ENERGY SPARING SMART CABIN SYSTEM USING YOLO ALGORITHM AND DEEP LEARNING ON RASPBERRY PI

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by

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CANDIDATES DECLARATION

We hereby certify that the work, which is being presented in the report, entitled **ENERGY SPARING SMART CABIN SYSTEM USING YOLO ALGORITHM AND DEEP LEARNING ON RASPBERRY PI** , in partial fulfillment of the requirement for the award of the Degree of **Bachelor of Technology** and submitted to the institution is an authentic record of our own work carried out during the period *May 2019* to *July 2011* under the supervision of **Dr. Ritu Tiwari** and **Dr. Somesh Kumar**. We also cited the reference about the text(s)/figure(s)/table(s) from where they have been taken.

Date: Signatures of the Candidates

This is to certify that the above statement made by the candidates is correct to the best of my knowledge.

Date: Signatures of the Research Supervisors

ABSTRACT

A smart cabin is a work environment where innovation empowers and enables individuals to work better and smarter. Faster Sensors and automated systems capture real-time data in a smart-cabin setting. Better automation approaches are being thought of and being simulated every day, so energy conservation becomes critical too. Smart cabins work by detecting the presence of humans inside the cabin and automate the appliances. Efficient designs can be developed using Raspberry Pi and implementing inventive notions on it. Smart cabins are not a common choice around during this current timeline. A few years later, once the security features are well developed, then you would see people embracing the concept of smart cabins without any questions.

Keywords: Raspberry Pi, Pi camera module, PIR motion sensor, YOLO algorithm, FPS, Raspbian, deep neural network.

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Finally, we are grateful to our Institution and colleagues whose constant encouragement served to renew our spirit, refocus our attention and energy and helped us in carrying out this work.

(Abhay Chaturvedi) (Akansha Tiwari)

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ABBREVIATIONS

PIR	Passive Infrared
YOLO	You Only Look Once
MB	Megabytes
V	Volts
A	Amperes
fps	frames per second
GPIO	General Purpose Input/Output
USb	Universal Serial Bus
SD	Secure Digital
IDE	Integrated Development Environment

CHAPTER 1

Introduction

In commercial buildings, many times the offices and cabins have electrical devices left switched on, though people were not present in the room and this is a common occurrence in all our daily lives too. So this becomes of utmost importance that this non-renewable form of energy being wasted is conserved as much as possible. Many home automation techniques are already proposed and implemented as well, but many among them are not completely related to electricity conservation and others are not very efficient. So, the proposed energy saving home/ cabin automation system which could be used to detect the presence of a person inside the cabin and automatically adjust the state of electrical appliances to reduce power consumption. This is done by implementing object detection YOLO algorithm on Raspberry Pi and collaborating its output with that of a PIR sensor to switch on the lights on the presence of a human only. YOLO algorithm is actually capable of processing 30 FPS when used on a Pascal Titan X [1,2]. Here we use Raspberry Pi Model 3 B+. A formatted pen drive (8GB) is used and for an operating system, Raspbian is installed. Raspberry Pi is used because it is low-priced and is ideal for experimentation, unlike laptops and computers. PIR sensors are cheap to buy and easy to code. There are several PIR sensors like pyroelectric, motion sensors, passive infrared, here we use a PIR motion sensor [3].

CHAPTER 2

Literature Survey

Authors in [4], suggest a Raspberry Pi hardware coupled with a PIR sensor, Magnetic sensor and Gas detector to provide a ”safety feature” for automated homes. Raspberry Pi installation and how it is interfaced with a PIR sensor is explained in [3]. This article suggests an ”intruder detection system” (discussed later in this article) only by using a number of PIR sensors with Raspberry Pi. K. N. Ha, K. C. Lee and S. Lee in [5] suggest a ”Resident location system” using multiple PIR sensors attached to the ceiling of all the rooms. Another innovation includes [6], that according to user activity, analyses and cuts off the standby power consumed by devices not in use. As these papers suggest, there are several previous works done on Home Automation systems using Raspberry Pi and PIR sensors. Also, there have been several efforts made towards the YOLO algorithm independently like Pedestrian Detection Based on YOLO Network Model [7]. But, for the best of our knowledge, none of them have used a PIR motion sensor integrated Raspberry Pi that uses deep learning using the YOLO algorithm to control the lights in a cabin according to the presence or absence of a person inside.

