyber web and electromagnetic relay. Raspberry Pi micro-controller board is employed to regulate the switches of appliances through the net.

A home automation platform as an open-source web has been created using Home Assistant services for getting user input. Once the GPIO pin of the Raspberry Pi 3 pin is activated, the relay closes the switch that controls the appliances such CCTV, door, fan, light and rice cooker. Therefore, the implemented automation system provides an efficient, comfortable and flexible user interface for controlling electric appliances remotely.
For future works, the circuit can be improved by adding additional sensors. A light sensor can be added to the lighting system circuit for detection of the current ambient light level and make a corresponding action. The fan can be modified to have adjustable fan speed according to current temperature using a temperature sensor. The rice cooker is designed for only one period of cooking. Thus, it can be improved by setting a timer for longer cooking time and based on several types of food including porridge, brown rice and others.

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References
[1] Pavithra, D. and R. Balakrishnan. IoT based monitoring and control system for home automation. in Global Conference on Communication Technologies, GCCT 2015. 2015.
[2] Lawu, B.L., et al. Prototyping design of mechanical based end-devices for smart home applications. in 2016 4th International Conference on Information and Communication Technology (ICoICT). 2016.
[3] Datta, N., et al. Designing and implementation of an application based electrical circuit for smart home application. in 2014 IEEE Student Conference on Research and Development. 2014.
[4] Shah, J., B. Modi, and R. Singh. Wireless home appliances controlling system. in 2014 International Conference on Electronics and Communication Systems (ICECS). 2014.
[5] Narender, M. and M. Vijayalakshmi. Raspberry Pi based advanced scheduled home automation system through E-mail. in 2014 IEEE International Conference on Computational Intelligence and Computing Research. 2014.
[6] Sandeep, V., et al. Globally accessible machine automation using Raspberry pi based on Internet of Things. in 2015 International Conference on Advances in Computing, Communications and Informatics, ICACCI 2015. 2015.
[7] Joshi, J., et al. Performance enhancement and IoT based monitoring for smart home. in International Conference on Information Networking. 2017.
[8] Azni, M.N., et al. Home automation system with android application. in 2016 3rd International Conference on Electronic Design, ICED 2016. 2017.
[9] Saad al-sumaiti, A., M.H. Ahmed, and M.M.A. Salama, Smart Home Activities: A Literature Review. Electric Power Components and Systems, 2014. 42(3-4): p. 294-305.
[10] Sravanthi, A., et al. Design and development of personal assistive device for elderly. in 2016 8th International Conference on Advanced Computing, ICoAC 2016. 2017.
[11] Soliman, M., et al. Smart Home: Integrating Internet of Things with Web Services and Cloud Computing. in 2013 IEEE 5th International Conference on Cloud Computing Technology and Science. 2013.
[12] Kumar, P. and U.C. Pati. Arduino and Raspberry Pi based smart communication and control of home appliance system. in Proceedings of 2016 Online International Conference on Green Engineering and Technologies, IC-GET 2016. 2017.
[13] Grgurić, A., M. Mošmondor, and D. Huljenić. Development of low cost energy efficient home sensing internet gateway: A pilot study. in 2016 IEEE International Black Sea Conference on Communications and Networking, BlackSeaCom 2016. 2017.
[14] Kasmi, M., F. Bahloul, and H. Tkitek. Smart home based on Internet of Things and cloud computing. in 2016 7th International Conference on Sciences of Electronics, Technologies of Information and Telecommunications, SETIT 2016. 2017.

[15] Khakimov, A., et al. Investigation of methods for remote control IoT-devices based on cloud platforms and different interaction protocols. in Proceedings of the 2017 IEEE Russia Section Young Researchers in Electrical and Electronic Engineering Conference, ElConRus 2017. 2017.

[16] Patchava, V., H.B. Kandala, and P.R. Babu. A Smart Home Automation technique with Raspberry Pi using IoT. in 2015 International Conference on Smart Sensors and Systems, IC-SSS 2015. 2017.

[17] Bruns, B. and C.C. Ogbonnaya. Expanding the accessibility of conventional smart home systems. in Proceedings of the SouthEast Conference, ACMSE 2017. 2017.