Object following Robot using Computer vision

ELEG/CPEG 475- Capstone Design Project I

Project Members :

Ali AL-Juraidan s00038341

Ali Jraggh s00043391

Bader AL-Mazeedi s00034811

Project Supervisor(s)

Amro Nour

Department of Electrical & Computer Engineering

AMERICAN UNIVERSITY of KUWAIT

Jan 7 2020

Abstract

This paper introduces a vision based object tracking robot which is driven by wheels and controlled by a raspberry pi that runs a dedicated software for image processing. The objective of this project is to design a robot which is automatically controlled by on board raspberry pi to track and follow a colored object. Robot will analyses the video stream to detect the colored ball, then using video array it will specify the location of the ball inside the video frame and depending on the current position the raspberry pi will decide to rotate right or left or to go forward until reaching the object. Set of software and packages are used to do this task, for the raspberry pi the operating system is Raspian with installed package of open CV, also hardware is required to accomplish this mission like the motors and the motors driver and the power supply.at the end the robot will automatically detect the object and move toward it until reaching it then stop.

Table of content

Table of Figures

List of tables

Chapter One: Introduction

1.1 Introduction

Object detection is a computer technology related to computer vision and image processing that deals with detecting instances of semantic objects of a certain class (such as humans, buildings, or cars) in digital images and videos. Well-researched domains of object detection include face detection and pedestrian detection. Object detection has applications in many areas of computer vision, including image retrieval and video surveillance. [1]

A robot is a machine especially one programmable by a computer capable of carrying out a complex series of actions automatically. Robots can be guided by an external control device or the control may be embedded within. Robots may be constructed on the lines of human form, but most robots are machines designed to perform a task with no regard to their aesthetics. [2]

Robots can be autonomous or semi-autonomous and range from humanoids such as Honda's Advanced Step in Innovative Mobility (ASIMO) and TOSY's TOSY Ping Pong Playing Robot (TOPIO) to industrial robots, medical operating robots, patient assist robots, dog therapy robots, collectively programmed swarm robots, UAV drones such as General Atomics MQ-1 Predator, and even microscopic nano robots. By mimicking a lifelike appearance or automating movements, a robot may convey a sense of intelligence or thought of its own. Autonomous things are expected to proliferate in the coming decade, with home robotics and the autonomous car as some of the main drivers. [2]

The branch of technology that deals with the design, construction, operation, and application of robots, as well as computer systems for their control, sensory feedback, and information processing is robotics. These technologies deal with automated machines that can take the place of humans in dangerous environments or manufacturing processes, or resemble humans in appearance, behavior, or cognition. Many of today's robots are inspired by nature contributing to the field of bio-inspired robotics. These robots have also created a newer branch of robotics: soft robotics.

From the time of ancient civilization there have been many accounts of user-configurable automated devices and even automata resembling animals and humans, designed primarily as entertainment. As mechanical techniques developed through the Industrial age, there appeared

more practical applications such as automated machines, remote-control and wireless remote-control. [2]

Figure 1 Robots

1.2 Problem statement

A big drawback in modern surveillance systems that it relies on human operators which can easily be distracted or make any mistaken decisions, so we need a system which can autonomously monitor a region continuously, making decisions while identifying the pre trained objects . Object tracking in this system using open CV computer vision is important in achieving automated surveillance and tracking.

1.3 Project description

This system will use the computing power of the raspberry pi minicomputer to capture a video stream from a camera, then using dedicated software to develop an application to detect an object from the video stream.

The tracking information will be used to steer a robot motors in the desired direction so the robot will follow the tracked object.

1.4 Project idea and Block diagram
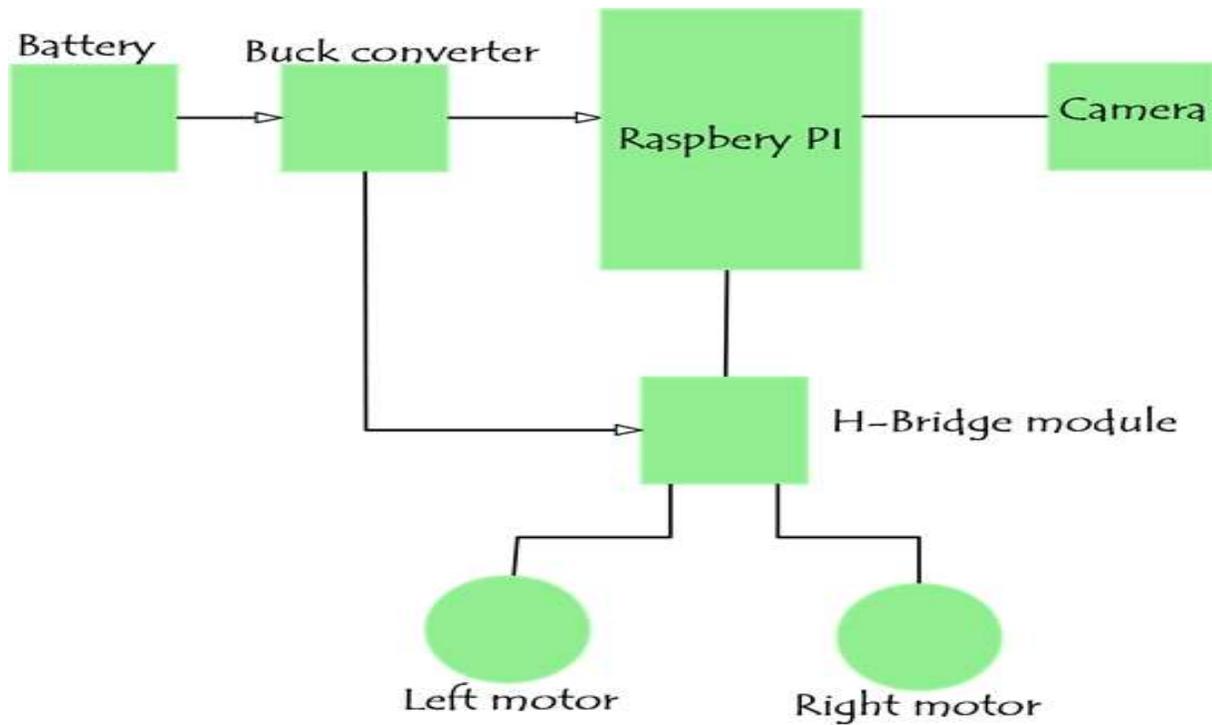
Figure 2 Block diagram

Figure above shows the block diagram of the system, the raspberry will read the video stream from the video cam.

There are two motors the will move the robot in all direction (forward, right, left, reverse) and the H-bridge is to interface the motors with the minicomputer.

1.5 Potential does it have

The possibilities are endless when it comes to future use cases for object detection.

1.5.1 Sports broadcasting

will be utilizing this technology in instances such as detecting when a football team is about to make a touchdown and notifying fans via their mobile phone or at-home virtual reality setup in a highly creative way. [4]

1.5.2 Video collaboration

Business leaders will be able to count the number of participants within a meeting to help them automate the process further and monitor room usage to ensure spaces are being used properly. A

relatively new "people counting" method that detects heads rather than bodies and motion will allow for more accurate detecting to take place, in crowded places specifically (IEEE), which will enable even more applications for the security industry. [4]

1.5.3 Security industry

The future of object detection has massive potential across a wide range of industries. We are thrilled to be one of the main drivers behind real time intelligent vision, high performance computing, artificial intelligence and machine learning, which has allowed us to create a solution that will never distort video, allowing for various AI capabilities which other companies simply cannot enable.[4]

1.6 Contribution

Object detection is a computer technology related to computer vision and image processing that detects and defines objects such as humans, buildings and cars from digital images and videos (MATLAB). This technology has the power to classify just one or several objects within a digital image at once. Object detection has been around for years, but is becoming more apparent across a range of industries now more than ever before. Object detection is a key ability required by most computer and robot vision systems. The latest research on this area has been making great progress in many directions. The computer vision industry is projected to hit $48.6 billion by 2022, with applications in industries ranging from video collaboration and medicine to education and security. Computer vision provides machines with the ability to see and visually sense the world around them, similar to how humans use their own eyes. It pertains to the automatic extraction, analysis and understanding of useful information from one or several images (BMVA.org). Object detection is one form of computer vision that's gaining momentum in both the enterprise and consumer-facing tech communities. [4]

1.7 Benefits

Using this project will apply the computer vision in monitoring and controlling real object in real time without the human supervision.

1. System will keep monitoring the video for long time without being tired
2. System will continue detecting the objects in real time without mistakes because no human is involved in the system.

3. This system can be used to track dangerous objects like disassembling pumps without putting any human life in risk.

Chapter Two: Literature Review

2.1 Historical Background

A literature review discusses published information in a particular subject area, and sometimes information in a particular subject area within a certain time period. A literature review can be just a simple summary of the sources, but it usually has an organizational pattern and combines both summary and synthesis.

Each project will be summarized with details about the components and the designed implementation.

