VISVESVARAYA TECHNOLOGICAL UNIVERSITY
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Project Report on

"CAMOUFLAGE TECHNIQUE BASED MULTIFUNCTIONAL ARMY ROBOT"

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CERTIFICATE

This is to certify that the project work entitled **"CAMOUFLAGE TECHNIQUE BASED MULTIFUNCTIONAL ARMY ROBOT"** is carried out by **AISHWARYA SURESH ARISHINAGUPPI**, **ANUSHA R Y, DEEKSHA RAJASHEKAR** bearing USN: **1CR16EC007, 1CR16EC019, 1CR16EC034** a bonafide student of **CMR INSTITUTE OF TECHNOLOGY** in partial fulfillment for the award of **Degree** in **Course** from **Visvesvaraya Technological University,** Belgaum during the academic year **2020**. It is certified that all corrections/suggestions indicated for Internal Assessment have been incorporated in the report deposited in the department library. The Project Report has been approved and satisfies the academic requirements with respect to project work prescribed for the said degree.

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ABSTRACT

Camouflage robot is solution for reducing human losses in military operations or terrorist attacks. They play major role in saving human lives. The proposed system consists of one Raspberry pi camera as part of camouflaging feature.Raspberry Pi camera senses the colour of surrounding and according to that robot will change its colour and the sensed colour will be displayed on the raspberry pi LCD display. Because of this feature this robot can't be easily detected by enemies. We have used Wireless transceiver for communication between transmitter and receiver. This robot can quietly enter into enemy area and send us the information via camera. The movement of this robot is wirelessly controlled through a bluetooth app. Since human life is always valuable, these robots are the substitution of soldiers in war areas.

In this modern era huge amount was spent for the defence field for the purpose of primitive and high security measures to safe the border security forces from the trespassers. Some defence organizations uses the help of robotics in the defence field and the efficiency of robots compared to the human was very high.The main motive of this project is to make the defence strong using the robots which will help defence to safeguard the human life.In this project we proposed the system using the Arduino uno and Raspberry Pi 3b+ which help the robot to do rescue operations.

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CHAPTER 1

INTRODUCTION

1.1 Concept of Camouflage

In today's era, lot of expenses are made in the field of defence for the sake of adopting primitive security measures for safeguarding the border from the trespassers. Some military organizations utilizes robot in the risk prone areas which are very much effective and efficient when compared to the army men. The main intention of this system is to get camouflaged to hide its existence from the outside world. These robots are also enhanced in order to give the guarantee of success in the hazardous region. The main objective of this paper is to implement a Wireless multifunctional Army Robot which is based on Camouflage technology. It can be controlled by smart phone using IOT**.**

The objective of this project is to minimize human casualities in terrorist attacks. This robot would be designed to tackle cruel terror attacks.

The robot can also be used in high altitude areas where human cannot survive. Moreover, the camouflaging feature makes it difficult to detect the robot by naked human eye. There is scope to improve the system by configuring it with multicolor camouflaging. Since human life is always precious, these robots are the replacement of fighters against terrorist in war areas.

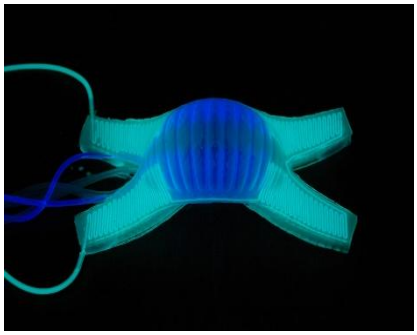
1.2 History of Camouflage Robot

Fig 1: Flexible, Color-Changing Robot Inspired By Octopus

A newly developed rubbery, octopus like robot can change colors to hide or stand out in its environment.

Scientists at Harvard have recently begun developing flexible robots from elastic plastics and silicone rubbers that crawl along using compressed air forced in and out of many tiny channels running through its limbs. These soft robots, inspired by creatures such as starfish, worms and squid, can, in principle, squirm through obstacle courses that might prove challenging or impossible for rigid metallic robots.
As researcher Steve Morin, a materials scientist at Harvard University, investigated squid and their properties to help advance soft robots, "I came across a wonderful video of a squid changing colors on the Web," he said. "They are truly fascinating, inspiring animals. We asked if we could replicate some of the functions of the squid, or simpler animals with simpler strategies for camouflage, with these robotic systems."

To make the new four-limbed robot change color, instead of pumping air in and out of its body, they used a separate layer of channels in which they can stream a variety of liquid dyes in and out. With the right combination of colors, the robot can therefore camouflage itself like an octopus does, or signal its presence like a firefly.



I think it is very surprising that simple micro-channels can be so effective at camouflage," Morin told Innovation News Daily. "One does not have to mimic the background to effectively disguise the robot simple colors, patterns and shapes can be very effective at camouflage, without mimicking the almost-unbelievable sophistication of some living organisms."
The researchers can also adjust the temperature of the dyes, which can also help the robot blend into or show off its background in the infrared spectrum. This feature was also inspired by nature, given how some snakes can sense infrared light using specialized organs.

Developing the color-changing robot took a year. "This quality is one of the advantages of soft machines — there is very little time between idea and prototype," Morin said.

Although robots that can sneak around like chameleons have a number of obvious devious applications, "we are not just interested in camouflage — we are just as interested, if not more interested, in display," Morin said. "There are many situations where we want soft robots to be very noticeable — search and rescue, for example."

In addition, such robots can help scientists test ideas for how animal disguises and displays work.

"What strategies are effective, what strategies are not?" Morin said.

