Home Automation System

1 Introduction

This report discusses the design and implementation of an Internet of Things (IoT) based home automation system. The system is built utilising an ESP8266 powered NodeMCU, a PIR sensor, a DHT11 sensor, and LEDs. The PIR sensor frequently detects motion, ascertaining whether someone is present in the room or not. The DHT11 sensor observes the room temperature continuously. This information is consistently uploaded to the internet via Wi-Fi. An application called Blynk is being used to display and track this information. If the room temperature is high, the Air Conditioner (AC) can be switched ON from the application, and if the temperature is low, it can be switched OFF. Correspondingly, if no one is in a room, the lights can be switched OFF remotely from the application and can be switched ON if required.

The purpose of designing this project is to acquire knowledge and understanding of the embedded systems and the Internet of Things. Wi-Fi enabled controllers like NodeMCU (ESP8266) deliver high performance and low power consumption in many embedded tasks and Internet of Things applications. The goal of this project is to learn IoT and software development as the home automation system is designed, implemented, and programmed. The aim is to efficiently use sensors, I/O devices such as the LEDs, and an application. This project would be an initial step into the more complex world of the Internet of Things Projects.

Until recent times, the idea of home automation was unfamiliar to most individuals, nonetheless, with technological advancements and as technology is becoming progressively accessible, homeowners are enhancing their homes across the world. Home automation facilitates homeowners to operate home devices and appliances such as lighting from a remote access point, like a phone application or a centralised unit in their homes with just a simple tap of their finger on any preferred technological device. It can assist homeowners in numerous ways. Home automation is advantageous as it adds safety measures through the homeowner's ability to control appliances in their homes. The main benefit is the simplicity and convenience it offers the homeowners. It increases the safety and security of their homes. Other advantages include energy efficiency as appliances can be remotely switched off when not in use, home systems will only be utilised when needed so savings will show up in the utility bills, it assists the homeowner significantly in reducing costs and saving money, it cuts down overheads drastically. It is less time consuming as homeowners will not have to walk around the house to control their appliances, it brings peace of mind as there will be no worrying about which appliance was or wasn't switched off.

The motivation of this project was primarily an interest to pursue a project in an interesting and appealing field of home automation.

2 Details of the design

2.1 Flowchart

Figure 1 below shows a diagrammatic representation of the workflow of the Home Automation System.