2.1.1 Real Time Object Counting using Raspberry pi

The main intention of this project is developing an algorithm that can count and identify the objects in a given scene by using Raspberry pi on real time basis. Features of an image containing objects to be detected are extracted uses a method called BLOB (Binary Large Object) analysis. This method is used so as to identify the objects/regions called BLOBs using pixel connectivity and further more parameters like area, centroid, and number of BLOBs available in the test image. Preprocessing of the input test image is done prior to the BLOB analysis like thresholding to get a binary image. The number of objects identified is displayed or read out using a speaker interfaced to the hardware. The hardware Raspberry Pi, running with UBUNTU (Ubuntu is an open source software operating system that runs from the desktop, to the cloud, to all internet connected things) operating system flashed into a memory card, works as a standalone device with the Raspberry Pi camera being used as an image acquisition device to constantly capture image frames of objects of interest. [5]

Figure 4 below shows the block diagram of project model. At first the RPI camera is connected to Raspberry pi and object counting program is performed in SIMULINK. In order to know how

many objects are counted within particular area we will connect the speaker to Raspberry pi it speaks the counted object number.
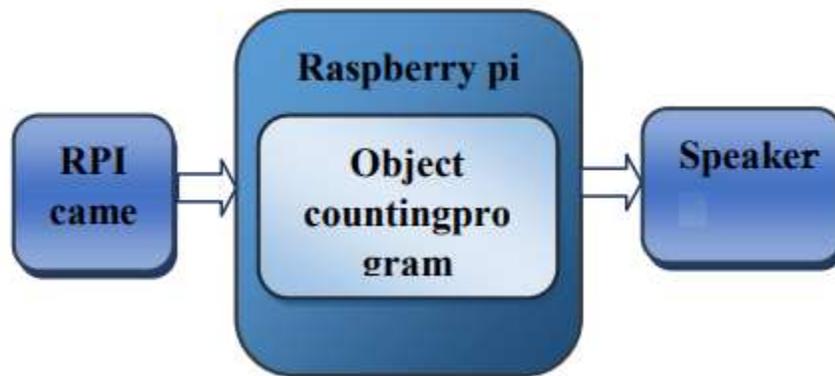
Figure 3 Real Time Object counting using Raspberry pi block diagram

Here the object counting is done using the following three steps that is

1. Thresholding: The process of thresholding is a gray-scale image will be converted into a binary image (that is the image consisting only black and white pixels).
2. Blob analysis: BLOB analysis is one of the fundamental techniques and it consist a set of related (connected) pixels in a binary image. In image processing a BLOB is described as area (region) of connected pixels.
3. Cell segmentation: Segmentation of cells is the fundamental approach method in digital image processing. In that cells were divided from the image back ground by using the foreground-back ground intensity is based on pre-processing step. [5]

2.1.2 Development of an obstacle avoiding

The overall robot construction has been designed in such a way that the robot is small enough and light weighted. A small robot, by physical advantage due to lower sensor position, is more responsive to small obstacles. It will be able to run on the floor of a room, approaching obstacles

of big and small sizes before it decides to avoid them. While, the light weight gives an advantage of battery energy saving. [6]

The system uses two lithium-ion batteries of the same voltage, that is, 4.2v. One battery is to supply the microcontroller and another one is to supply the interface module and the motors. the interface module has been designed to set the two motors in a serial connection. Direction of each motor is determined by a relay's state, that's controlled by the microcontroller.

The module employs 3 sets of sensor; each consists of a blue LED and a visible light photo diode. Blue LEDs are chosen due to their highest energy efficiency compared to LEDs of other colors. It is also explained that each photodiode will receive blue light waves off its paired LED that are reflected by an obstacle residing in front of it, within a certain range of distance. This proximity sensor module has ability to detect not only an obstacle residing in the front but also those residing at right front and left front sides. It has three sensor sets that are located and directed at three different situations. The first one is located at center and directed to the front. The second one is located at the right and directed to the right front. The third one is located at the left and directed to the left front. [6]

Figure 4 an obstacle avoiding robot

2.1.3 Microcontroller based Visible Light Follower Robot

The main aim of this Project is to design a Robot which is capable of following light and it automatically stops when there is no light available in its presence. [7]

In this project Light Dependent Resistance to detect the Light was used; it is a special type of resistance whose value depends on the brightness of light, which is falling on it. It has resistance of about 1mega ohm when in total darkness, but a resistance of only about 5k ohms when brightness illuminated. It responds to a large part of light spectrum. The controlling device of the whole unit is a Microcontroller to which input and output modules are interfaced. The Microcontroller is programmed in Embedded C language which intelligently performs the specific task. Here, the Microcontroller gets input from the LDR's attached to the robot. This input is processed by controller and acts appropriately on the motors of the Robot. [7]

- **Features of The project**
    1. Can be easily monitored.
    2. Moves in the direction of light
    3. Ease in understanding the working module.
    4. Easy to operate.
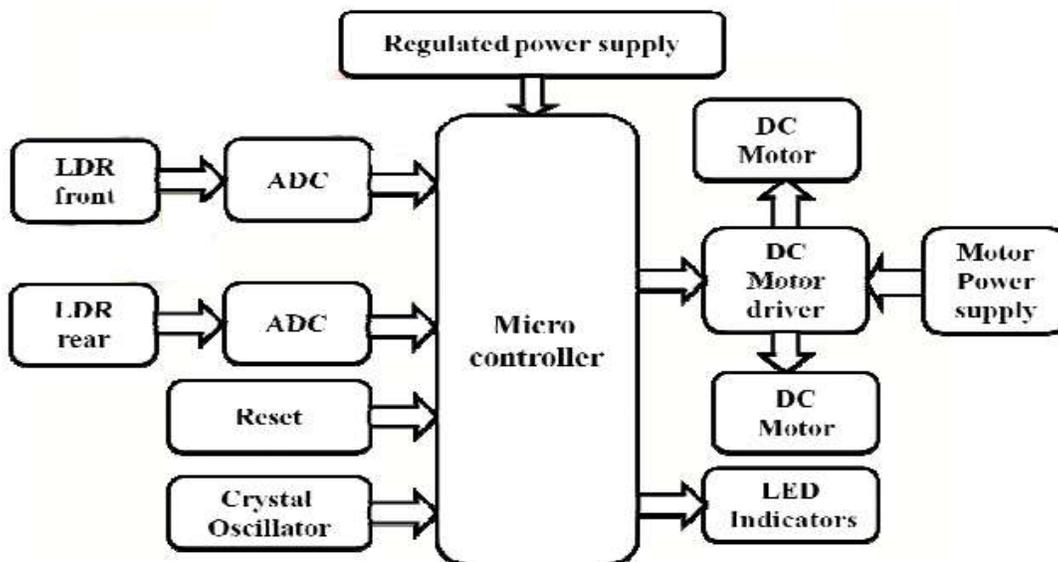
Figure 5 Microcontroller based Visible Light Follower Robot   block diagram

2.1.4 Radio Frequency (RF) Controlled Wireless Robot

RF controlled robot is controlled by using Four push button placed at transmitter side. Here users only need to push the buttons to control the robot. A transmitting device is used in user hand which also contains a RF Transmitter and a RF Encoder. This transmitter part will transmit command to robot so that it can do the required task like moving forward, reverse, turning left, turning right and stop. All these tasks will perform by using four push buttons that are placed on RF transmitter. [8]

- **Working of RF Controlled Robot:**

RF controlled robot move according to button pressed at Transmitter.

Button Pressed at Transmitter	Moving Direction of Robot
First (1)	Left
Second (2)	Right
First and Second (1 & 2)	Forward
Third and Fourth (3 & 4)	Backward
No Button Pressed	Stop

Table 1 Working of RF Controlled Robot

Figure 6 Radio Frequency (RF) Controlled Wireless Robot

Chapter Three: Hardware and Software Requirements

In this section of the documentation we are going to list the complete required hardware to build up the system with an explanation for each part with its main features as well. Also the project requires software to run on the raspberry pi operating system this will be explained too.

3.1 Hardware Requirements

3.1.1 Raspberry pi

Raspberry Pi 4 Model B is the latest product in the popular Raspberry Pi range of computers. It offers ground-breaking increases in processor speed, multimedia performance, memory, and connectivity compared to the prior-generation Raspberry Pi 3 Model B+, while retaining backwards compatibility and similar power consumption.

For the end user, Raspberry Pi 4 Model B provides desktop performance comparable to entry-level x86 PC systems.

This product's key features include a high-performance 64-bit quad-core processor, dual-display support at resolutions up to 4K via a pair of micro-HDMI ports, hardware video decode at up to 4Kp60, up to 4GB of RAM, dual-band 2.4/5.0 GHz wireless LAN, Bluetooth 5.0, Gigabit Ethernet, USB 3.0, and PoE capability (via a separate PoE HAT add-on).