A current limitation of soft robots is that they run on external air supplies. In the future, the researchers imagine flexible droids that carry their own compressed air and pumps to enable autonomous operations.
In addition, "we would like to move toward more complex microfluidic systems, ones with valves, for example," Morin said. "This direction will allow soft machines to perform more advanced fluid handling procedures, like those that are important for sampling the environment, hazardous sites, places where people do not want to work or it is dangerous for them to work."

CHAPTER 2

LITERATURE SURVEY

2.1 Reference Papers

2.1.1 UNMANNED MULTI-FUNCTIONAL ROBOT USING ZIGBEE ADOPTER NETWORK FOR DEFENSE APPLICATION.

When we consider military robots today, there has been a huge development as compare to those robots used in earlier times. Today, military ground robots & unmanned vehicles are used worldwide. However, the significant growth of the current military robots comes as the nature of combat changes in every region while the globally integrated enterprise replaces nationalistic dominance. It can be said that military robot automation of the defense process is the next wave of military evolution. This proposed system gives an exposure to design a simple robot that can be used to do multifunction in defense. Manual control is also employed to control the robot from the control room which is located far away from the border area. The system uses non-commercial Zigbee standard for wireless communication since this provides access to the as-yet unpublished specifications and permission to create products for market using the specifications. Our system is aimed towards the Zigbee technology up to 30 meters distance. In future we can increase the distance up to 100m distance. The proposed system is focusing on the welfare infantry to minimize the causalities to a great extent. This also helps on remote bomb detonation and diffusion.

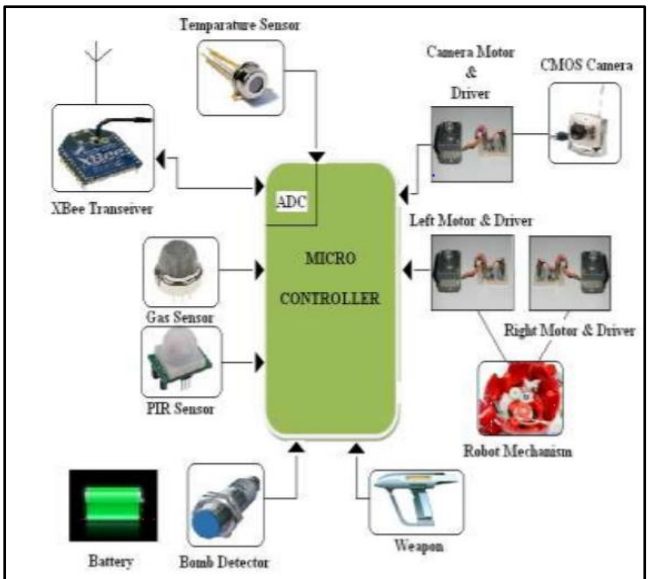


Fig. 1. Block Diagram of Robot Section

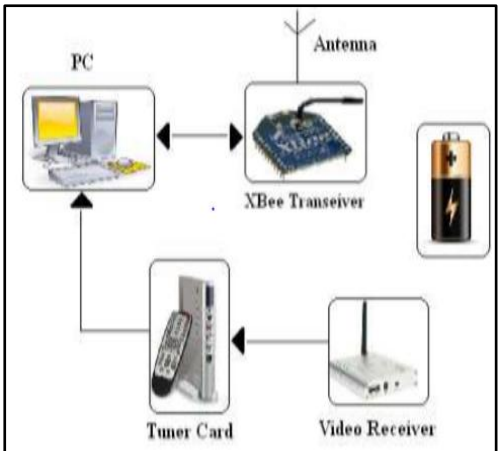


Fig. 2. Block Diagram of Controller Section

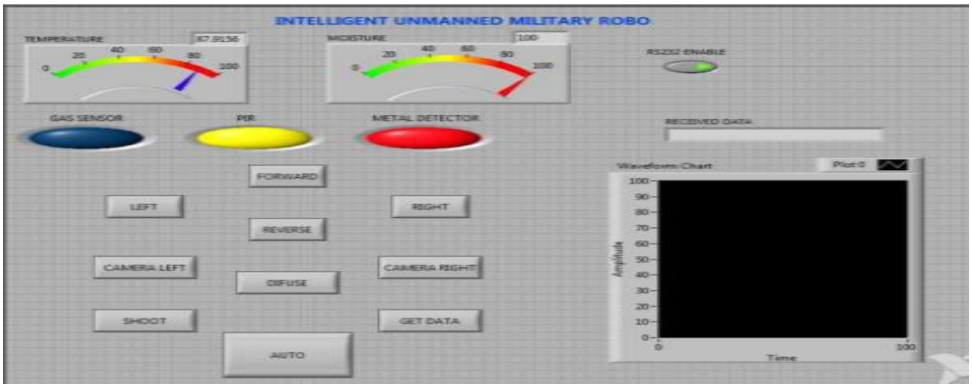


Fig 2: Unmanned Multifunctional Robot

2.1.2 HUMAN TRACKING SYSTEM FOR VICTIMS TRAPPED FROM COLLAPSED BUILDING

PIR section Here we used four PIR sensors. The arrangement of PIR sensor is explained below. The first PIR sensor is placed to cover West and East area. The second PIR sensor is cover North-West and South-East directions. The third PIR sensor is placed to cover South and North directions. Fourth sensor is placed and covers South-West and North-East and directions. Each sensor are placed 2 cm distance gap. The schematic diagram of PIR sensors is shown below. Figure-2. The Schematic Diagram of PIR sensors.