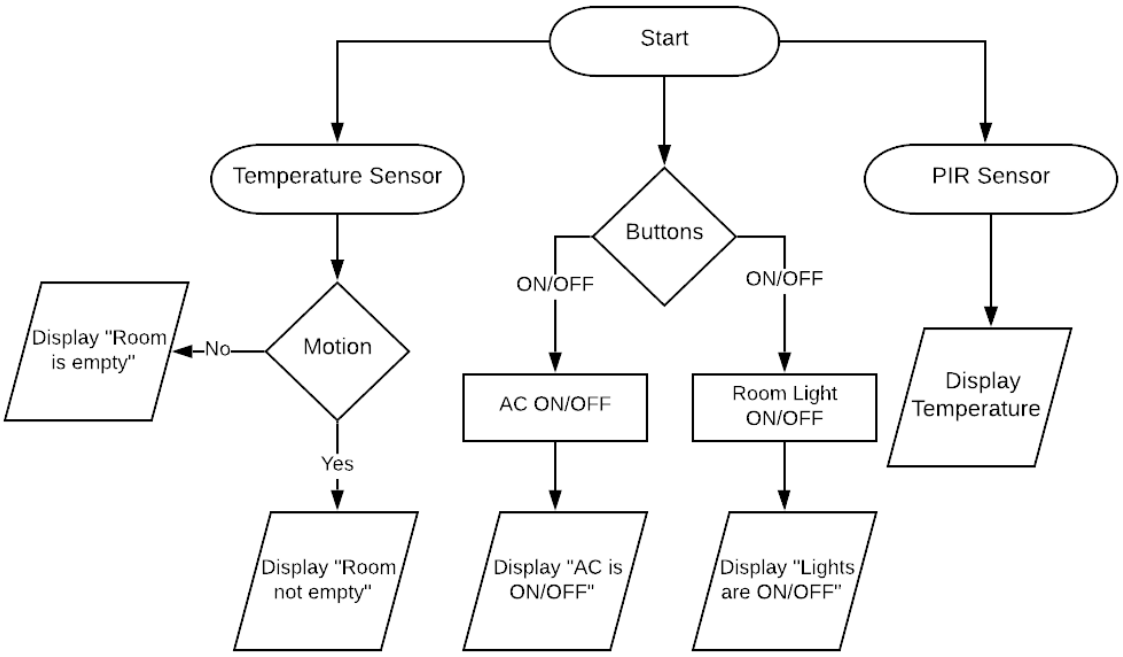


Figure 1: Flowchart

2.2 Components Used

The following components have been used for this project.

- **NodeMCU/ESP8266**

NodeMCU is a firmware and development kit for prototyping and building IoT products as shown in figure 2. It comprises firmware that runs on the ESP8266 Wi-Fi SoC from Espressif Systems and hardware which is based on the ESP-12 module ("ESP8266 NodeMCU", n.d.). It integrates 802.11b/g/n HT40 Wi-Fi transceiver, which means that other than connecting with the Wi-Fi network, it can also create its own network meaning other devices can connect to it directly. Thus, NodeMCU/ESP8266 is versatile. It operates on 3.3V and uses Wi-Fi to communicate through TCP/IP protocol.

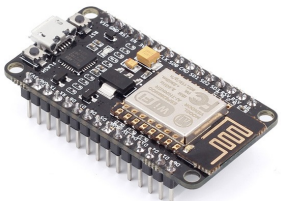


Figure 2: NodeMCU

- **PIR Motion Sensor**

Figure 3 shows a PIR sensor which senses motion, this sensor detects whether an individual had moved in or out the sensors range ("PIR Motion Sensor", 2014). Some of the benefits of

Figure 3: PIR Sensor

utilising this sensor are that it is very small in size, inexpensive, easy to use, low-power and it does not wear out. Hence, it is frequently utilised in appliances used in homes and businesses. It works by detecting levels of infrared radiation, it measures infrared light radiating from objects in its field of view. This sensor is widely used in automatic lighting applications and security alarms. This sensor has been selected to be used in this project, so it can detect if there is any motion in a specific room in the house and send information on the application by displaying a message informing the user whether that room is empty or not. This allows the user to make certain decisions accordingly. For instance, if there is no motion detected in the room, the app will display 'Room is empty', the app will also display a message saying whether the lights in that room are ON or OFF. So, user can switch room lights OFF remotely from the application or can switch them ON if needed.

- **DHT11 Temperature Sensor**

The DHT11 is a low-cost temperature and humidity sensor as shown in figure 4. The surrounding environment is measured with this sensor. It can effortlessly be interfaced with micro-controllers, so it can measure the temperature and the humidity promptly. It is accessible as a sensor as well as a module. The sensor and the module differentiate from each other by the pull-up resistor and a power-on LED ("DHT11 basic temperature-humidity sensor + extras", n.d.). The DHT11 sensor uses a capacitive humidity sensor element and thermistor for sensing temperature. This sensor is being used for this project because it is fairly simple to use. It will measure the temperature of a room in the house and display a temperature gauge on the application. The user can use that information to control the Air Conditioner in that room as the app will also display a message saying whether the Air Conditioner (AC) in that room is ON or OFF. For instance, if the temperature of the room is high, the Air Conditioner (AC) can be switched ON from the application, and if the temperature is low, it can be switched OFF.

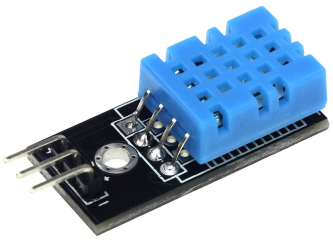


Figure 4: DHT11

- LEDs

For this project, simple LEDs shown in figure 5, will be used to mimic the room light and the Air Conditioner (AC). If applying this project to real-life applications to turn ON and OFF real appliances, we can use relays which are electrically operated switches.

Figure 5: LEDs

2.3 Electrical Design

Microsoft PowerPoint has been used to create the electrical design diagram for this project. Figure 6 shows the complete electrical design of the home automation system.