The dual-band wireless LAN and Bluetooth have modular compliance certification, allowing the board to be designed into end products with significantly reduced compliance testing, improving both cost and time to market. [9]
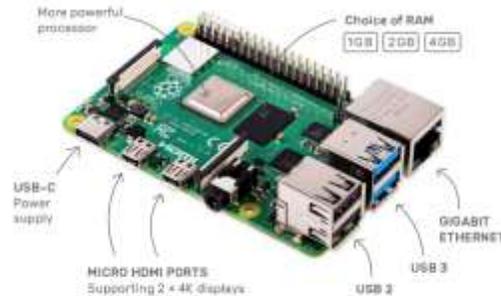
Figure 7 raspberry pi 4 layouts

1. Broadcom BCM2711, Quad core Cortex-A72 (ARM v8) 64-bit SoC @ 1.5GHz
2. 1GB, 2GB or 4GB LPDDR4-3200 SDRAM (depending on model)
3. 2.4 GHz and 5.0 GHz IEEE 802.11ac wireless, Bluetooth 5.0, BLE
4. Gigabit Ethernet
5. 2 USB 3.0 ports; 2 USB 2.0 ports.
6. Raspberry Pi standard 40 pin GPIO header (fully backwards compatible with previous boards)
7. 2 × micro-HDMI ports (up to 4kp60 supported)
8. 2-lane MIPI DSI display port
9. 2-lane MIPI CSI camera port
10. 4-pole stereo audio and composite video port
11. H.265 (4kp60 decode), H264 (1080p60 decode, 1080p30 encode)
12. OpenGL ES 3.0 graphics
13. Micro-SD card slot for loading operating system and data storage
14. 5V DC via USB-C connector (minimum 3A)
15. 5V DC via GPIO header (minimum 3A)
16. Operating temperature: 0 – 50 degrees C ambient [9]

- **GPIO (general-purpose input/output)**

A powerful feature of the Raspberry Pi is the row of GPIO (general-purpose input/output) pins along the top edge of the board. A 40-pin GPIO header is found on all current Raspberry Pi boards (unpopulated on Pi Zero and Pi Zero W). Prior to the Pi 1 Model B+ (2014), boards comprised a shorter 26-pin header. [10]
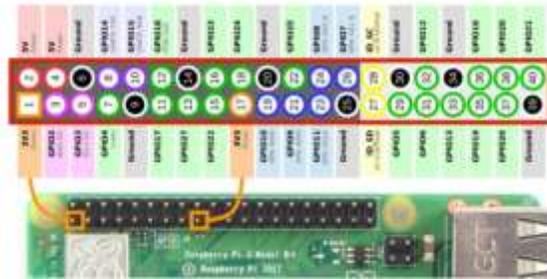

Figure 8 general-purpose input/output

Any of the GPIO pins can be designated (in software) as an input or output pin and used for a wide range of purposes. [10]

Two 5V pins and two 3V3 pins are present on the board, as well as a number of ground pins (0V), which are unconfigurable. The remaining pins are all general purpose 3V3 pins, meaning outputs are set to 3V3 and inputs are 3V3-tolerant.

A GPIO pin designated as an output pin can be set to high (3V3) or low (0V).

A GPIO pin designated as an input pin can be read as high (3V3) or low (0V). This is made easier with the use of internal pull-up or pull-down resistors. Pins GPIO2 and GPIO3 have fixed pull-up resistors, but for other pins this can be configured in software. [10]

3.1.2 Raspberry pi camera (Camera Module V2)

The v2 Camera Module has a Sony IMX219 8-megapixel sensor (compared to the 5-megapixel OmniVision OV5647 sensor of the original camera).

The Camera Module can be used to take high-definition video, as well as stills photographs. It's easy to use for beginners, but has plenty to offer advanced users.

 There are lots of examples online of people using it for time-lapse, slow-motion, and other video cleverness.

User can read all the gory details about IMX219 and the Exmor R back-illuminated sensor architecture on Sony's website, but suffice to say this is more than just a resolution upgrade: it's a leap forward in image quality, colour fidelity, and low-light performance. It supports 1080p30, 720p60 and VGA90 video modes, as well as still capture. It attaches via a 15cm ribbon cable to the CSI port on the Raspberry Pi.

The camera works with all models of Raspberry Pi 1, 2, 3 and 4. It can be accessed through the MMAL and V4L APIs, and there are numerous third-party libraries built for it, including the Picamera Python library. [11]

The camera module is very popular in home security applications, and in wildlife camera traps.
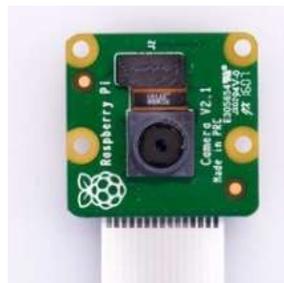
Figure 9 Raspberry pi cameras (Camera Module V2)

3.1.3 Robot chassis

- **DC Motor**

A DC motor is any of a class of electrical machines that converts direct current electrical power into mechanical power. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic; to periodically change the direction of current flow in part of the motor. Most types produce rotary motion; a linear motor directly produces force and motion in a straight line. DC Motor has been used for movement of the robot [12]

Figure 10 Robot chassis

3.1.4 Lithium battery

Lithium-ion is a low maintenance battery; an advantage that most other chemistries cannot claim. There is no memory and no scheduled cycling is required to prolong the battery's life. In addition, the self-discharge is less than half compared to nickel-cadmium, making lithium-ion well suited for modern fuel gauge applications. lithium-ion cells cause little harm when disposed.[13]

O.	Items	Specifications
1	Charge voltage	4.2V
2	Nominal voltage	3.7V
3	Nominal capacity	5000mAh @ 1/3C Charge & Discharge
4	Charge current	Standard Charging/Discharging: 0.5C
5	Standard Charging method	0.5C CC(constant current)charge to 4.2V, then CV(constant voltage 4.2V)charge till charge current decline to ≤0.05C
6	Charging time	Standard Charging: 6.0hours(Ref.) Rapid charge: 2hours(Ref.)

Table 2 Li-ion specification

Figure 11 lithium battery

3.1.5 LM2596 step-down switching regulator

The LM2596 regulator is monolithic integrated circuit ideally suited for easy and convenient design of a step−down switching regulator (buck converter). It is capable of driving a 3.0 A load with excellent line and load regulation. This device is available in adjustable output version and it is internally compensated to minimize the number of external components to simplify the power supply design. Since LM2596 converter is a switch−mode power supply, its efficiency is significantly higher in comparison with popular three−terminal linear regulators, especially with higher input voltages. The LM2596 operates at a switching frequency of 150 kHz thus allowing smaller sized filter components than what would be needed with lower frequency switching regulators. Available in a standard 5−lead TO−220 package with several different lead bend options, and D2PAK surface mount package. The other features include a guaranteed 4% tolerance on output voltage within specified input voltages and output load conditions, and 15% on the oscillator frequency. External shutdown is included, featuring 80 A (typical) standby current. Self-protection features include switch cycle by cycle current limit for the output switch, as well as thermal shutdown for complete protection under fault conditions. [14]

Figure 12 LM2596 step-down switching regulator

- **Features**
  1. Simple High Efficiency Step-Down Regulator
  2. Adjustable Output Voltage
  3. TTL-Shutdown Capability
  4. Input Operating Range As High As 40V

3.1.6 H-bridge (L293D)

An H-bridge is an electronic circuit that allows a voltage to be applied across a load in any direction. H-bridge circuits are frequently used in robotics and many other applications to allow DC motors to run forward & backward. These motor control circuits are mostly used in different converters like DC-DC, DC-AC, AC-AC converters and many other types of power electronic converters. In specific, a bipolar stepper motor is always driven by a motor controller having two H-bridges. The H-bridge motor driver circuit is used to reverse the direction of the motor and also to break the motor. When the motor comes to a sudden stop, as the terminals of the motor are shorted. Or let the motor run free to a stop, when the motor is detached from the circuit. [15]

The L293D is a 16-pin Motor Driver IC which can control a set of two DC motors simultaneously in any direction. The L293D is designed to provide bidirectional drive currents of up to 600 mA (per channel) at voltages from 4.5 V to 36 V. [15]
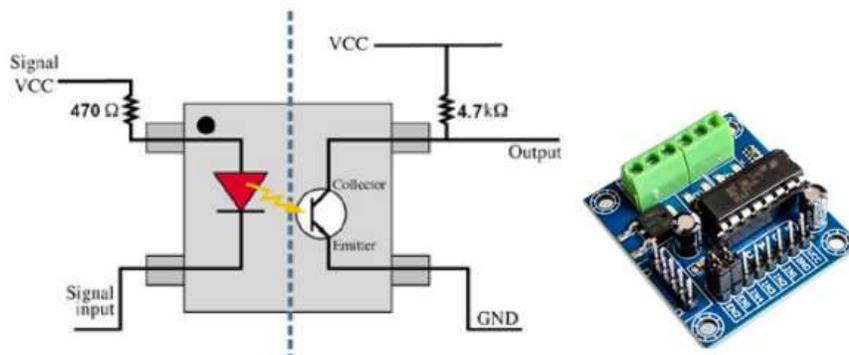

Figure 13 L293D H-bridge

The term H-Bridge is derived from the typical graphical representation of such a circuit. An H bridge is built with four switches (solid-state or mechanical).

