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Home automated system using Bluetooth and an android application

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ABSTRACT

This article describes the implementation of a Bluetooth technology and an android application with voice prompts based home-automated system using an Arduino microcontroller. The system is aimed at designing an automated appliance control that is user-friendly and convenient to use. The design comprised an Arduino ATMEGA328 microcontroller board, Bluetooth module (HC-06), and an android application (MIT App Inventor 2). The Arduino controls any connected component and was programmed with C++ programming language by using Integrated Development Environment (IDE). Relays and Triacs are used for the switching mechanism. Once the system is connected, the user controls the electrical appliances connected to the home-automated system, which can also be controlled using voice prompt with the help of a Google assistant inbuilt with the android smartphone. The system switches the home appliances ON and OFF using the android app, Bluetooth module, and voiced prompt. It can also be timed to switch off appliances for a pre-time of 12 h, thus making the application easy and convenient to operate via a smartphone.

Introduction

Home automation is the use of one or more computerized remote to control basic home appliances remotely and sometimes automatically [7]. It is designed to contr[1]ol lighting points, entertainment systems, and home security such as access control as well as alarm systems. Automation and wireless technology have become a key technology in the twenty-first century. It helps communication between one point to another without the use of cables, and this makes the system to be more secure [1]. The attractiveness of controlling electrical devices through a phone has been increasing because of its high performance and availability. Connecting appliances through smartphone is useful for the elderly and physically disabled persons, who can access and control the appliances from where they are located and access them remotely without the help of others. Time is a precious thing; everybody wants to save time as much as they can (Kannapiran and Arvind, [6, 2]).

Home automation systems are a technological means of intelligent monitoring, control, feedbacks and actions of home appliances according to the needs of the home occupants. Wireless medium such as ZigBee, Bluetooth, wireless Fidelity (Wi-

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Fi), Short Message Service (SMS), Android Application, Wireless Sensor Network (WSN), Radio frequency identification (RFID) and Software Defined Network just mention a few serves as a medium of communication between the appliances and the control unit and according to [17] home automation are essential for non-invasive and non-intrusive implementation of the advanced automation system.

Android, a vivid operating system, has 76.24% usage worldwide, and 78.05% of Nigeria's total smartphone market share [9]. Android has become the topmost used mobile gadget operating system (OS) on the market today. The Android smartphone has become the most popular and commonly used Operating System in our world, especially in Nigeria. This had made us base the control terminal of the home automated system on an android application as it has been shown that majority cannot do without their phone with them almost all the time [2].

Conventional home controlled systems and its components are all wired to the same cable that connects them to the home control panel. The key problem with conventional home controlled systems is that they require the mobility of the user to operate it, hence the need for automation.

Literature review

Radio frequency identification (RFID) was used to design and monitor the indoor activity of elderly people in a smart home by Nisar et al. [14]. The RFID monitored and collected the movement activity of the elder person using RFID tags, information collected was used to take critical decisions about the health of the elderly person. But RFID can't work where its radio waves do not cover. Similarly Nisar and Ibrahim [15] presented A Smart Home Model Using Android Application where the vital signs of the elderly are monitored. A communication module and sensors such as accelerometer, gyroscope, force and temperature were attached to the knee and walking analyzer to monitor and extract of a person's unique walking pattern, which is used to classify the walking pattern an individual whether walking anomaly and walking with a level of stability. The signals are taken by the sensors and information gathered from walking analyzer and knee monitor was used to design a smart sleep room where vital signs like body temperature, breathing patterns and cardiac are monitored these signs are sent through a smartphone and a local wireless network to monitor elderly persons' health. The processes involved in this design are too cumbersome and if sensors are not properly attached signal might fail and waking pattern will not be got.