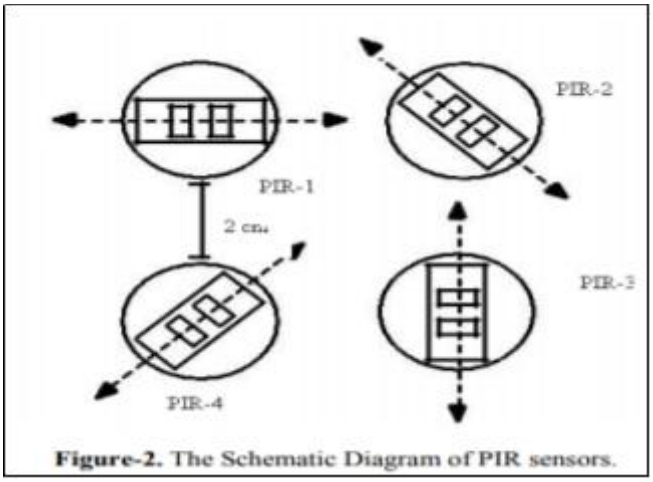


Fig 3: The schematic diagram of PIR sensors

ii. Pull down section Here the PIR's output is only in zeros and ones. If the output is one then this can be directly fed in to PIC and the output zero means the output is also zero in order to increase the voltage up to 3.3v to support Vdd. So that pull up section is used and then connected to the PIC by using L293D which used to interface PIR and PIC.

iii. Pull up section This is used to run the motor from zero position. It moves in following direction forward, right and left.

By this project it will be great help indeed to rescuers in detection of the human beings at the disaster sites. It moves in all directions and finds the alive humans presence and save their life. This system is user friendly easy to communicate, it is economical, semi-autonomous and efficient device by software programming interfacing for detection. It consists of two sections. One is moving section; here the robot will run on the disaster area and searches the alive humans. The second section is control section which interaction between the rescue team to control the movement of the Robot.

2.1.3 Yadnika Warang , Tejali Mahadik , Supriya Ojha , Asha Rawat – Camouflage Robot-A Color Changing Spy Robot

CC2500 is a FSK /MSK Transceiver module. It provide extensive hardware support for packet handling ,data buffering ,burst transmissions , clear channel assessment, link quality indication and wake on radio . It's data stream can be Manchester coded by the modulator and decoded by the demodulator .It has a high performance and easily to design your product. It can be used in 2400-2483.5MHz ISM/SRD band systems, Consumer Electronics, Wireless game controllers, Wireless audio wireless vKB/Mouse and others wireless systems. The wheels of robot and movement of camera are controlled by DC motors. The user controls it with the help of GUI designed, where it also shows the video streaming of the environment. At the robotic unit, microcontroller is used for the control of DC motors.

Fig -1: CC2500 Module

Fig 4 :CC2500 module

Camera will send real time video and snapshots after a particular time interval, which could be seen on a remote monitor, and action can be taken accordingly. DC motors are being used for the movement of robotic wheels for camera movement i.e. upward and downward movement . The robot is surrounded by relay of LED's which turns ON when a color is detected and camouflages the robot. Heart of our robot is Atmel's AT89S52. The AT89S52 Microcontroller is an 8-bit microcontroller with 8K Bytes of InSystem Programming Flash Memory. For wirelessly transmitting commands to the robot ZigBee transceiver.

2.1.4 Dr.S.Bhargavi and S.Manjunath - Design of an Intelligent Combat Robot for war fields

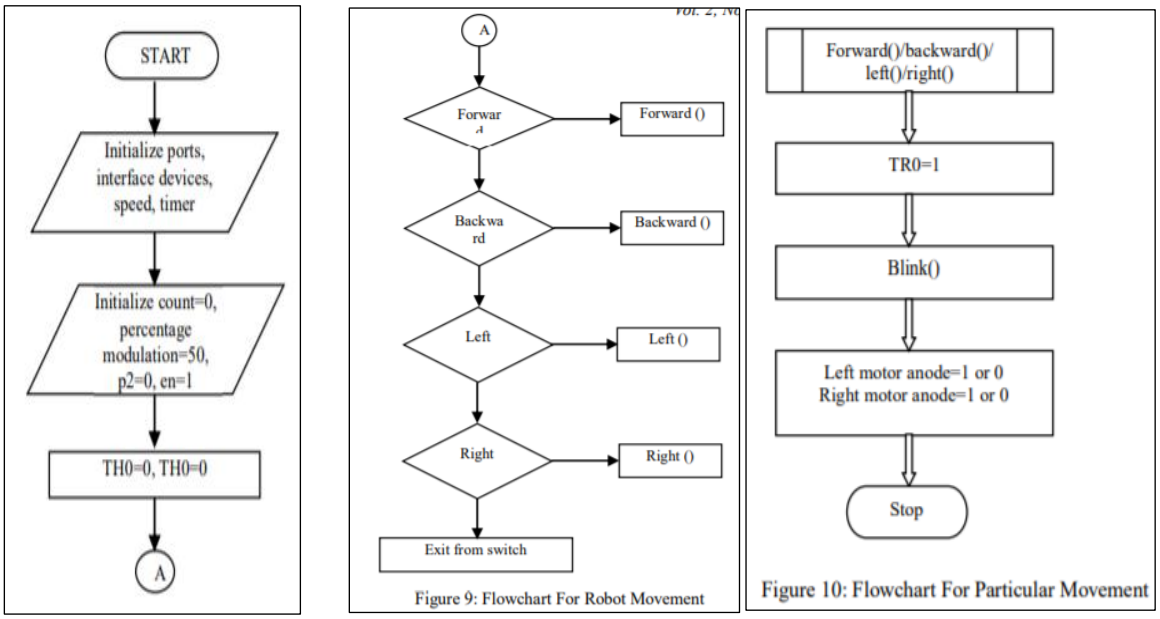
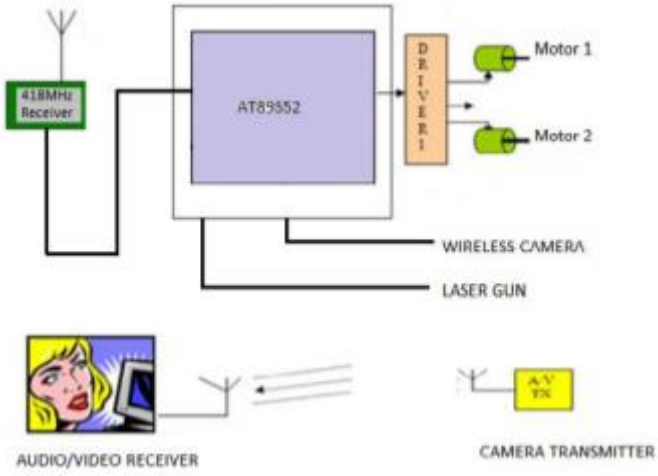