When the switches S1 and S4 are closed (and S2 and S3 are open) a positive voltage will be applied across the motor. By opening S1 and S4 switches and closing S2 and S3 switches, this voltage is reversed, allowing reverse operation of the motor. [15]
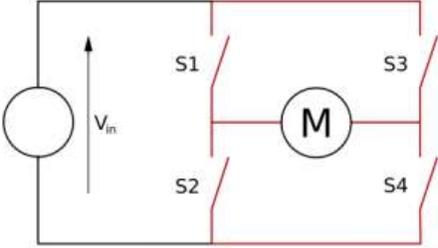

Figure 14 H-bridge working principle

Using the nomenclature above, the switches S1 and S2 should never be closed at the same time, as this would cause a short circuit on the input voltage source. The same applies to the switches S3 and S4. This condition is known as shoot-through. [15]
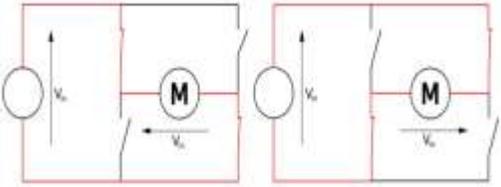
Figure 15 the two basic states of an H bridge

The H-bridge arrangement is generally used to reverse the polarity of the motor, but can also be used to 'brake' the motor, where the motor comes to a sudden stop, as the motor's terminals are shorted, or to let the motor 'free run' to a stop, as the motor is effectively disconnected from the circuit. [15]

3.2 Software Requirements

In this section we will focus on two main things, the operating system of the raspberry pi and the open CV software that is used for image processing.

3.2.1 Operating system for raspberry pi

Raspberry Pi is the most popular SBC – Small Board Computer around the world. It can do pretty much everything that a desktop computer can do and suitable for all ages who are keen to explore computing. Raspberry comes with all the software; you require for basic computing. But if you want to extend the functionalities to some extent, you will need to take the help of OS running on your device. It performs as a bridge between the user and Raspberry hardware. OS is the most crucial program that helps you to develop and execute programs. It enables the hardware to communicate with the software for generating meaningful interactions. Also, it manages CPU, memory, disk drives, printers, establishes user interface, and provides services for applications software.

Although Raspbian is the official Raspberry Pi OS, there are other alternative operating systems also available out there you can run on the Raspberry Pi projects. [16]

3.2.2 Raspbian

This is the official OS and it can be used on all models of Raspberry. This free operating system is known as the modified version of the popular OS Debian. It can serve all the general purposes for the Raspberry users. One can indulge in any project development or prototype building and can expect any kind of support from this OS.

- User can install the setup wizard that allows users to set up a new password, username, and connect to a wifi network.
- Overcome the popular security concern of the pi devices known as the pi/raspberry and eliminates the hassle to go online.
- Due to the difference in specification, many applications do not run on all the models of Raspberry, but Raspbian has filled this gap.
- The Recommended Software Tool allows user to download any software if user connected to the internet whenever.
- Offers features like searching, toolbars configuration, key layout shortcuts, thumbnails, and multi-page controlling with the newly introduced tool qpdfView.[16]

3.2.3 DietPi

If user is looking for an extremely light Debian OS, then dietPi might be the best choice. It can be referred to as 3 xs lighter than the other Raspberry Pi OS available out there. Besides, the installation is really easy and automated. If user configure dietpi.txt before powering on, no user input will be required. [16]

- Diet Processing Tool that comes with the package helps user to determine the priority level of the installed programs and control schedulers.
- User can adjust the performance of the hardware and software while customization ability is also available.
- Uses the minimum space in Ram, which helps to run single-board computer in the maximum potential, and the image's size starts at just 400mb.
- Suitable for the new users and the performance is boosted as user can control the amount of logging according to his need using DietPi-Ramlog.

3.2.4 Open CV software

OpenCV (Open Source Computer Vision Library) is an open source computer vision and machine learning software library. OpenCV was built to provide a common infrastructure for computer vision applications and to accelerate the use of machine perception in the commercial products. Being a BSD-licensed product, OpenCV makes it easy for businesses to utilize and modify the code. [17]

The library has more than 2500 optimized algorithms, which includes a comprehensive set of both classic and state-of-the-art computer vision and machine learning algorithms. These algorithms can be used to detect and recognize faces, identify objects, classify human actions in videos, track camera movements, track moving objects, extract 3D models of objects, produce 3D point clouds from stereo cameras, stitch images together to produce a high resolution image of an entire scene, find similar images from an image database, remove red eyes from images taken using flash, follow eye movements, recognize scenery and establish markers to overlay it with augmented reality, etc. OpenCV has more than 47 thousand people of user community and estimated number

of downloads exceeding 18 million. The library is used extensively in companies, research groups and by governmental bodies.

It has C++, Python, Java and MATLAB interfaces and supports Windows, Linux, Android and Mac OS. OpenCV leans mostly towards real-time vision applications and takes advantage of MMX and SSE instructions when available. A full-featured CUD and OpenCL interfaces are being actively developed right now. There are over 500 algorithms and about 10 times as many functions that compose or support those algorithms. [17]

Chapter Four: Hardware and Software Implementation

In this chapter we will introduce the component connections and the pin out of each used part

4.1 Power supply

The system requires 5 volts to operate since the raspberry and the camera and the motors all operates on 5 volts, hence a good quality voltage source is required and there should be no noise and ripple.

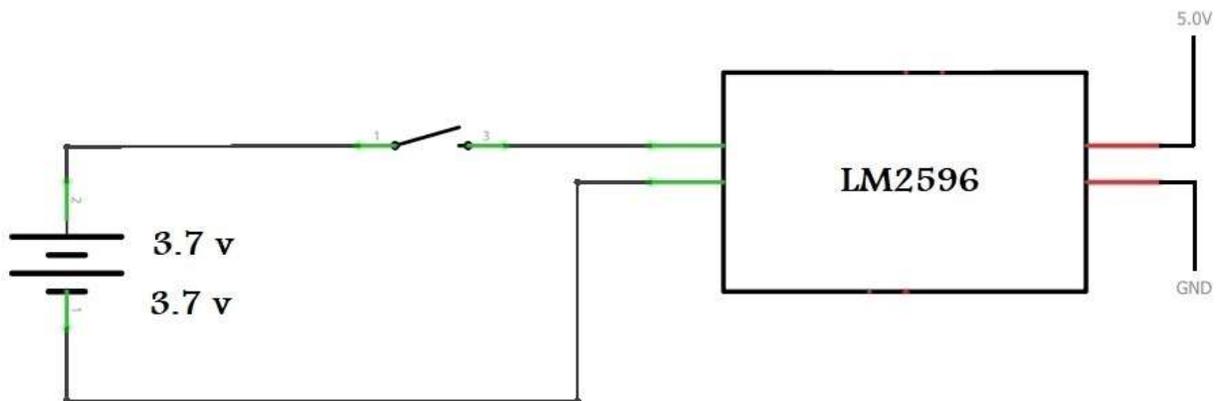For this reason we used a two in series batteries then a buck converter as shown in figure below

Figure 16 Power supply circuit

Each lithium battery will supply a 3.7 Volts which is less than the required 5 volts, for this reason we used two batteries in series to get a voltage above the 5volts then by using a buck converter we will step down the voltage from the battery voltage to 5 volts.

4.2 Motor connection and interface to raspberry pi

Raspberry pi is very powerful computer but this is applicable for the computing power and when talking about the electrical output power of the Arduino it is very weak and cannot drive heavy.

Loads like the motors, for this reason we used the motor driver IC (L293D) to drive the motors depending on the raspberry commands as shown in figure below

Figure 17 Motor connection and interface to raspberry pi

The L293D has two output for each motor and two inputs to control the motor direction and one input for speed controlling, at the end each motor requires three pins to be connected to the

raspberry pi and since we have two motors then we need six wires and six pins from the raspberry to the motor driver IC.