Also, Nisar and Ibrahim [16] proposed "a smart home model using android application" the home model uses ZigBee module to communicate between the android phone and the smart home model. This is not an effective medium of communication, as an external ZigBee transceiver must be connected to the android phone. This leads to waste in power, use of many components as compare to Bluetooth that is part of an android phone already. In the same vein, Nisar et al. [17] proposed a smart home automation for the elderly using Wireless sensor network and android application, the system was divided into modules namely sensor, control and actuator. The sensor module served as the transmitting medium, the control module controlled the smart house, remote monitoring of other sub-modules and the actuator modules showed the response of all appliance connected in the actual system as illustration, the drawback of this system is that failure to the control modules is failure of the whole system.

Moreso et al. [2] presented a low-cost Bluetooth based home automation system using an Android phone was presented by. An Arduino Mega 2560-R3 board and relays were used to connect the home appliances as input/output ports of the board, a Bluetooth were used to establish wireless communication between them. Furthermore, Wanjale et al. [12] designed and implemented an Android application with a Bluetooth module and Arduino UNO board for home-based automation. Users can interact with the android phone and send a control signal to the Arduino UNO that will control other embedded devices/sensors. Similarly, Tyagi et al. [11] controlled Home appliances through voice commands with Arduino and Android OS. In the same vein, Sriskanthan and Karande [8] networked all home appliances and controlled them through Bluetooth. The network contained a remote, mobile host controller and home appliances. The home appliance communicated with the host controller through the Bluetooth devices, which operated the Home appliances through a RS232 network using Bluetooth module. Yuksekkaya et al. [3] developed a GSM, Internet, and speech recognition based home appliances automation. The Signals from the Radio Frequency (RF) antenna were processed by the microprocessor, which in turn was used to control the appliances. Also, Pandya et al. [7] also presented a Bluetooth-based home automation, but the only difference is that it had an authentication mechanism that made it secure and accessible to authorized users. Teymourzadeh et al. [10] designed and implemented a smart home automation system based on a mobile phone and GSM modem. In this design, an incoming message was sent from the user phone to the GSM modem as a text message via the cellular network. It then decodes the SMS to activate the connected appliances; this is not a cost-effective method of automation, as there is no means of getting feedback from the system. Jubadi and Zulkifli [13] proposed how to use a Television (TV) remote control to control room lighting and other appliances in their work entitled "Programmable Infrared Accessory Light Switch". An Infrared (IR) remote and one IR receiver was programmed to store the frequency of the existing remote and use them directly to control appliances. Gurek et al. [5] explored internet-based home appliance connectivity but, a major demerit is this: when there is no internet connectivity, the system fails especially in a country like Nigeria. Diarah et al. [4] in their work titled, "Design and Implementation of a Microcontroller Based Home Automation System Using Aiwa Remote", explore the use of television remote to control home appliances, this is not efficient as users have to be physically present to activate the system by pointing the remote towards the appliance.