Fig 5 : Flowchart for robot movement

Remote controllers are designed to direct the orientation of robot and to operate the laser gun. Robot keeps on moving in two modes i.e., Manual mode and self-mode. It's brought under user's control in the case of manual mode. In self-mode, robot starts moving over surface and takes action according to the scenario. To detect the obstacles, we have deployed Infrared sensors (left sensor and right sensor) in the front portion of the module. While moving on the surface, if the left sensor is detected, robot takes back the position for a moment and moves right. If the right sensor is detected, robot gets back and moves left.



gure 1: Block Diagram of Intelligent Combat Robot

Fig 6 : Block diagram of intelligent combat robot

Heart of our robot is Atmel's AT89S52 [5]. Microcontroller acts as master controller decodes all the commands received from the transmitter and give commands to slave microcontroller. It also acts as Slave microcontroller which is responsible for executing all the commands received from the master and also generating PWM pulses for the speed control. Based on the input codes master will give command to slave microcontroller and robot will behave as follows:moves in forward direction,moves in reverse direction,speed controls in both the direction,it can even turn left or right while moving forward or in reverse direction,Instant reverse or forward running without stopping.

According to our survey, the reviewed systems used colour detection sensor which have a problem of detecting colour due to which had limitations over a particular range. Metal detector and gas sensors were used which made the system more complex. Those detectors and sensors are removed to reduce the weight of the robot. Also the system consist TV tuner card which made the system complex. So in order to reduce the cost and complexity it is removed.

The aim of camouflage is to make the detection and recognition target difficulty in the machine assisted eye searching target in the big breadth background around. The sensor switches each primary color RGB, one by one and checks what intensity of color is reflected by the surface of detection. This reflected intensity is converted to 8 bit value. For example a RED surface will strongly reflect RED. While a Yellow surface will reflect RED and GREEN both. According to the induction principle of the three primary colours

which create various other colors in nature, once the value of three primary colours is confirmed, the color of the tested object is known. Knowing the value of RGB helps people gain the color of the light which is projected onto the sensor since each color correspond to only one value of RGB.The proposed system provides a helping hand to our security forces in detection of intruders. The robot can also be used in high altitude areas where human cannot survive. Moreover, the camouflaging feature makes it difficult to detect the robot by naked human eye. There is scope to improve the system by configuring it with multicolor camouflaging.

2.2 Camouflage Techniques

There are various available techniques in order to achieve this camouflage. Few of the available techniques are :

2.2.1 LED Matrix Based Camouflage

Science is developing new technologies to ease human life. One such invention of this technology is specialized robots in the field of Artificial Intelligence. The word robot means "A machine capable of carrying out a complex series of actions automatically, especially one programmable by a computer". These robots help to make human life much easier especially in dangerous areas & works. One of the concern areas of today is the military. Military robots are specially used to take the risky job which is difficult to be handled manually by humans. These robots act as the assistant of a soldier. Today, many military organizations take the help of military robots to perform risky jobs due to their accuracy of performing the jobs .These robots used in military are usually employed with the integrated system, including video screens, sensors, gripper and cameras. The main motive behind Camouflage Robot is to reduce human losses in military operations or terrorist attacks. Camouflage Robot acts as a virtual spy and can be sent into the strategic locations of military importance for observation and warfare purpose. Since it's very hard to detect it by a naked human eye, the Camouflage robot can be also used to test the various security systems developed in the market and act as a measure to evaluate its efficiency. The main objective of the Camouflage Robot is to enhance the machinery of the defense system. Secondary objective is to work in the field of Zoology for wildlife photography. The idea of the Camouflage Robot is based on the chameleon's camouflage techniques. The aim of the project is to design, manufacture and operate a robot via PC, used as remote control device, a smallmobile robot which can duplicate the colors where it moves on, hence being camouflaged to the outside world. To achieve these goals, we used a LED matrix (RGB) which can diffuse uniform colors. Initially, the robot can camouflage itself in red, green and blue color. The main application of our robot is to camouflage and pilot from afar an object, no matter what its size is. So, in the Defense sector, such a system would allow large sized vehicles (e.g. armored vehicles) to be much more camouflaged: indeed, the camouflage in the army has become necessary to army missions, to move into an enemy land without being seen and protect soldiers since they can act from afar. Besides, in the Intelligence sector, we could use spying robots like drones. As a last example, in the area of wildlife Photography, hidden picture or video

systems would allow totally new shots with the principle of our robot. Finally, one of the main advantages of the Chameleon Robot is that it is not only resistant to mild weather but also will not harm the environment.

Fig 7: Robot Front View

2.2.2 **Biomimetic chromatophores for camouflage**

Chromatophores are the pigment-containing cells in the skins of animals such as fish and cephalopods which have chromomorphic (colour-changing) and controllable goniochromic (iridescent-changing) properties. These animals control the optical properties of their skins for camouflage and, it is speculated, for communication. The ability to replicate these properties in soft artificial skin structures opens up new possibilities for active camouflage, thermal regulation and active photovoltaic. This paper presents the design and implementation of soft and compliant artificial chromatophores based on the cutaneous chromatophores in fish and cephalopods. We demonstrate artificial chromatophores that are actuated by electroactive polymer artificial muscles, mimicking the radially orientated muscles found in natural chromatophores. It is shown how bio-inspired chromomorphism may be achieved using both areal expansion of dielectric elastomer structures and by the hydrostatic translocation of pigmented fluid into an artificial dermal melanophore.