4.3 Software implementation

In this section the software of the system will be discussed, first the user has to open the terminal and type the project name as below
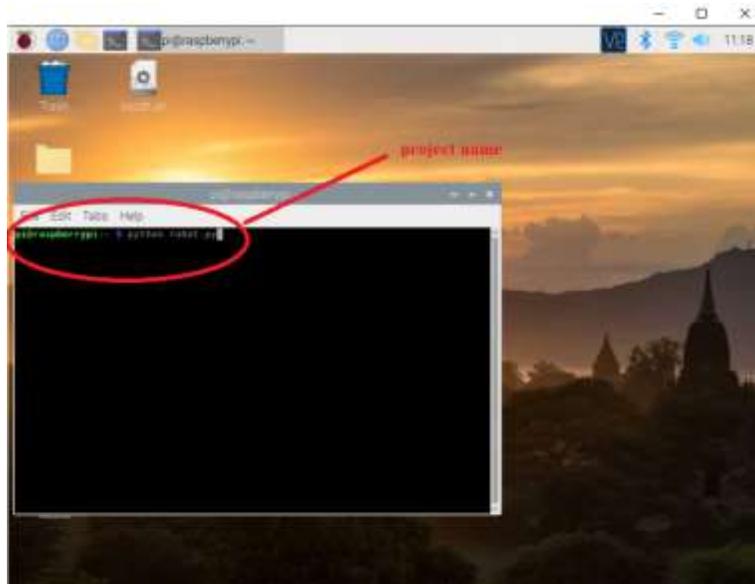

Figure 18 Starting the program

The code will be started and the robot will be on duty, there are four possibilities for the robot to take:

1. First action is happen when the ball is not detected as shown in figure below, the robot will make a 360 degree rotation to find the ball
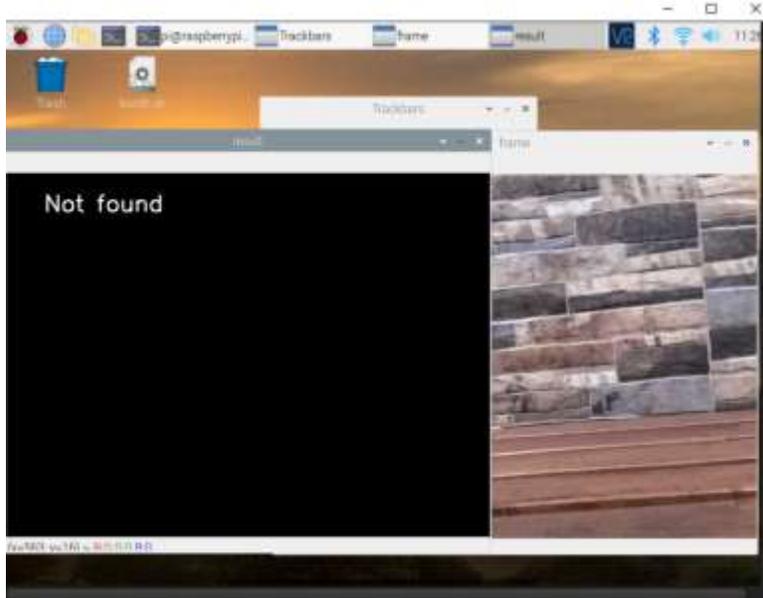
Figure 19 Ball is not detected

2. Second action happens when the ball is detected but it is far away, in this case the robot will go forward to get closer to the ball
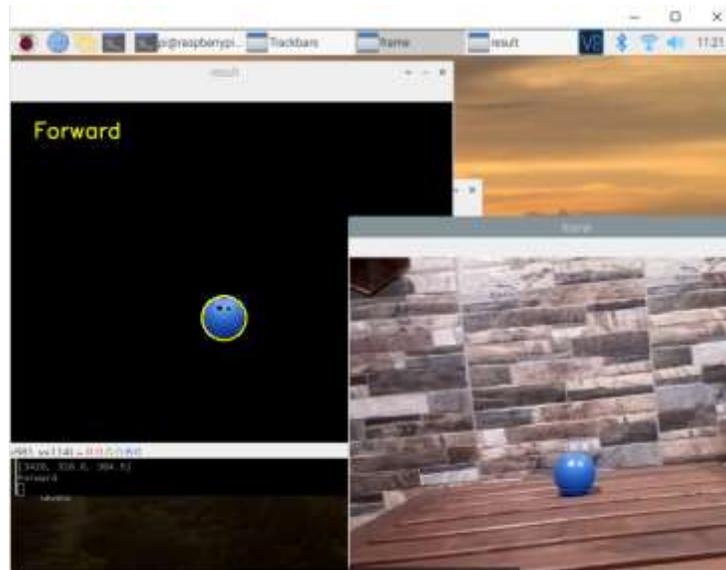

Figure 20 Ball is far from the robot

3. Third action is happened when the ball is not in the center of the screen, in this case the robot will decide to turn left or right to make the ball in the center as shown in the following two figures
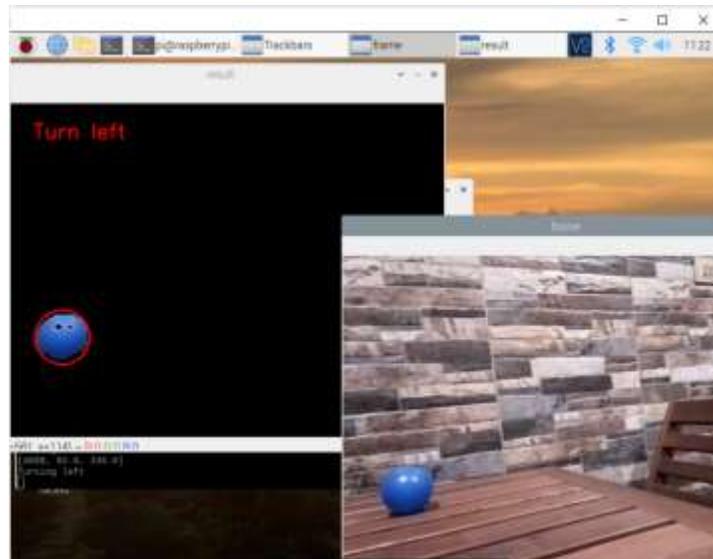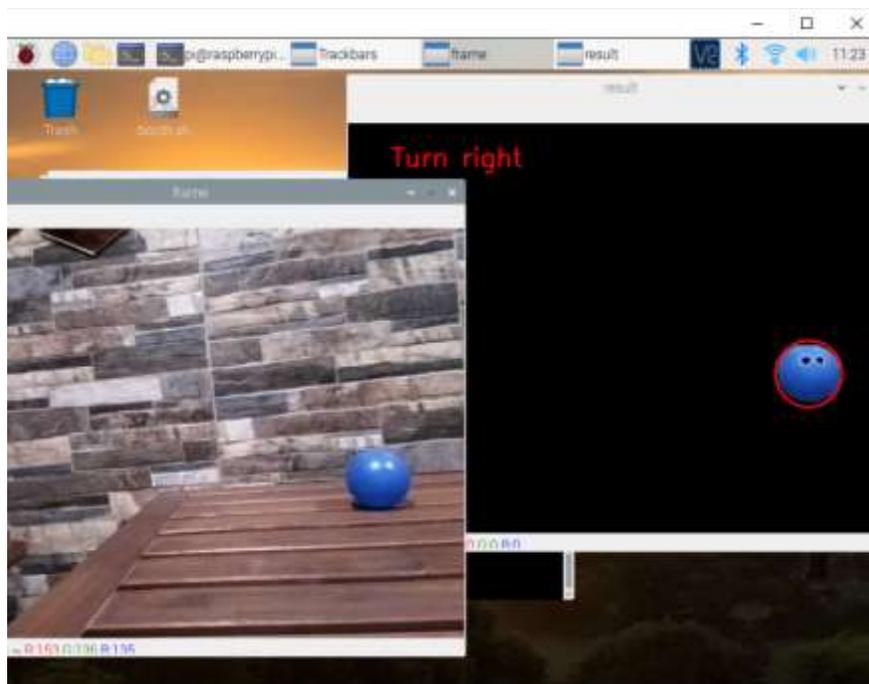
Figure 21 Ball on the left

Figure 22 Ball on the right

4. Finally when the ball size in the video is large enough this means that it is close to the robot, so the robot must stop
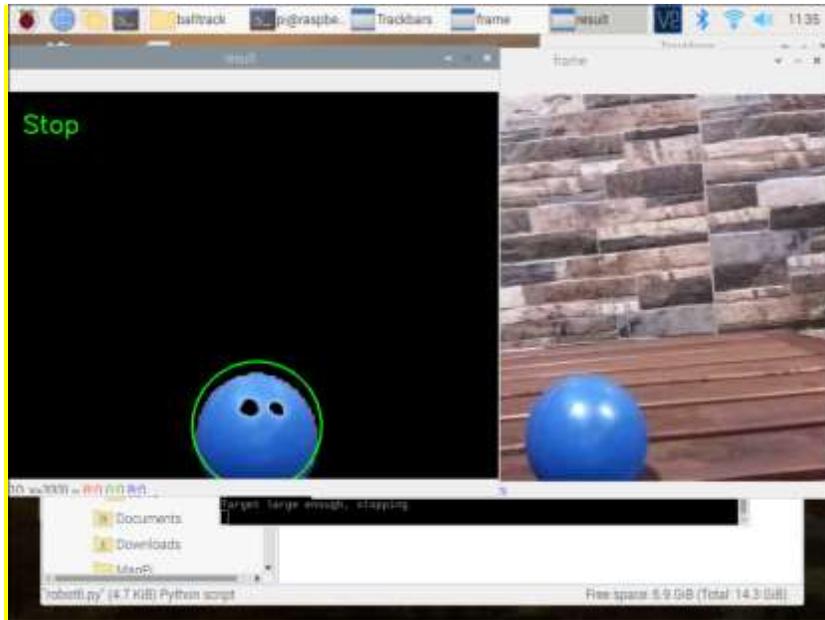
Figure 23 Ball is reached