CHAPTER 3

Requirements Analysis and Specification

3.1 Raspberry Pi

The Raspberry Pi is low cost small sized computer CPU that plugs in to screen and by the use of keyboard and mouse, it enables the computing opportunity. The version of Raspberry Pi which we used in our project is model 3 B+, 1.4 GHz Quad-core processor, dual-band wireless LAN, Bluetooth 4.2, and has faster ethernet. A model of Raspberry Pi 3 b+ is shown in Figure 3.1.

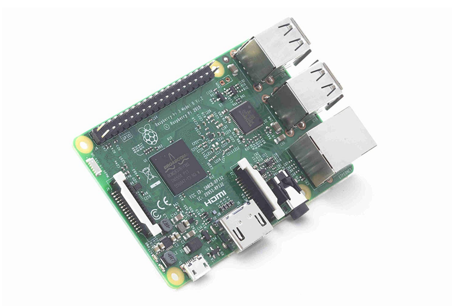

Figure 3.1: Raspberry Pi [8].

3.2 Pi Camera Module

The Raspberry Pi camera, as shown in Figure 3.2, is a high quality 5 megapixel Sony IMX219 image sensor custom designed add-on board for Raspberry Pi. In terms of the still image, the camera is capable of taking 3280x2464 pixel static image [9].

Figure 3.2: Raspberry Pi camera module [10].

3.3 PIR Sensor

A passive infrared sensor(PIR) is an electronic sensor that reads infrared radiation and outputs signal on detecting the motion of an object in its file of view. A PIR sensor is shown in Figure 3.3.

Figure 3.3: PIR Sensor [11].

3.4 Breadboard

A Breadboard is an electronic board that is used to design and test the circuit. See figure 3.4.

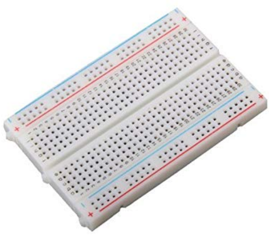

Figure 3.4: Breadboard [12].

3.5 LED

A light emitting diode (LED) is a semiconductor that emits lights of different colors when passed electricity to it. See Figure 3.5.

Figure 3.5: Light Emitting Diode (LED) [13].

3.6 Resistors

Resistors are the components used to reduce the flow of current in the circuit. See Figure 3.6.

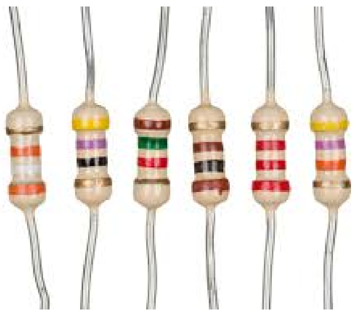

Figure 3.6: Resistors [14].

CHAPTER 4

System Design, Project Description and Methodology

4.1 System Design

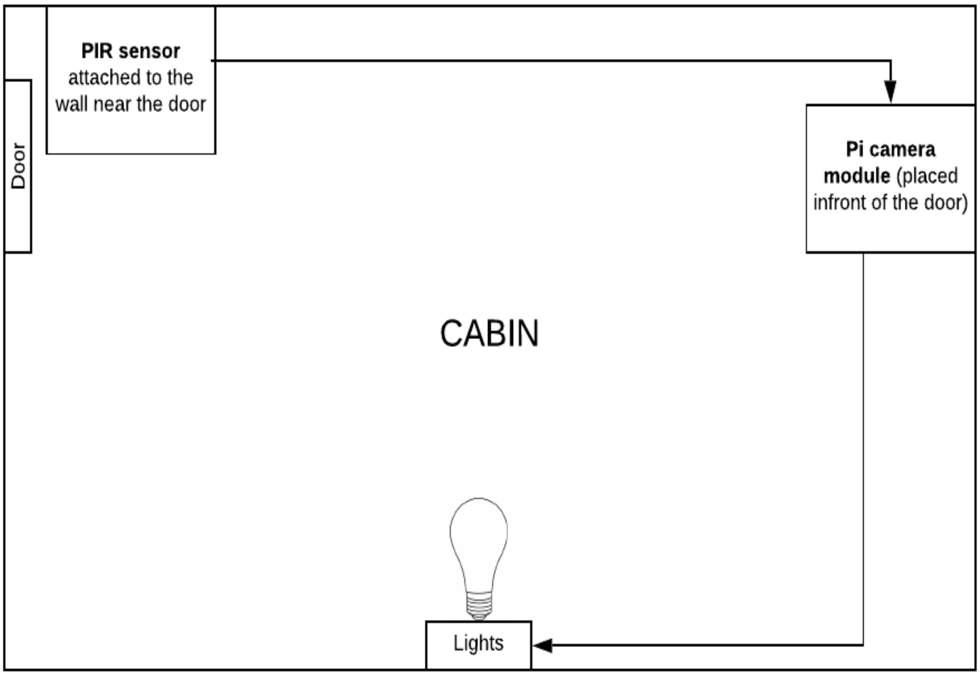

Figure 4.1: Block Diagram of Smart cabin system.