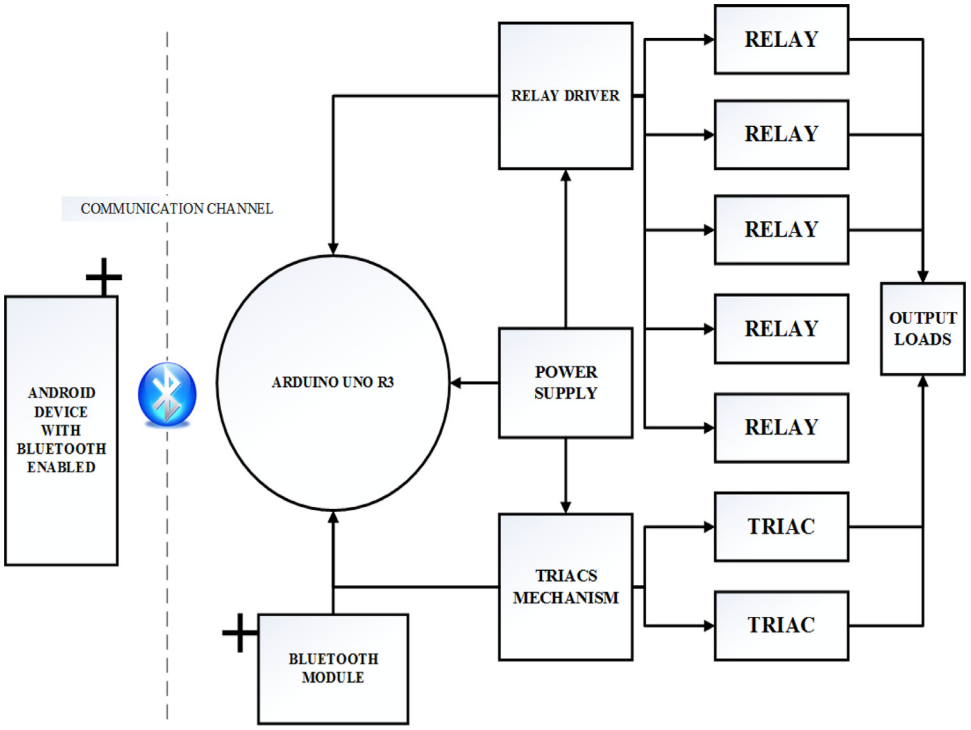

Fig. 1. Block diagram of the system architecture.

Materials and methods

This paper was implemented using the hardware and software approach. This was achieved by using a Bluetooth module (HC-06) to communicate between the hardware system and the smartphone as shown in Fig. 1. The software part was based on an android application created using MIT App Inventor 2, which is an easy to use online platform used to develop the android application. The entire system was controlled by on two devices, namely the microcontroller and a wireless network know as Bluetooth. The system architecture comprosed five major sections namely, microcontroller unit, notification unit, relay and triac unit, communication channel, and power supply unit as shown below. The input, which can either be a voice prompt or a graphical user interface (GUI) command but not both, serves as input to the mobile smartphone through the Android application. The received command is transmitted using the Bluetooth, which is inbuilt in the mobile smartphone.

System designs: hardware design and implementation

Relay driver

The relay driver circuit is powered by Darlington IC ULN2003A that has seven pairs of a transistor with seven inputs and output pins. The Darlington IC used eliminates the use of multiple components. The relay is powered by 12 V from the power supply and it has two terminals, one terminal is connected to the 12 V supply while the other terminal is connected to 5 V from the Arduino board which acts like a neutral that activates the relays. The Darlington IC has the circuitry inside it that can increase the current to the relays and it has seven transistorized output pins, which eliminate the use of several single transistors, but the output is only activated when the input pin of the IC is supplied with lower voltage. The Darlington IC ULN2003A is shown in Fig. 2.

Power section

The mains power supplied to the system is 220VAC stepped down to 12VAC by the transformer while the four Diode converted from 12VAC to 12VDC through the process of rectification to avoid dead time in rectification cycle and because it was being used to power sensitive device components like microcontroller and Bluetooth module. A LM7812 12volt voltage regulator powered the Darlington IC, relay, and the Diacs, while a 5volt voltage regulator LM7805 was used to power the Arduino, Bluetooth, and optocoupler. Before the optocoupler, the Triac was used to drive a load that required a variable speed like a fan while the Diac was used to activate the gate of the Triac. Just like in the transistor, the Diac gets the required signal from the Arduino to drive the triac this will allow variable voltage to pass through the Triac. The Arduino signals the Diac to activate the triac, while the optocoupler acted as a detector to detect the 220VAC and controlled voltage

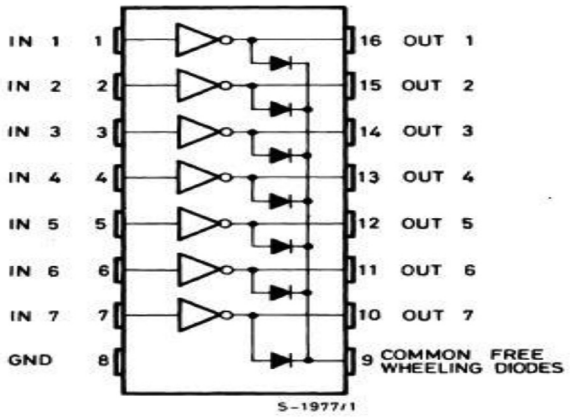

Fig. 2. Darlington IC (ULN2003A).