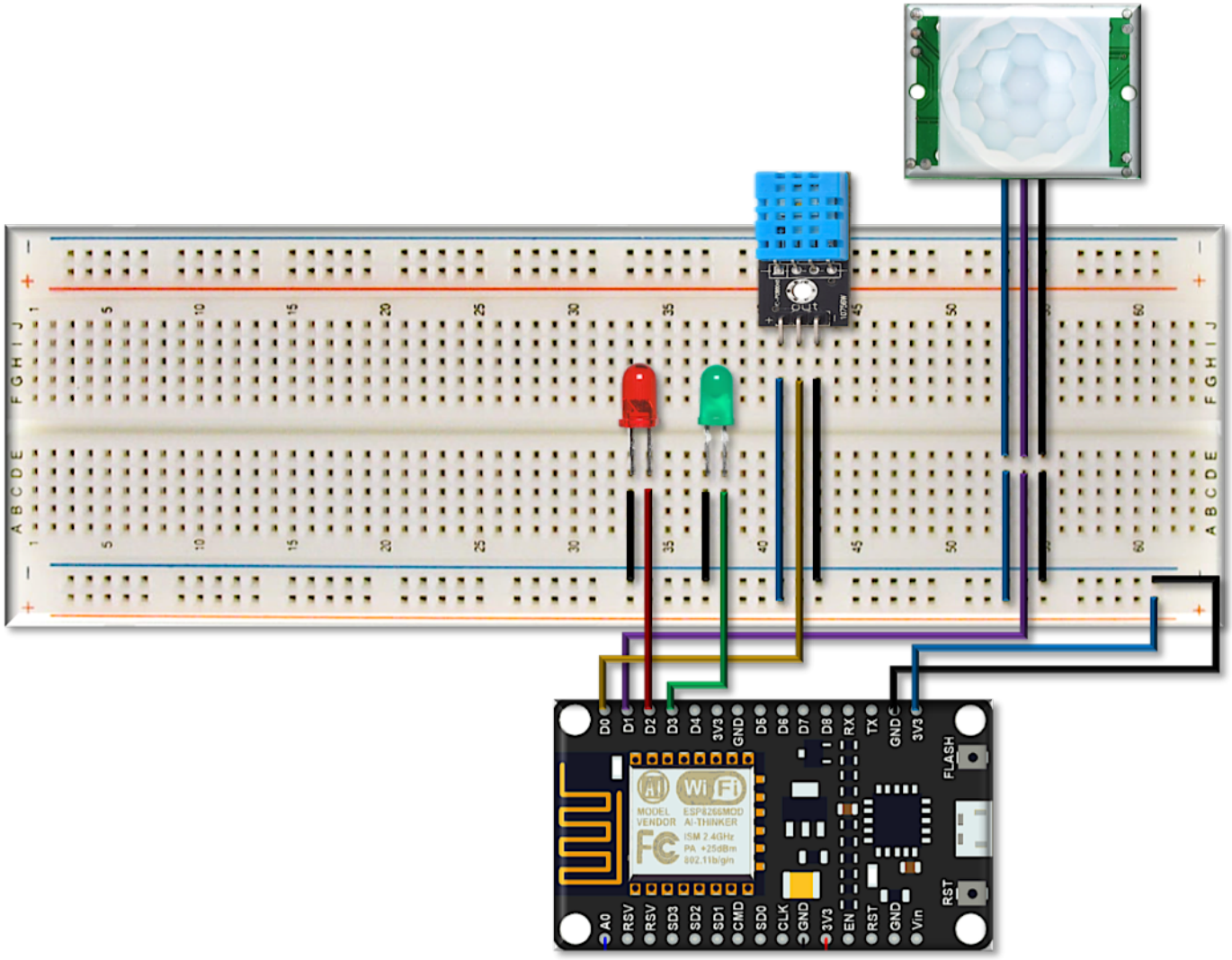


Figure 6: Electrical Design

NodeMCU/ESP8266 is the brain of this internet of Things (IoT) based home automation system. The DHT11 temperature sensor detects the temperature, it is connected to the digital pin 0 (D0) of the NodeMCU. The PIR motion sensor detects motion in the room, it is connected to the digital pin 1 (D1) of the NodeMCU. The red LED is used to mimic the working of an Air Conditioner (AC) which is connected to the digital pin 2 (D2) of the NodeMCU, and the green LED is used to mimic the working of the Room Light which is connected to the digital pin 3 (D3) of the NodeMCU. The NodeMCU itself is powered via a micro USB cable connected to the computer, an external battery of 7-12V can also be used to power it. Using a battery can be beneficial as it is easy to carry, and it can be placed anywhere.