4. 4 Engineering Standard

4.4.1 Wi-Fi standard

The 802.11 standards are defined through several specifications of WLANs. 802.11-1997 was the first wireless networking standard in the family, but 802.11b was the first that is widely accepted one, followed by 802.11a, 802.11g, 802.11n, and 802.11ac. Other standards in the family (c–f, h, j) are service amendments that are used to extend the current scope of the existing standard, which may also include corrections to a previous specification. The original version of the standard IEEE 802.11 was defined in 1997 and clarified in 1999. [18]

Wi-Fi stands for Wireless Fidelity and a type of wireless local area network technology. It is based on IEEE 802.11 specification. Wi-Fi compatible devices can connect to the Internet via a WLAN network and a wireless access point. This technology is most commonly used to connect internet routers to devices like computers, phones, tablets. Wi-Fi is less secure than wired networks. From a user's perspective, most smart phone users have limits on the amount of data they can download on their phones, and to use it, they need to be within range of a tower. The wireless network is consisting of three essential elements that are radio signals, antenna and router. The radio waves are keys which make the Wi-Fi networking possible. The range of the Wi-Fi depends upon the

31

environment, indoor or outdoor ranges. The Wi-Fi cards read the signals and create an internet connection between the user and the network. The speed of the internet in the device using Wi-Fi connection increases as the computer gets closer to the main source and decreases when the computer gets further away. Communication across a wireless network is a two-way radio communication.

- Wi-Fi receiver translates data into a radio signal and transmits it using an antenna.
- Then the radio signal is received by the wireless router which decodes it. Once decoded, the information will be sent to the Internet using a physical, wired Ethernet connection.

The IEEE 802 Standard comprises a family of networking standards that cover the physical layer specifications of technologies from Ethernet to wireless. IEEE 802 is subdivided into 22 parts that cover the physical and data-link aspects of networking. The better known specifications (bold in table below) include 802.3 Ethernet, 802.11 Wi-Fi, 802.15 Bluetooth/Zigbee, and 802.16.

- All the 802.11 specifications use the Ethernet protocol and Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) for path sharing. The original modulation used in 802.11 was phase-shift keying (PSK). However, other schemes, such as complementary code keying (CCK), are used in some of the newer specifications. The newer modulation methods provide higher data speed and reduced vulnerability to interference. [18]

4.4.2 Ethernet standard

The performance of LANs under different Ethernet wiring standard having different frame size are compared and the observations from our simulations outcomes are: [19]

1. The number of collision counts in 10BaseT is always more than 100BaseT for all the frame sizes because of the nature of 10BaseT
2. Hubs are more utilized in case of 10BaseT because of the large value of collision count so the more retransmission attempts will be required.
3. The performance of a switch is better for 100BaseT wiring standard at the case of 1500 bytes frame size than that the case of 10BaseT because it filters more traffic. When the frame size is 1024 bytes, filtered traffic will be approximately the same for both 10BaseT and 100BaseT. When frame size is further reduced to 512, 128 and 64 the results show that the performance

of 10BaseT becomes better than 100BaseT because the switch filtered more traffic than 100BaseT.

4. If we have LAN in which high traffic is not required and the frame size will be fixed to 512, 128 or 64 bytes, 10BaseT will give us good result and performs better as compared to 100BaseT Ethernet wiring standard.

5. At the case of small frame size we will not able to transfer more traffic per seconds (traffic receiving and forwarding is less) so we cannot use them in heavy traffic.

4.4.3 Bluetooth standard - 802.15.1-2002 - IEEE Standard for Telecommunications

This IEEE Standards product is part of the 802 family on LAN/MAN. Abstract: The lower transport layers [(Logical Link Control and Adaptation Protocol (L2CAP), Link Manager Protocol (LMP), baseband, and radio] of the Bluetooth™ wireless technology are defined. Bluetooth is an industry specification for short-range radio frequency (RF)-based connectivity for portable personal devices. The IEEE 802.15.1 Task Group has reviewed and provided a standard adaptation of the Bluetooth specifications (version 1.1) medium access control (MAC) (L2CAP, LMP, and baseband) and physical layer (PHY) (radio). Also specified is a clause on service access points (SAPs), which includes a logical link control (LLC)-MAC interface for the ISO/IEC 8802-2 LLC. A normative annex is included that provides a Protocol Implementation Conformance Statement (PICS) proforma, and an informative high-level behavioral ITU-T Z.100 specification and description language (SDL) model for an integrated Bluetooth MAC sublayer are also specified. [20]

4.5 Constraints

For project evaluation many aspect should be studied and illustrated; those aspects includes the following

4.5.1 Manufacturability

This system consists of many components that can be purchased from the local market, the raspberry pi board should be loaded with the system SD card, so all the components purchased as readymade items but we have to add SD card to complete the product.

4.5.2 Sustainability

The system requires 5V DC to operate so a good quality adapter should be used for long time of operation; also the raspberry pi is sensitive to ESD, so it is good to put it in a dedicated enclosure for better protection.

4.5.3 Economic

If talking about the features that this system has, it is very cheap specially when compared to the existed systems, video capturing and storing and detection requires many components with high end technology like network cameras and NVR (network video recorders) in this solution we made an all in one solution.

4.5.4 Ethical

From ethical point of view, the system will not be hidden, the camera is clear and every one can see it, so no privacy violation to the visitor will occur.

Add to this the system will be installed inside a home or a private area, so the home owner can install the camera in his home without being afraid of privacy violation

4.5.5 Health and safety consideration

The lithium batteries must be recycled using the proper way.For safety reasons the lithium batteries should kept out of children reach and away from any heat source, also it must be recycled in a right way.

Chapter Five: Conclusions and Future works

5.1 Required for raspberry pi to work

5.1.1 A microSD card

Raspberry Pi needs an SD card to store all its files and the Raspbian operating system. a microSD card with a capacity of at least 8 GB is required
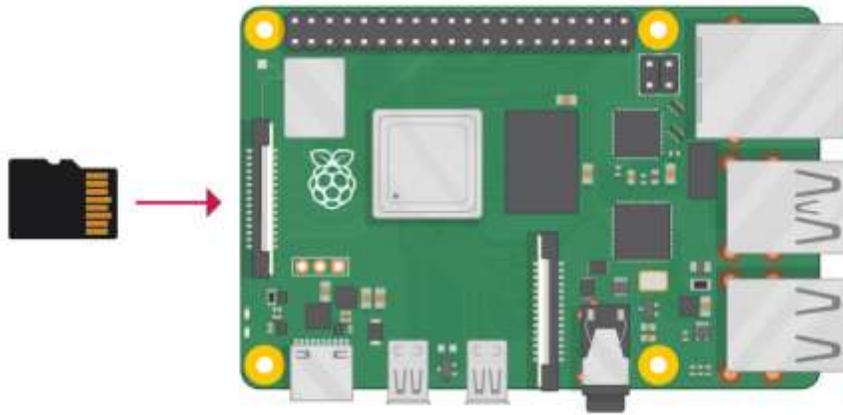
Figure 24 required for raspberry pi to work

5.1.2 A keyboard and a mouse

To start using Raspberry Pi, user needs a USB keyboard and a USB mouse.

Once user set Pi up, user use a Bluetooth keyboard and mouse, but we will need a USB keyboard and mouse for the first setup.

5.1.3 A TV or computer screen

To view the Raspbian desktop environment, we need a screen, and a cable to link the screen and the Pi. The screen can be a TV or a computer monitor. If the screen has built-in speakers, the Pi is able to use these to play sound.

5.1.4 HDMI

The Raspberry Pi has a HDMI output port that is compatible with the HDMI port of most modern TVs and computer monitors. Many computer monitors may also have DVI or VGA ports.