2.2.3 E-Ink based Technique

E Ink is made into a film and then integrated into electronic displays, enabling novel applications in phones, watches, magazines, wearables and e-readers, etc. E-ink technology in early e-readers works by using tiny microcapsules that are suspended in a liquid placed within a film layer. This technique uses only limites colours and we would be able to print the patterns as we need to get the required display.It is very thin as a paper and difficult to recignise in human eye

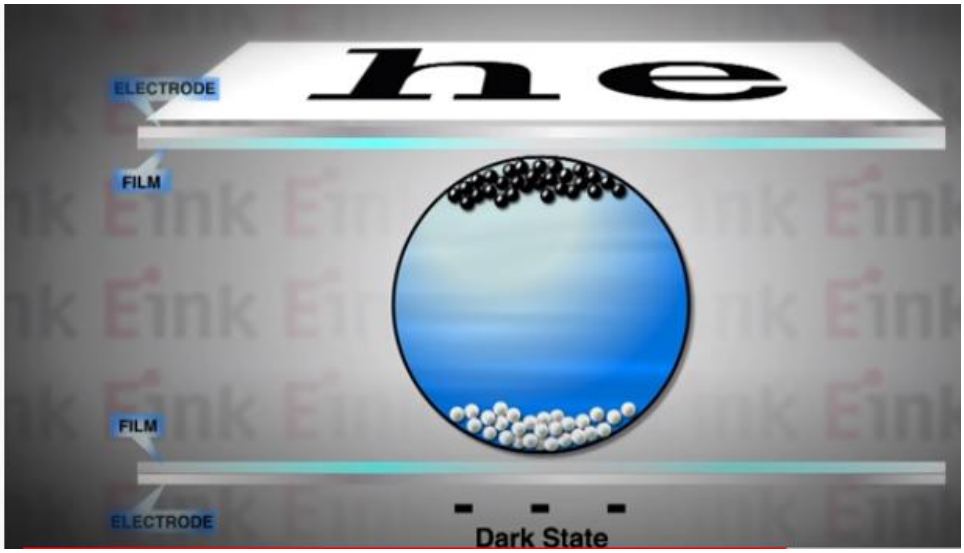


Fig 8: E-Ink display

CHAPTER 3

WORKING PRINCIPLE

3.1 E-Ink Based Display

E-ink technology in early e-readers works by using tiny microcapsules that are suspended in a liquid placed within a film layer. ... By applying different fields at various parts of a screen, e-ink produces a text display. E-ink displays are especially popular due to their resemblance to printed paper.

E Ink's two pigment electronic ink system is made up of millions of tiny microcapsules, each about the diameter of a human hair. Each microcapsule contains negatively charged white particles and positively charged black particles suspended in a clear fluid. E Ink is made into a film and then integrated into electronic displays, enabling novel applications in phones, watches, magazines, wearables and e-readers, etc. E-ink technology in early e-readers works by using tiny microcapsules that are suspended in a liquid placed within a film layer. The microcapsules, which are about the same width as human hair, contain both positively charged white particles and negatively charged black particles.Applying a negative electrical field causes the white particles to come to the surface. Conversely, applying a positive electrical field causes the black particles to come to the surface. By applying different fields at various parts of a screen, e-ink produces a text display.E-ink displays are especially popular due to their resemblance to printed paper. Besides being considered by many as easier on the eyes than other display types, e-ink also boasts lower power consumption, particularly when compared to traditional backlit liquid crystal display (LCD) screens. These advantages, along with its early adoption by major e-reader manufacturers such as Amazon and Sony, caused e-ink to dominate the early e-book reader market.

The biggest advantage of E-ink is that it can be easily printed on surfaces like walls, billboards, clothes and so on. This idea has already caught the eye of many advertising agencies and you may have noticed advertisements on walls using this technology. The ink is so flexible that it is possible to develop roll-up displays for electronic devices. They also need very little power for its usage. When compared to LCD displays, they consume almost 100 times lesser power than LCD’s do.

Another advantage includes its readability. As the text is printed in format, it does not cause strain to the eyes. There are studies going on in increasing the resolution in products so that they can be viable in book or other small-print publications