2.4 Software

The initial plan was to use ESPlorer IDE (Integrated Development Environment) to write the code for this project, but due to some technical difficulties, issues were faced with connecting the ESPlorer to the NodeMCU firmware. For that reason, Arduino IDE is used to write the code. The Arduino Integrated Development Environment is a cross-platform application that is written in functions from C/C++. It is used for writing and uploading programs to boards that are compatible with Arduino, hence, it is being utilised for this project.

Blynk

Blynk is an IOS and Android application designed for the Internet of things. The hardware can be controlled remotely with this application, it can display sensor data, store it and visualise it etc. (“Blynk”, n.d.). It can connect up to 400 hardware models such as Arduino, ESP8266, Raspberry Pi etc. It is a digital dashboard where the drag and drop widgets can be used to create a graphical interface for the project.

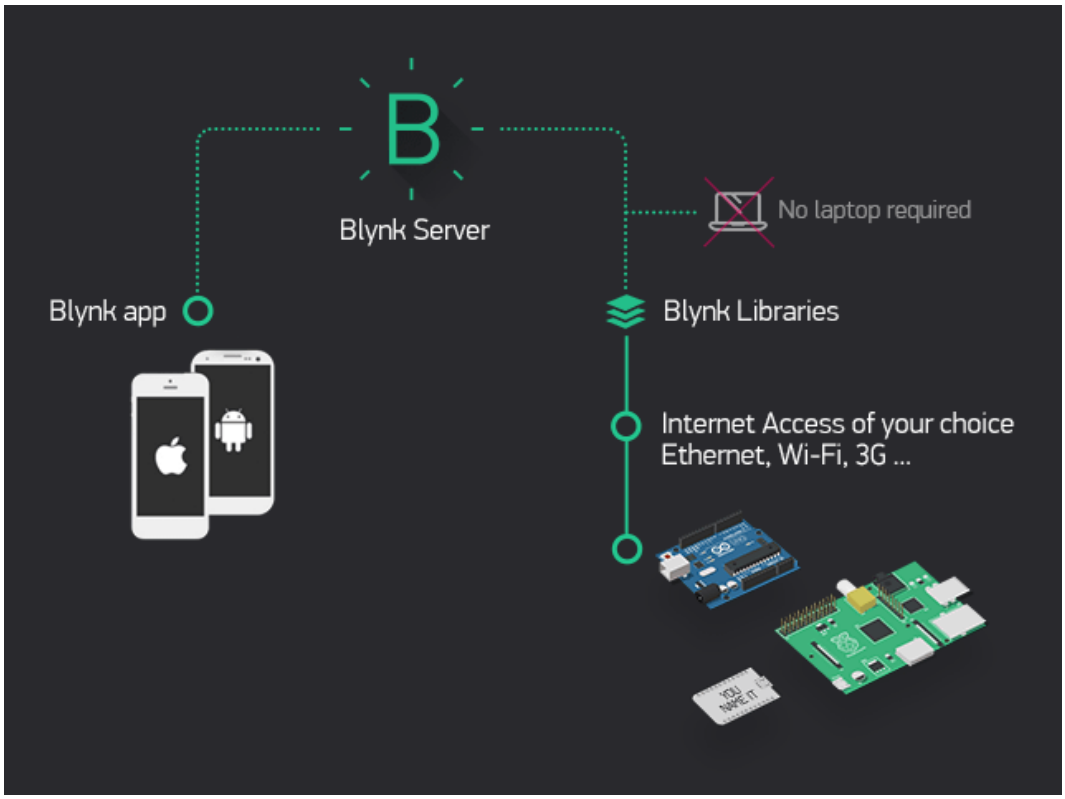
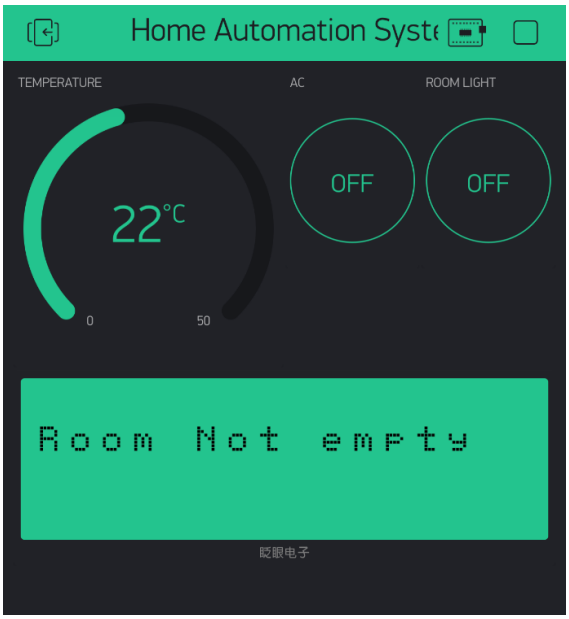
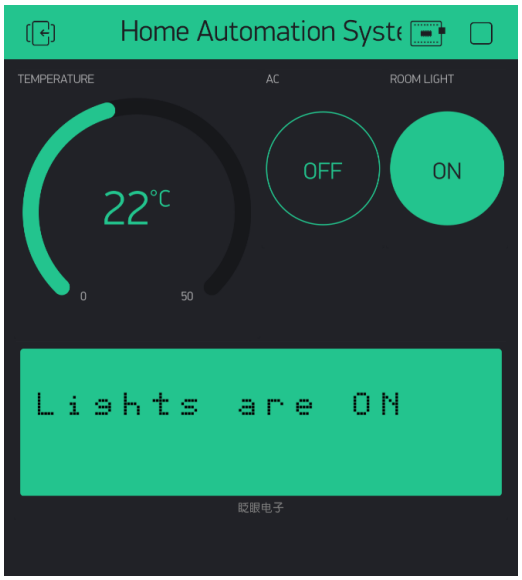
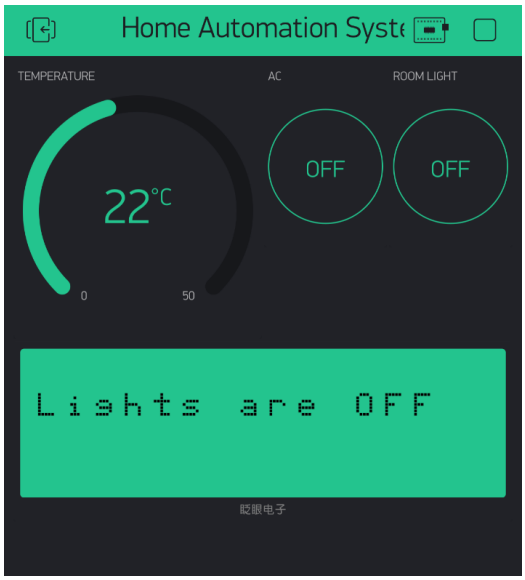


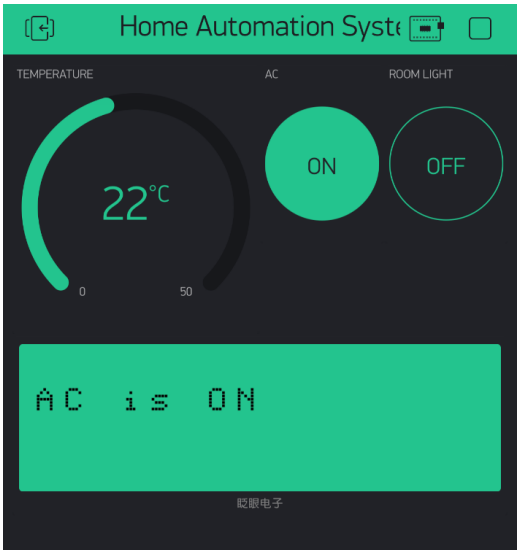
Figure 7: Blynk Architecture (“Blynk”, n.d.)