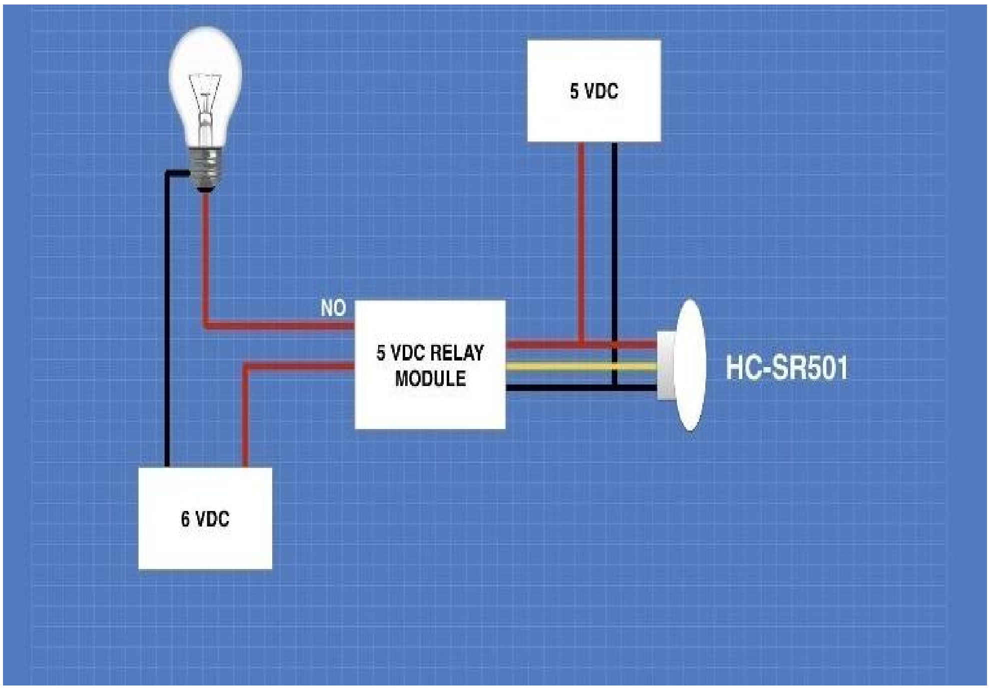

Figure 4.2: Circuit Diagram of PIR sensor with a bulb [15].

4.2 Project Description and Methodology

The basic working would comprise of PIR sensor detecting the movement of the door, which would allow Raspberry Pi to switch on the light for a specified time, say 20 seconds. This would be enough for the camera attached with Raspberry Pi to detect if a person has entered the cabin or not. If yes, then the system would keep the lights on until the person is present in the room. The lights then go off when the person leaves the cabin. If no, then the system would switch off the lights. To elaborate, a neural network model using the YOLO algorithm is trained in the laptop by using datasets and obtaining a frame rate of 5-6 frames per second [2]. The original algorithm was capable of detecting and distinguishing between 9000 objects, which was then minimized to 20 objects only [16]. Since Raspberry Pi has memory limited to just 512MB or 256MB only, we train the model in our laptops and minimize the model and then place it on Raspberry Pi. Raspberry Pi with its camera module would do the same. Raspberry Pi is then coupled with a PIR sensor, which is placed at the wall near the door. The PIR sensor gives an output to Pi when the door moves, Pi then switches on the light for 20 seconds(as programmed) and then Pi camera senses the surroundings and Raspberry Pi then uses the trained neural network model to identify if a person has entered the room or not. If a person has entered the room and camera module and neural network model confirms it, then the lights stay on till the time presence is detected, else the lights go off. The 20-second condition is based on the case where a person may open the door but not enter it. If this was not programmed then even if a person enters the room and enough light is not available for the camera, it would not be able to draw a fitting conclusion about the presence of a person. PIR motion sensors are highly sensitive and work for a range of 6-7 meters. As soon as the sensor detects the presence of a human, it sends a signal, as illustrated in Figure 4.4, of 5V for a minute. After that, Raspberry Pi receives this signal using GPIO [17]. A PIR Sensor connected to Raspberry Pi through GPIO is shown in Figure 4.3