5.2 Installing operating system

Using the Raspberry Pi Imager is the easiest way to install Raspbian on SD card. To do so we must Download and launch the Raspberry Pi Imager
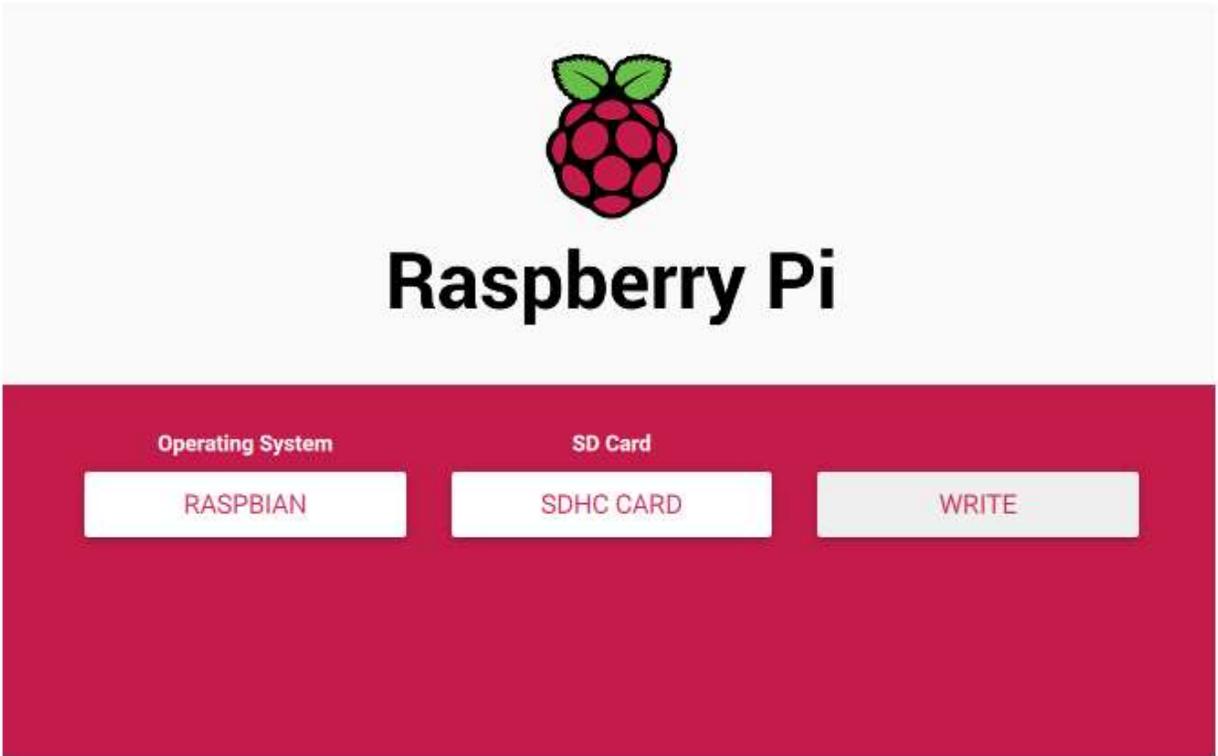
Figure 25 raspberry pi imager

Then simply click the WRITE button. And Wait for the Raspberry Pi Imager to finish writing. Then we can eject your SD card.

5.3 Connect Raspberry Pi

It's important to do this in the right order, so that all components are safe.
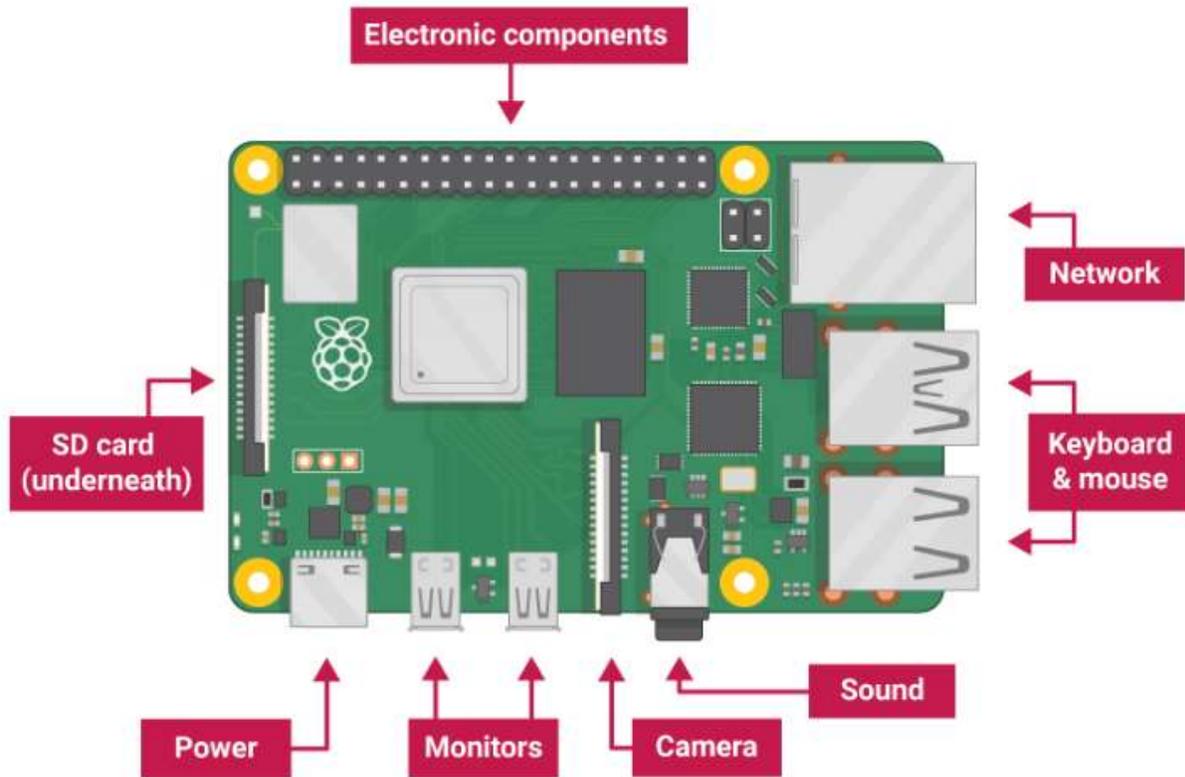
Figure 26 raspberry pi connection

- Insert the SD card with Raspbian into the microSD card slot on the underside of the Raspberry Pi.

- Find the USB connector end of your mouse's cable, and connect the mouse to a USB port on Raspberry Pi

- Connect the keyboard in the same way.

- Make sure that screen is plugged into a wall socket and switched on.

- Look at the HDMI port(s) on the Raspberry Pi.Use a cable to connect the screen to Raspberry Pi's HDMI port

- Connect screen to the first of Raspberry Pi 4's HDMI ports, labeled HDMI0.

- If net is required then connect Raspberry Pi to the internet via Ethernet,

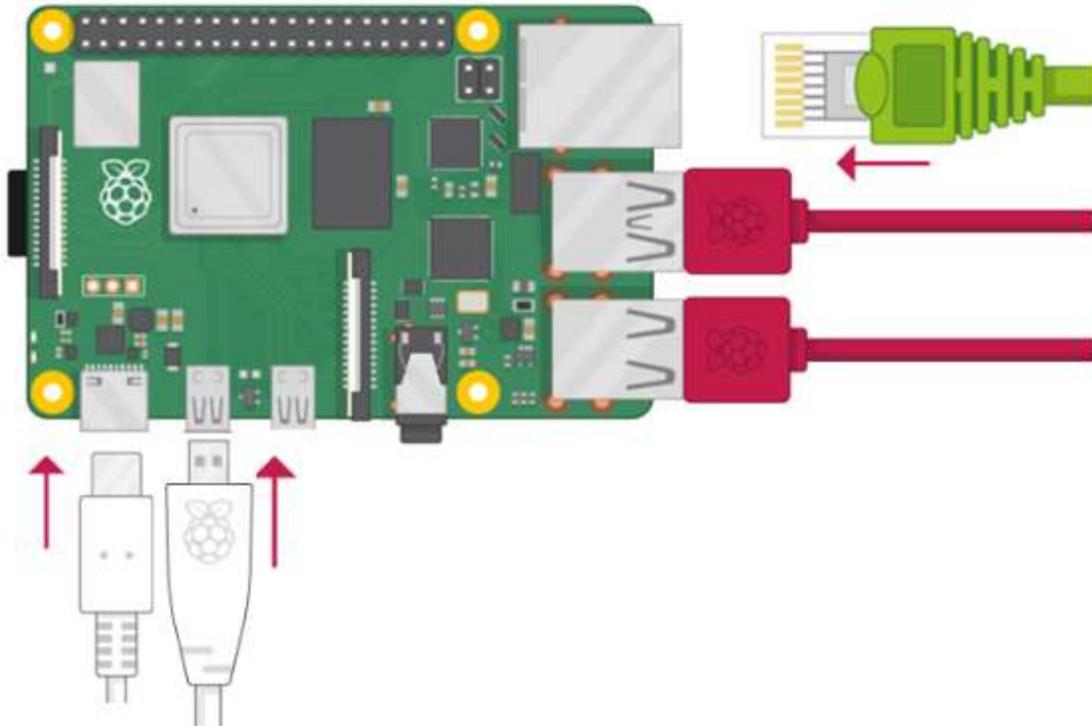- Plug the USB power supply into a socket and connect it to Raspberry Pi's power port.