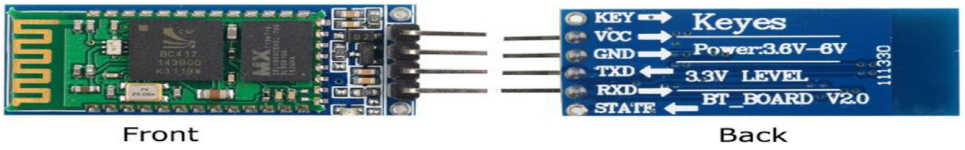

Fig. 3. Bluetooth module.

to the load (fan). All these are interchanged in the Arduino code. The Light -Emitting Diodes are connected to the relay, and it served as an indicator when the relays are activated and a resistor connected with it is to resist current flow.

Bluetooth

The Bluetooth module used in this design is HC-06 as shown in Fig. 3. It receives the command and passes it onto the Arduino microcontroller. The microcontroller reads the command through a serial port and therefore the Arduino microcontroller compares the command from the android phone to the code written on the Arduino Uno. If it matches the command, the corresponding output pin goes high. The relay driver receives the signal from the microcontroller and activates the corresponding appliance (load). The HC-06 works with a supply voltage of 3.6VDC to 6VDC, however, the logic level of RXD pin is 3.3 V and is not 5 V tolerant.

Connecting the Bluetooth module to the Arduino-Uno board. The process of connecting the Arduino-Uno and the Bluetooth module followed the steps 1–3 to enable the android application to control the Arduino-Uno (microcontroller).

Step 1: The Bluetooth module and microcontroller was connected through their respective VCC pins.

Step 2: The Bluetooth module and microcontroller was connected through their respective GND pins.

Step 3: Similarly, the transmitter (Tx pin) of the Bluetooth module to the receiver (Rx pin) of the microcontroller and the receiver (Rx pin) of the Bluetooth module to the transmitter (Tx pin) of the microcontroller.

Arduino microcontroller

This is the processing brain behind the work of this home automation, and it was used to interface the entire system together. The Arduino board contains sets of both digital and analog input/output (I/o) pins that were interfaced to various expansion boards or breadboards (shields) and other circuits. It was programmed using *C++* programming language. Fig. 4 shows the circuit diagram for both hardware and software implementation.

Software design and implementation

This section discusses the software and algorithm used in developing the android application and programming of the Arduino board Integrated Development Environment software, namely Arduino IDE and Proteus IDE. Fig. 5 show the operational flowchart of the software implementation.

Arduino IDE

The Arduino IDE is an open-source software that writes, compiles, and upload codes directly into the microcontroller. The version used in this paper is version 1.8.9. The Arduino IDE environment is used for writing the desired software code and for compiling, uploading code into the given Arduino board. Its environment supports both C and C++ language. It is also used for debugging, editing, compiling, and uploading code in its environment to physical hardware modules.