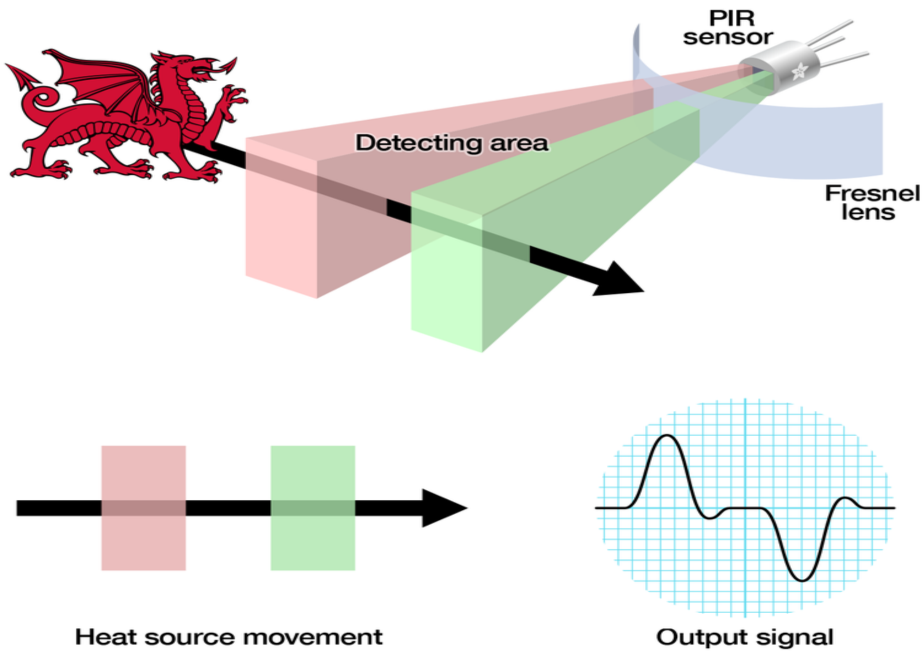

Figure 4.3: Working of PIR Sensor [18].

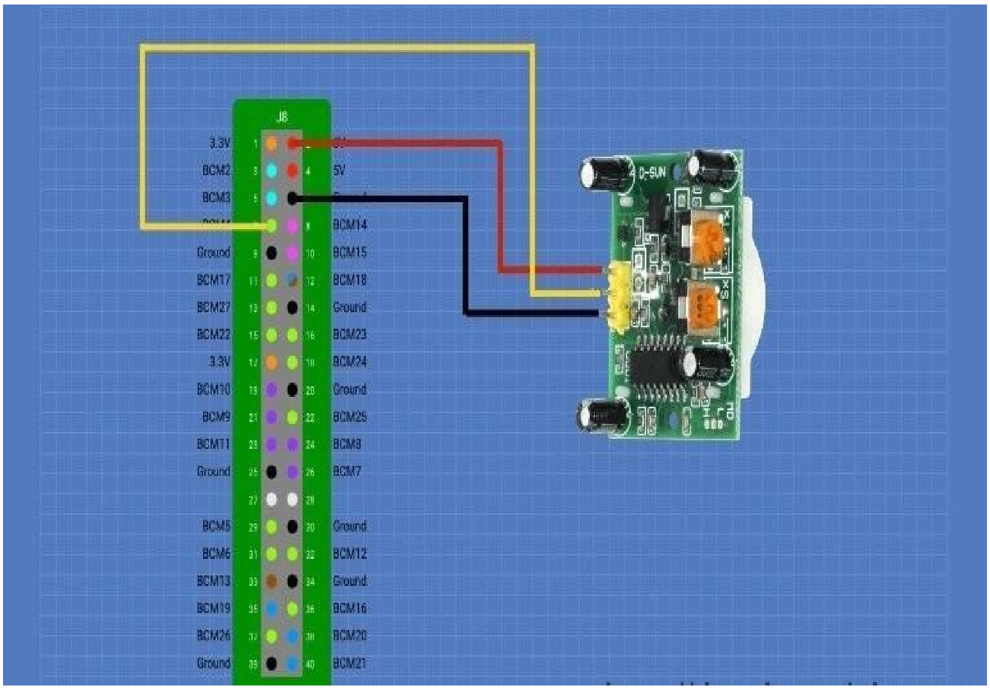

Figure 4.4: PIR Sensor connected to Raspberry Pi through GPIO [15].