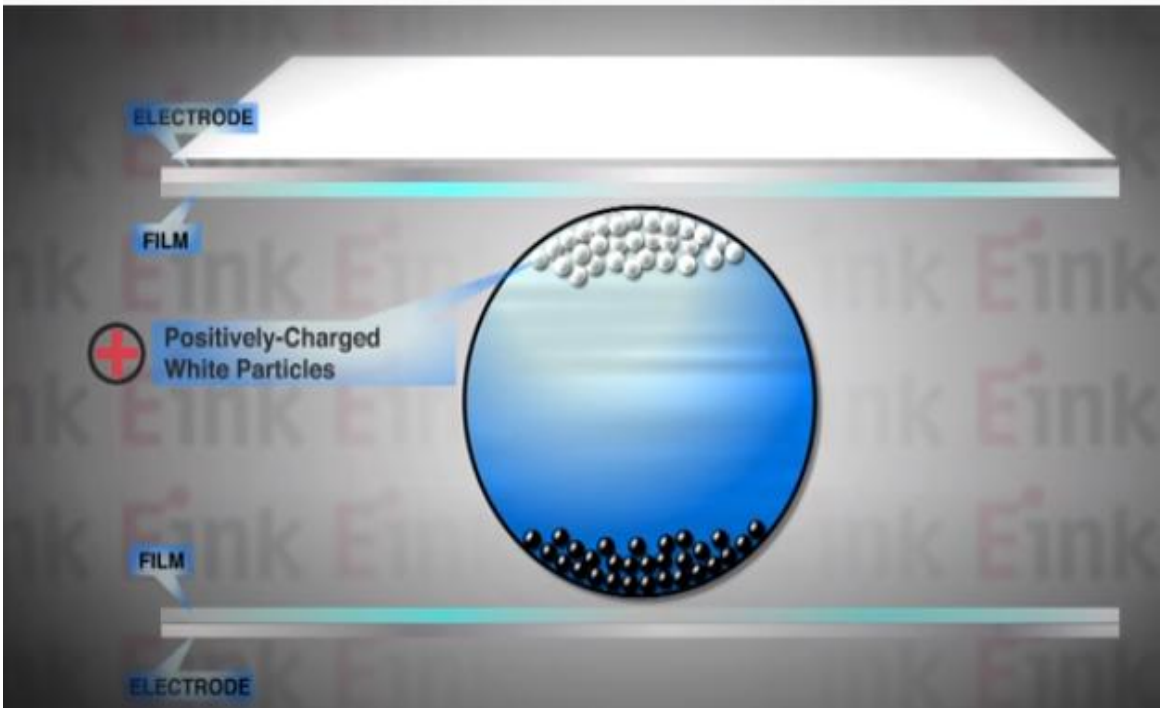


Fig 9: Working of E-Ink

From the figure you must have noticed that when a charge is applied to the microcapsules, the chips are forced to move to the top or pulled down to the bottom. When they move to the top, the chips make the capsules look white and when they are pulled down to the bottom, the capsules look dark. This is because the person seeing it only sees the dark ink. When these small black and white spots are arranged in patterns, words, sentences and images can easily be formed.

3.2 Robot Design

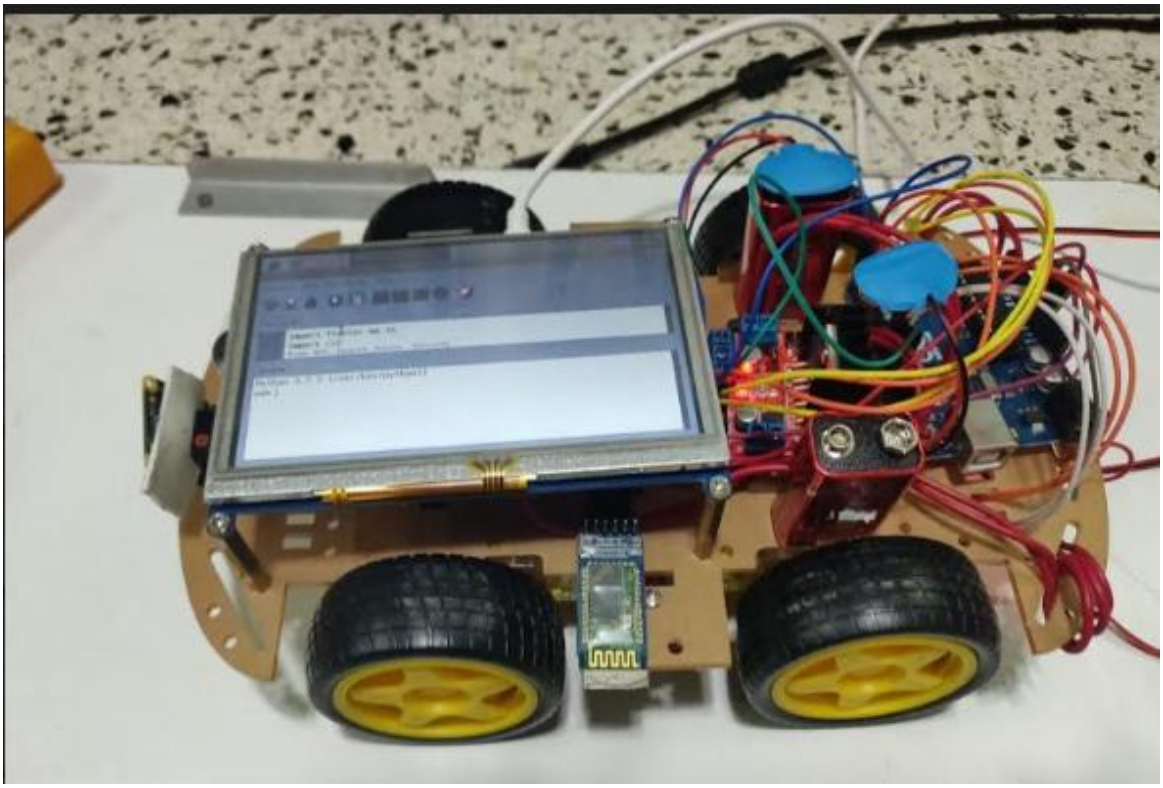


Fig 10: Robot Top View

The robot chassis which I am using in this project is supplied with 4 geared motors. Since L298N has slots for only two motors, I have joined the left side motors as one set and the right side motors as other set and connected both these sets to the output of L298N Module.

The display is mounted on top of the robot. We have placed the camera in front of the robot which can sense the colour of the object infront of it. The camouflage is achieved on top of the robot. We operate the robot using a bluetooth app on our mobile phones. We have placed all the components on top of the chassis and we can move the robot.

The display need to be powered on using external power supply since it requires more current. The bluetooth module used is HC 05 and the app used is Bluetooth RC. we have used 2 L298 motor drivers. Two 9V batteries .

Arduino UNO above the chassis and Rasberry pi placed below the display.