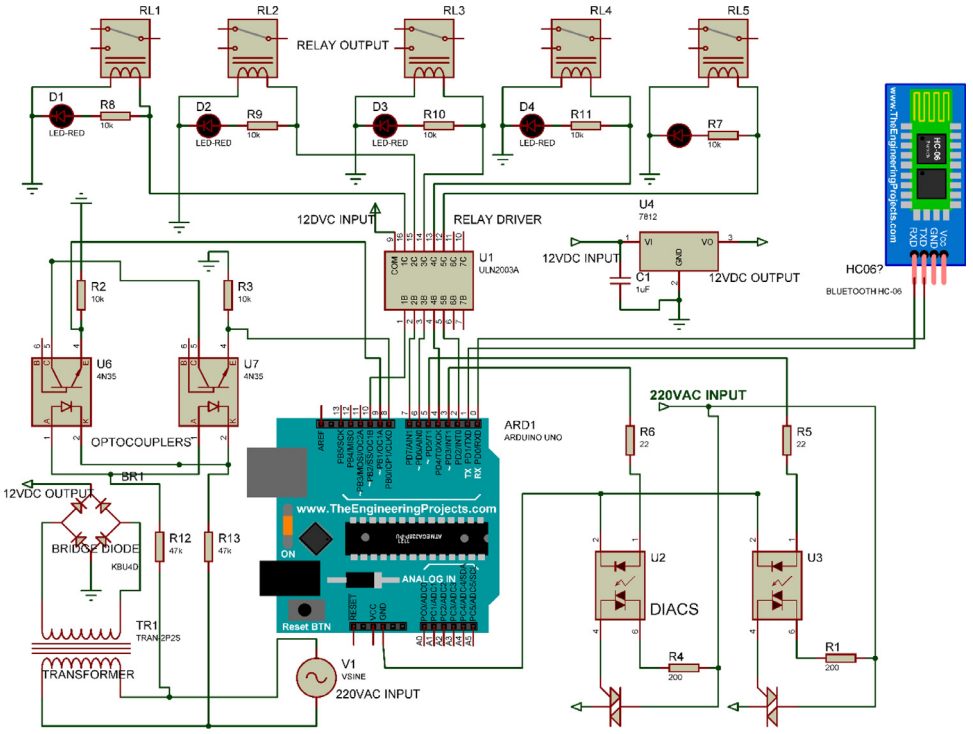

Fig. 4. Circuit Diagram of the Home automation.

Proteus IDE

Proteus IDE is a virtual system modeling (VSM) and circuit simulation application software. It also has a virtual system studio, a free universal IDE for Proteus. Also, Proteus VSM can be used for advanced embedded simulation, offering-system level simulation based on the schematic circuit. It has a wide range of components in its database or library. Besides its own database component, more components can be designed as part of the library component if they are not part of the original software library. Such a library component includes Arduino and Bluetooth Library for Proteus, etc.

MIT app inventor 2

The android developing platform MIT app inventor 2 is the latest version of an online app used in developing android applications. It contains blocks that are dragged and dropped at the desired blocks in the corresponding place. The developed Application can be installed on an Android phone/tablet with a Bluetooth module. Figs. 6 and 7 shows code blocks for Bluetooth connection and voice recognition, relay switch respectively.

Testing and discussion

The implementation of both the hardware and software programming was done initially on a Vero board. To determine whether the different components are working fine, all the components were tested using a digital multimeter to check that they conform to their datasheet. The test carried out includes a relay switching test, which is to ensure that the relay switches as expected and the desired signal went through the android application. Timing test was also done since the android application was developed to include a time picker which can activate or de-activate the electrical appliances connected to the system. To reduce power consumption and manage power effectively, an Observe, Learn and Adapt (OLA) algorithm through the use of machine learning tools as suggested by [18] can be adopted and the home automation system can also be switched into sleeping mode when not in use such that power consumption will be low as well as power supplied to a sensor or some sensors can be cut when it is not in use at a particular time, this can be done manually or automatically.

The incorporation of voice command/prompt in this research work made the difference between existing methods such as Amirah [2] which presented only a Bluetooth based home automation, Wanjale et al. [12] presented an Android application with a Bluetooth module and Arduino UNO board for based home automation. Jubadi and Zulkifli, [13] proposed how to use a Television (TV) remote control to control room light and other appliances.