CHAPTER 5

Implementation Results

YOLO algorithm, that initially consisted of 9000 object detection information was minimized to 20 objects only. This resulted in an increase in frames per second from 1-2 fps to presently operating at 5-6 frames per second on a computer. Raspberry Pi was configured using a USB drive in place of an SD card and Raspbian was installed as an operating system in Raspberry Pi. Person detection was successfully carried out after using YOLO on Raspberry Pi and an LED was tested. Pi module takes 6-7 seconds to catch an image, process it and use the object detection algorithm to confirm the human presence, and to accordingly switch on the LED lights. This process repeats every 6-7 seconds. This delay of 7 seconds is obtained because of the image capture and processing speed of the Raspberry Pi. This routine is repeated every 6-7 seconds, so if no presence is detected the lights switch off. Further efforts include to connect the PIR sensor to help the camera gain vision during dark hours and attachment of relay to an extension to allow further amendments and append extra functionalities.

5.1 Test Cases and Test Results

Case 1: When no human is detected via the camera.

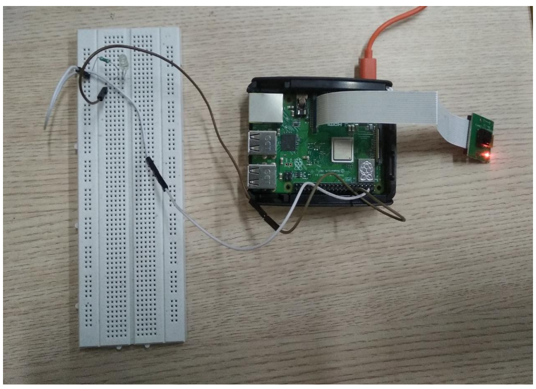

Figure 5.1: LED off when no human is detected.

Case 2: When a human is detected via the camera.

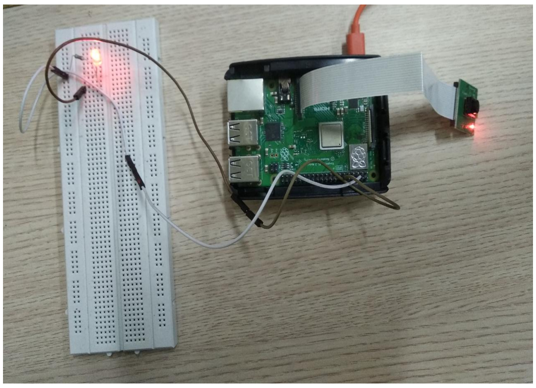

Figure 5.2: LED go on when no human is detected.

Case 3: When lights are on and no human is detected for a span of 6-7 seconds, lights go off automatically.

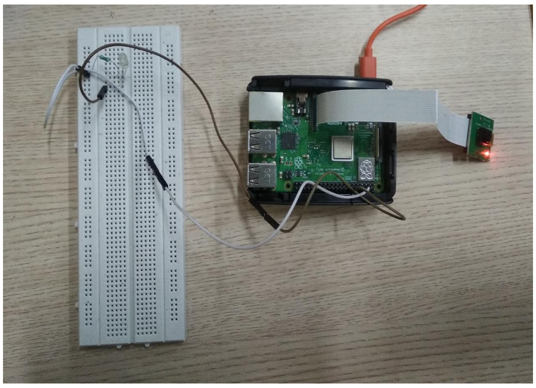

Figure 5.3: LED off when no human is detected.

CHAPTER 6

Screenshots of Project with Descriptions

6.1 Raspberry Pi with camera module

As Figure 6.1 indicates, the red light on the camera is on, which means the camera is in processing mode.