Figure 27 raspberry pi connected

After that the user should see a red LED light up on the Raspberry Pi, which indicates that Raspberry Pi is connected to power. As it starts up (this is also called booting), user will see raspberries appear in the top left-hand corner of your screen.
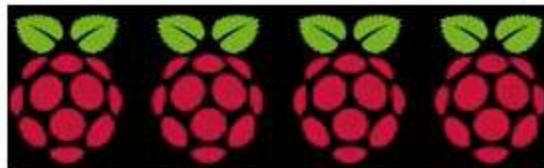

Figure 28 logo of raspberry pi

5.4 Camera connection

All current models of Raspberry Pi have a port for connecting the Camera Module. [21]
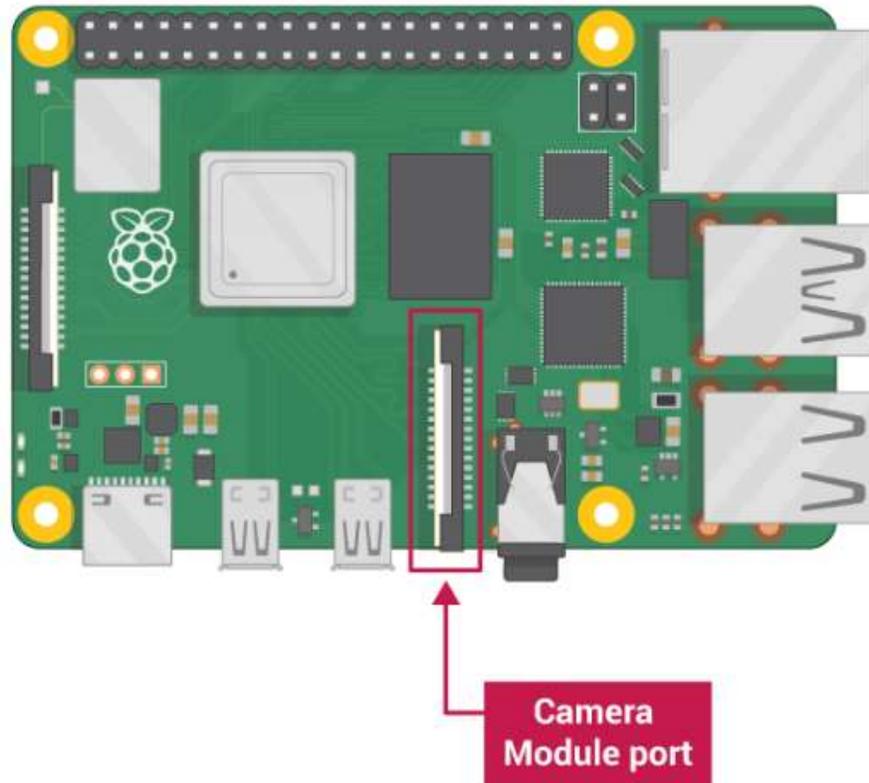
Figure 29 camera connection

To install the camera we did the following

- Ensure your Raspberry Pi is turned off.

- Locate the Camera Module port

- Gently pull up on the edges of the port's plastic clip

- Insert the Camera Module ribbon cable; make sure the cable is the right way round

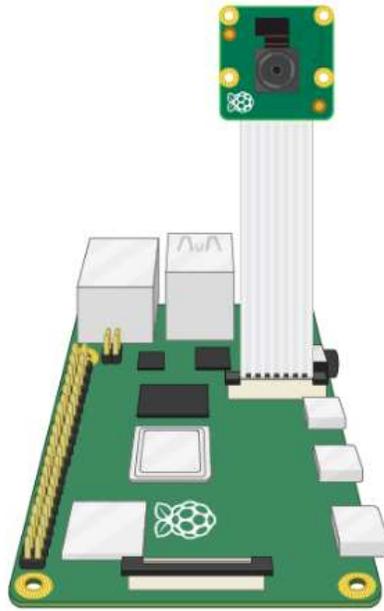- Push the plastic clip back into place.[22]

Figure 30 camera module

- Startup Raspberry Pi.

- From main menu open the **Raspberry Pi Configuration** tool. .[22]

Figure 31 raspberry pi configuration

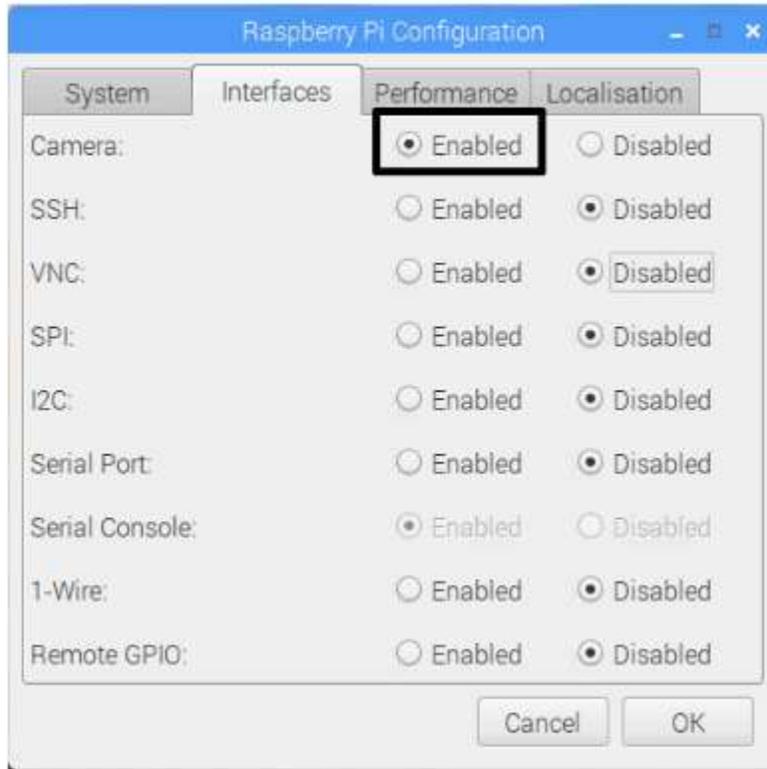Then we must enable the camera from the menu as shown below

Figure 32 enabling the camera module

5.5 Conclusions

1. Raspberry pi 4 is really powerful minicomputer and has a strong operating system
2. Open CV (computer vision) can read and write images, capturing videos and save it.
3. It also can detect specific objects such as faces, eyes, cars, in the videos or images
4. Easy to code: Python is high level programming language, free and Open Source.
5. Python is Object-Oriented Language, and support GUI Programming.
6. Raspberry pi requires high current (up to 2A) and must be supplied from good DC source
7. The video frame rate is low due to limited CPU speed of raspberry pi

5.6 Future works

The following features can be added to the system to make useful upgrades

1. Use raspberry pi camera with night vision instead the normal cam to get better video resolution and faster response
2. A mobile phone application can be developed to control the robot manually or set to object following mode
3. The application could include some GUI to set the desired object color to be followed
4. Robot can be trained to detect faces instead of object, so the robot will follow the owner anywhere as an assistant.
5. The robot can be used as a baby setter since it will follow the child and record a video and report the location of the child.

References

1. D. Fox, W. Burgard, H. Kruppa, and S. Thrun, "A probabilistic ap-proach to collaborative multi-robot localization," Autonomous Robots,vol. 8, no. 3, pp. 325–344, 2000.

2. S. Roumeliotis and G. Bekey, "Distributed multi robot localization, "IEEE Trans. Robot.Autom., vol. 18, no. 5, pp. 781–795, Oct. 2002.

3. https://www.watelectronics.com/know-all-about-raspberry-pi-board-technology/

4. https://www.panacast.com/object-detection-what-is-it-and-how-is-it-useful/

5. International Journal of Advanced Research in Computer and Communication EngineeringVol.4,Issue7,July201:https://www.researchgate.net/publication/281538274_Real_Time_Object_Counting_using_Raspberry_pi

6. JURNAL SISTEM KOMPUTER – Vol. 5, No 2, November 2015, ISSN : 2087-4685, e-ISSN:2253456,MohammadNasucha,https://www.researchgate.net/publication/295519484_DEVELOPMENT_OF_AN_OBSTACLE_AVOIDING_ROBOT

7. http://www.sooxma.com/docs/Abstracts/SET148.%20Microcontroller%20based%20Visible%20Light%20follower%20Robot.pdf

8. https://circuitdigest.com/electronic-circuits/rf-controlled-robot-without-microcontroller

9. https://static.raspberrypi.org/files/product-briefs/200206+Raspberry+Pi+4+1GB+2GB+4GB+Product+Brief+PRINT.pdf

10. https://www.raspberrypi.org/products/raspberry-pi-4-model-b/specifications/

11. https://www.raspberrypi.org/documentation/usage/gpio/

12. https://www.reichelt.com/de/en/robot-chassis-kit-for-all-arduino-systems-robot-car-kit-01-p219024.html

13. https://mikroelectron.com/Product/li-ion-battery-3-7-v-5000mah-18650/

14. https://components101.com/regulators/lm2596-3a-step-down-voltage-switching-regulator

15. https://www.elprocus.com/h-bridge-motor-control-circuit-using-l293d-ic/

16. https://www.ubuntupit.com/best-raspberry-pi-os-available/

17. https://opencv.org/about/

18. Abdelrahman, M B R; Mustafa, B A; Osman, A A. (2015): A Comparison between IEEE 802.11a, b, g, n and ac Standards. IOSRJCE, 17 (5), pp. 26-29.

19. https://www.researchgate.net/publication/330208314_Ethernet_Wiring_Standards_with_Different_Frame_Size_to_Enhance_the_Performance_of_LAN

20. https://standards.ieee.org/standard/802_15_1-2002.html

21. https://projects.raspberrypi.org/en/projects/raspberry-pi-setting-up

22. https://projects.raspberrypi.org/en/projects/getting-started-with-picamera/1