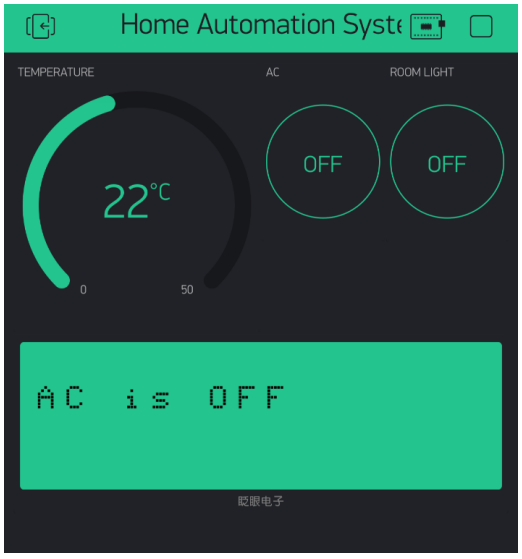
The following screenshots shows the design and working of Blynk for the Home Automation System.











2.5 Cost Estimation

The following table shows the cost of the components used:

	Components	Price
1	NodeMCU (ESP8266)	£4.99
2	PIR Motion Sensor	£3.36
3	DHT-11 Temperature Sensor	£2.80
4	Elegoo Upgraded Electronics Fun Kit	£15.99
		Total Price: £27.14

3 Discussion

3.1 Summary

In this project, a low-cost and energy-efficient Internet of Things based Home Automation System is created. The system used different sensors and peripherals to control and automate appliances. A free and easily accessible application called Blynk is used to control home appliances via the internet. This system controls an Air Conditioner and Room Light in a single room using sensor data from the mobile application. The temperature of the room can be monitored on the app, and the user can switch the Air Conditioner (AC) ON/OFF accordingly. The application will continuously inform the user if the room is empty or not, and the user can switch the lights ON/OFF accordingly.

3.2 Benefits

Benefits of this system:

- The home appliances are managed from one place. All the technology in the home can be connected through one interface.
- Being able to control the functions of the home from a distance. The AC can be switched ON, so the house becomes cooler before someone gets home. The app can be checked to see if the lights were left ON.
- Energy-efficiency and improved appliance functionality.
- Flexible so new appliances and devices can be easily integrated with this system.
- This Home Automation System is very cost-efficient compared to other Internet of Things based solutions. It can be used with appliances; old appliances are not required to be replaced.

3.3 Limitations

Limitation of this system:

- This system cannot be used without a good and strong internet connection, the homeowners will not be able to control the appliances. No internet connection means the system cannot be accessed or controlled.

- Installing Home Automation System can be difficult for an individual with limited knowledge of programming and NodeMCU, it usually costs money to hire someone professional to do it for them.
- It may require extensive wiring or other components which can add to the costs.

3.4 Solution and Suggestions

Solutions to the limitations:

- Other kinds of Internet of Things platforms can be used that can be installed on the local machines and work locally without the internet, though, they require Wi-Fi signals. Some examples include Kaa IoT Platform, Thinger, ThingsBoard.io, etc.
- Wi-Fi doesn't have to be used. Blynk application can communicate with the micro-controllers through other communication protocols. Bluetooth can be a good option is the range doesn't exceed 10 meters.
- Wiring problems can be resolved with printed circuit board (PCB) design where a single device can be acquired as a small PCB chip, another copy of the PCB chip is required to add another device.
- The system can be designed in a more user-friendly way to allow users to add more devices easily. Every micro-controller has a unique ID stored in its memory, new widgets need to be added in the application for new devices, that ID is what differentiates the devices from each other.

References

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ESP8266 NodeMCU. Retrieve from https://cityos-air.readme.io/docs/esp8266-nodemcu

PIR Motion Sensor. (2014). Retrieved from https://learn.adafruit.com/pir-passive-infrared-proximity-motion-sensor