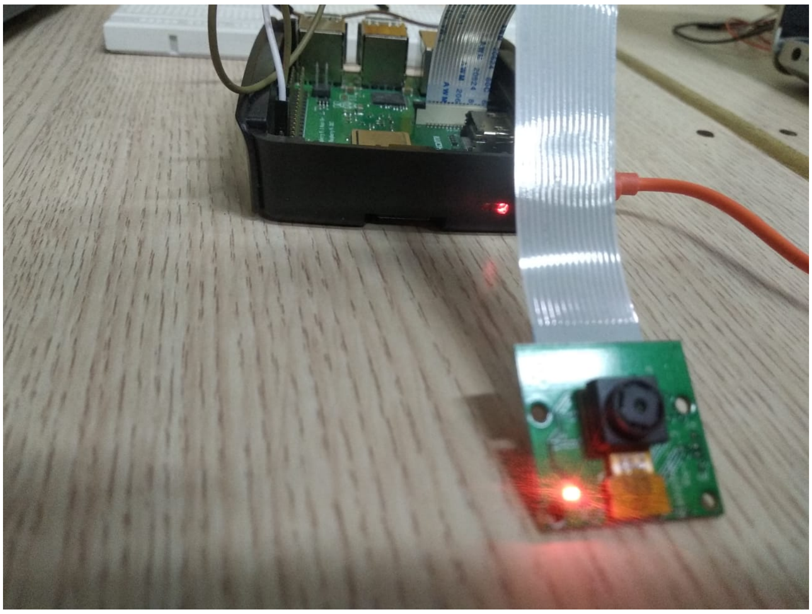

Figure 6.1: Raspberry Pi with camera module.

6.2 Human detection done by YOLO algorithm

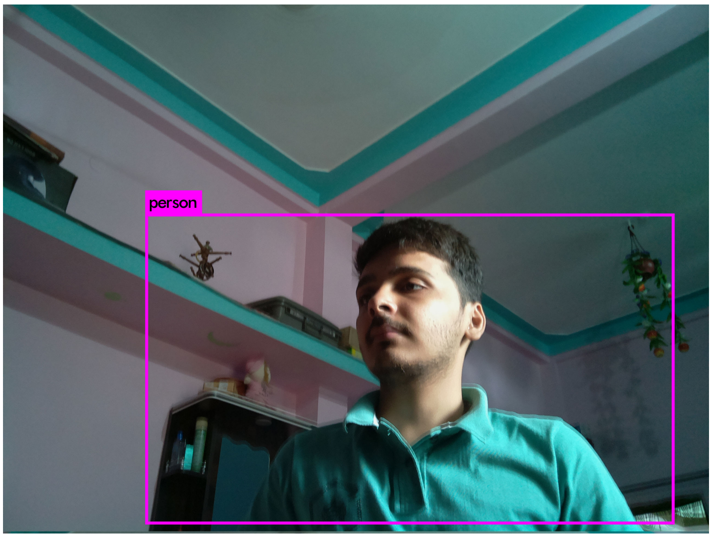

Figure 6.2: Person detected by camera module.

6.3 Output of the LED on Pi IDE

Every 7 seconds an image is processed and evaluated and the status of LED is displayed as in Figure 6.3.

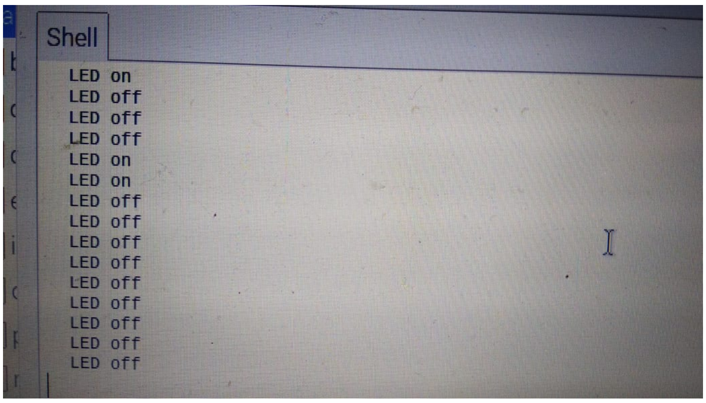

Figure 6.3: Pi IDE.