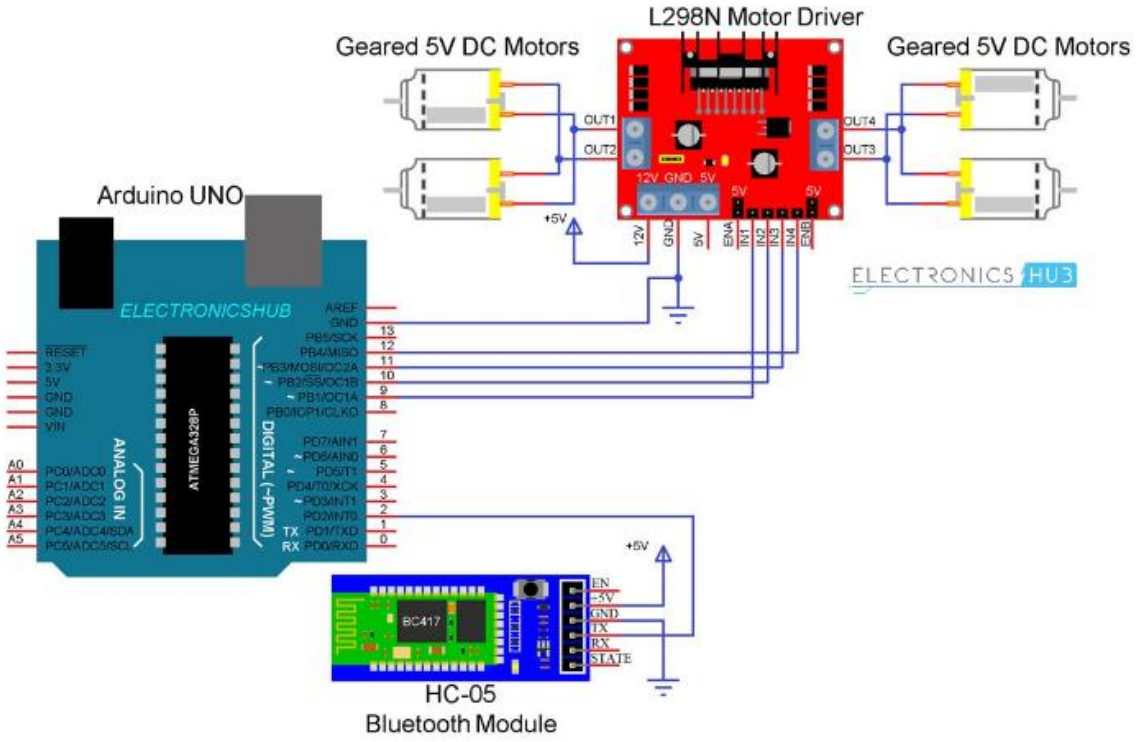


Fig 11: Design for motor movement

Coming to the design of the circuit, first is the HC-05 Bluetooth Module. The +5V and GND pins of the Bluetooth Module are connected to +5V and GND of Arduino.

Since I will be only transmitting data related to the Robot's movement from Android Phone to Bluetooth Module and do not intend to receive any data from Arduino, I will connect only the TX pin of the Bluetooth Module to RX Pin of Arduino.This RX pin of Arduino is based on SoftwareSerial library (Pin 2 and Pin 3 are configured as RX and TX on Arduino). The RX pin of the Bluetooth is left open.L298N Motor Driver Module. Digital I/O Pins 9 through 12 of Arduino are configured as Input pins of the Motor Driver and are connected to IN1 through IN4 of the L298N Motor Driver Module. Both the Enable Pins are connected to 5V through provided jumper.