Nisar et al. [14] attached RFID tags to elderly person to monitor their movement, also Nisar & Ibrahim, [15] attached a walking analyzer and sensor to knee of elderly persons for proper monitoring their health status and control of appliances in the same view Nisar & Ibrahim, [16] attached ZigBee module to communicate between the android phone and the smart

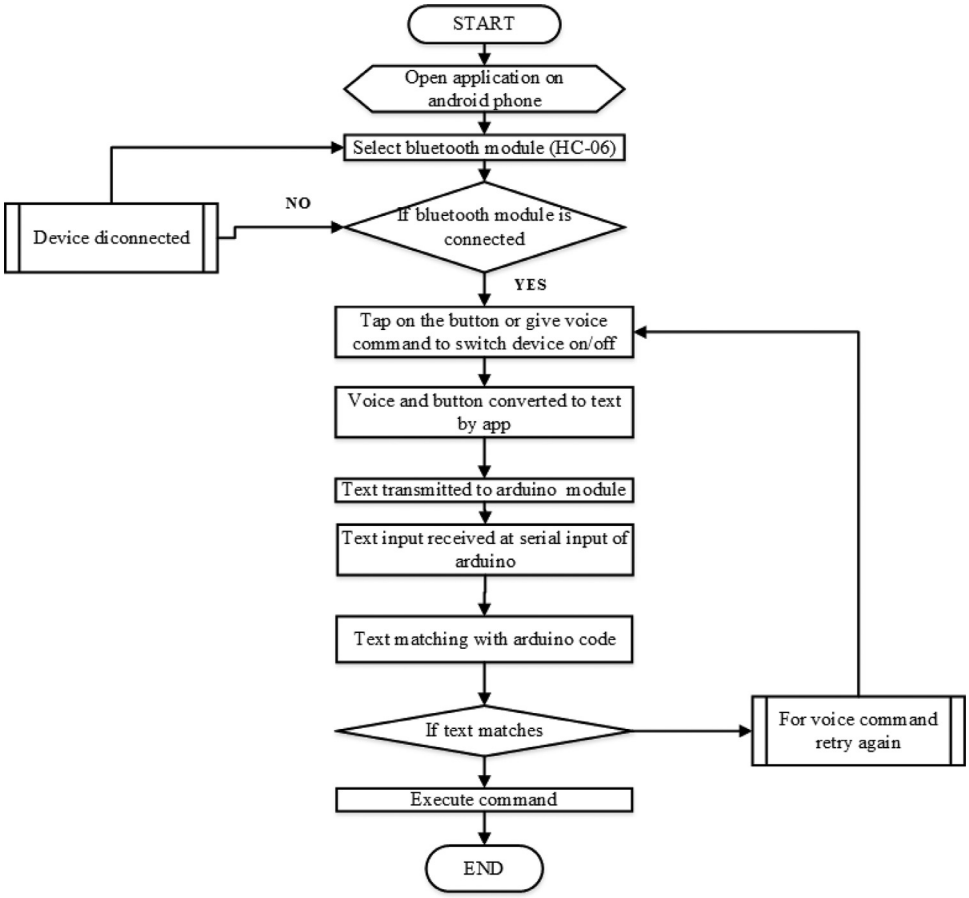

Fig. 5. Operational flowchart of the home automation system.