6.4 Representation of the system as a black box

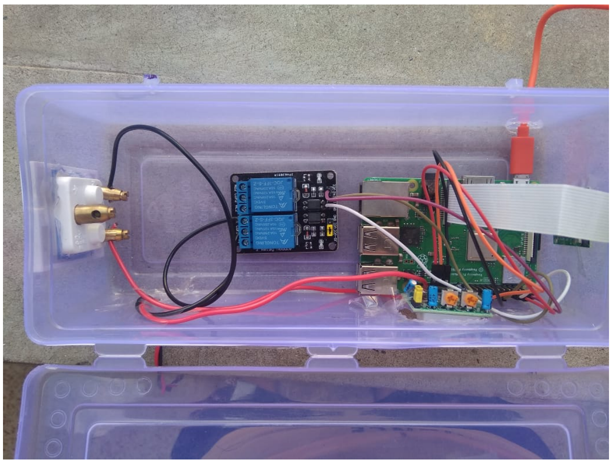

Figure 6.4: Prototype circuit of the final smart cabin system.

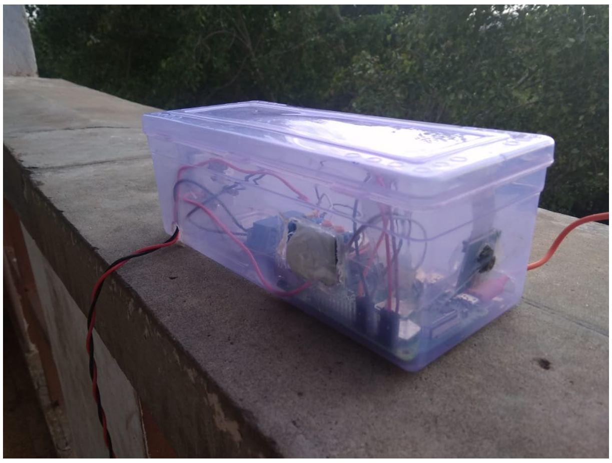

Figure 6.5: Camera and PIR sensor at the shown ends of the black box.

Figure 6.6: Socket to plug in electricals.

CHAPTER 7

Conclusion and Future Scope

7.1 Conclusion

At the end of the day, it is about energy consumption and smart ways to reduce it. This article introduced an automated light system, which works with a neural network model working in the PIR sensor coupled Raspberry Pi. This article proposed a raw model of a smart cabin, which switches on the lights when a person enters the room, which is determined by the neural network model and switches them off as the person leaves. The better part of the proposal is Raspberry Pi which is open to any new adjustments we are willing to make. The challenge faced was to couple the output of the neural network model with that of the PIR sensor in the Raspberry Pi IDE. There have been many home automation systems proposed and applied with Raspberry Pi, but as specified earlier, according to our knowledge, none of them uses a neural network on Raspberry Pi with the YOLO algorithm.

7.2 Future Scope

Raspberry Pi is equivalent to a mini-CPU, so countless ideas and their applications are possible. Also, machine learning is a very broad territory and therefore the algorithm used is open to a variety of programmable and advanced results [19]. This article is a response to a time-bound problem of smart cabins at hand. However, further progress can be made in terms of energy savings. Light sensors can be tied to the system and can detect if lights are really required to be switched on or daylight available is enough. This will save every 20 seconds of energy that are exploited to switch on the lights for the camera module to detect human presence. Further, each day new technologies are being introduced, so a series of smart and less power consuming bulbs are developed, they can be coupled with the proposed system [20]. Another easy alternative would be to use a night-vision camera for Raspberry Pi, which is a little costly than a normal camera. That would solve the problem of having to switch on the light every time the PIR sensor detects movement of the door. This would even eliminate the PIR sensor from the system. And this would also be a feasible alternative considering Raspberry Pi uses a current of only 2.5A [21]. With lights, several other appliances that we use are required only in our presence, like fans, coolers, and ACs. These can also be programmed in the system, thus saving a lot of energy. The smart cabin system is not only limited to cabins/ offices but can be extended to corridors and homes. An optimized objected detection system can be developed using a probabilistic image based model and manipulating the camera characteristics [22]. An advanced version of the YOLO algorithm can be developed and modified to count and identify the names of people present in a room and thus solving the problem of the daily hassle faced during the attendance in classrooms. Further, using the same face-detection technique an ”intruder alert system” can be developed [16]. Another future application can support ”home security”. The same system consisting of Raspberry Pi can be paired with a temperature sensor, an alarm and a mail sending system in a home, which gets active if a programmed value, say 50 degree Celsius is exceeded. If the condition arises Raspberry Pi would switch on the alarm and a mail will be sent to the resident about the threat [4]. Further, the same system can be optimised and added with suggested components in [23] to monitor fall detection for elderly person using posture detection. The same has been suggested using a convolutional neural network in [24].

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