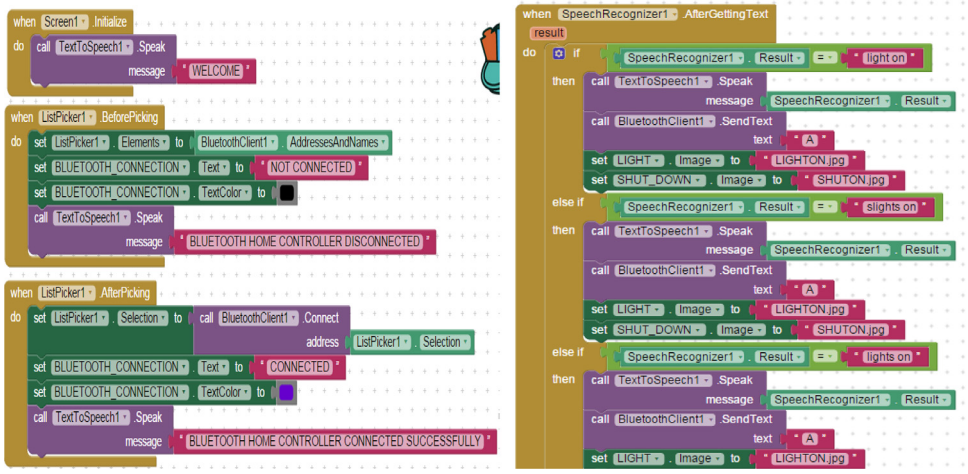

Fig. 6. Bluetooth connection and voice recognition code block.

home, although all the above mentioned researches and this research focused on elderly persons our main was to make the home automation simple such that nothing is attached to the body and it is easy to control appliance. Also, this research did not put into much emphasis on health like Nisar et al. [14], Nisar and Ibrahim, [15] and Nisar and Ibrahim, [16] did. But ultimately all these methods have made home automation easy and convenient to use.

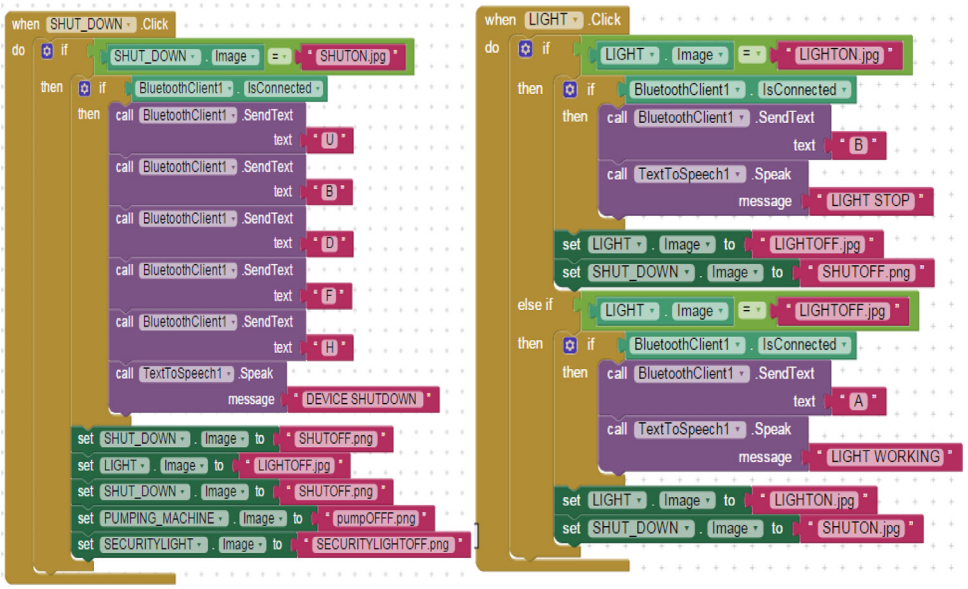

Fig. 7. Relay switching code block.

Conclusion and future work

An Arduino based home automation system using Bluetooth and an android application with voice command has been designed and implemented. The Home automation system used an Android application and a Bluetooth technology in the design; this is because they are easy to use, fast, readily available, and reliable in communications between the remote user and devices. A low cost and highly reliable home automation system that can assist handicapped/old aged people, as well as a user-friendly device was developed. Other features can be added in the future such as biometrics so that unauthorised persons can not have access to the appliances and an also timing schedule can developed for each appliances connected this will effectively conserve energy.

Declaration of Competing Interest

None

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