3.3 Block Diagram

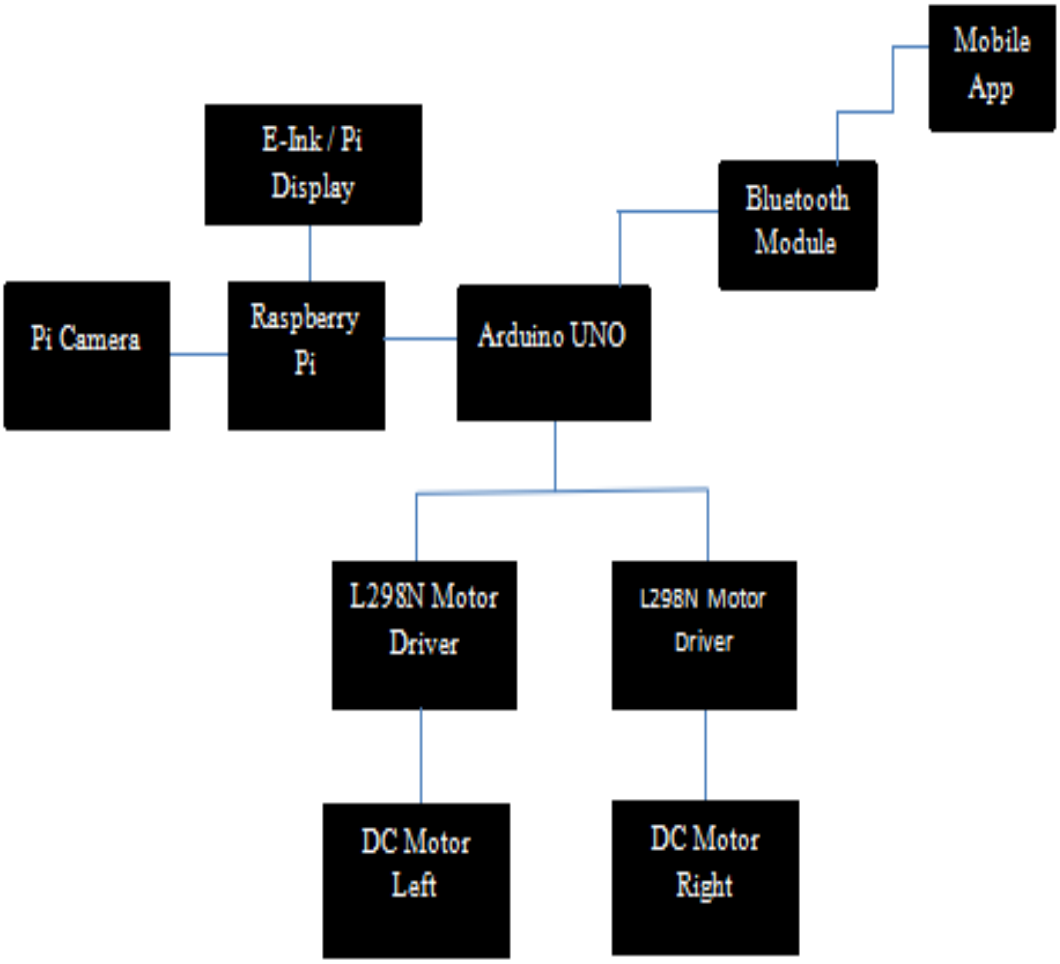


Fig 12 :Block diagram of the project

3.4 Flow Chart

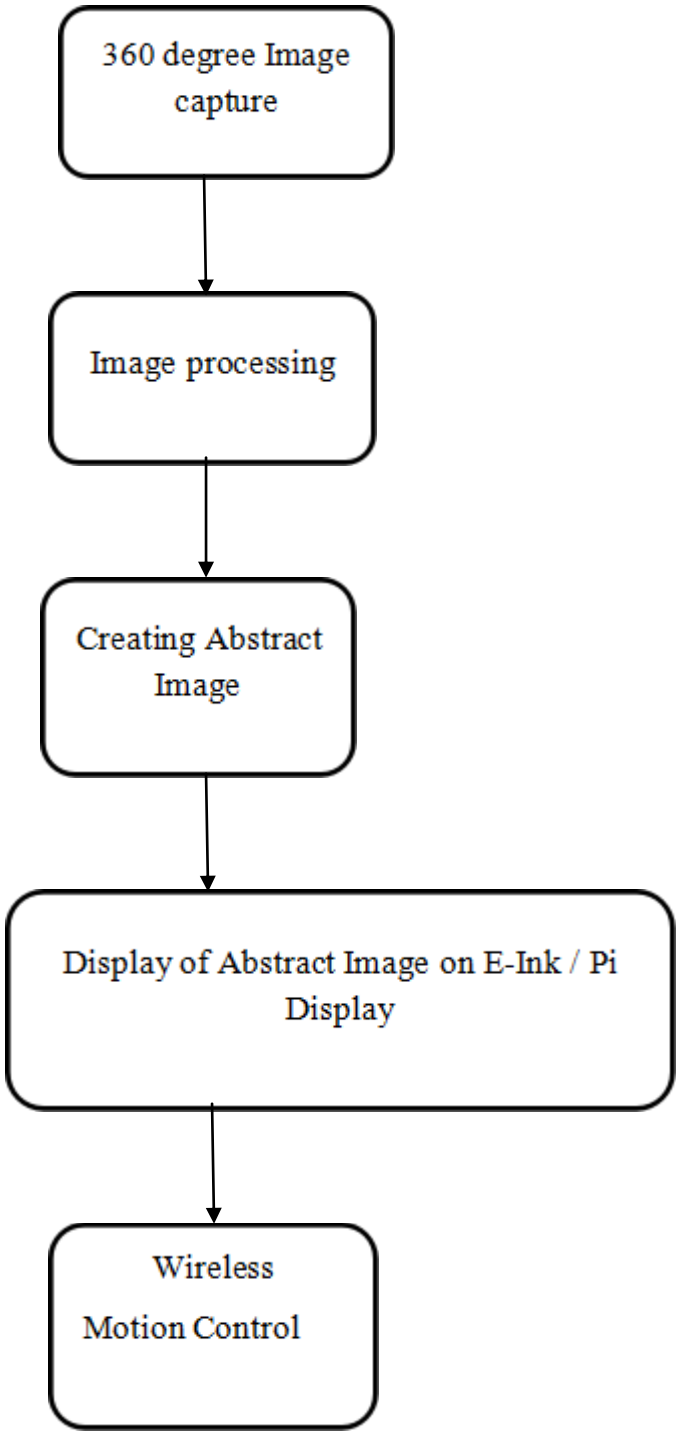


Fig 13 : Flow chart of the project

CHAPTER 4

HARDWARE

4.1 Mechanical Hardware Requirements

4.1.1 Robot Chassis

Fig 14 : Robot chassis

Chassis has multiple holes and slots so that you can fit your electronics easily on this rigid chassis. Raspberry pi compatible holes and standoffs are included so it can be easily mounted on top. Build Multiple types of Robots from one chassis. Has slots for all your general needs. This chassis base consists of 4 wheels. It has two plates made of cardboard inorder to cover the upper and lower surface of the robot body. There are various screws being provided inorder to fix the upper and lower base of the chassis.

4.1.2 Geared DC motor

Fig 15: DC motor

A gear motor is an all-in-one combination of a motor and gearbox. The addition of a gear head to a motor reduces the speed while increasing the torque output. Most of our DC motors can be complimented with one of our unique gearheads, providing you with a highly efficient gear motor solution. Once the design calculations are performed, and the application parameters are defined, you can use this data to determine which motor or gear motor will best fit your application. Some of the most common specs to consider when selecting a motor or gear motor would be:

- Voltage
- Current
- Power
- Torque
- RPM
- Life Expectancy / Duty Cycle
- Rotation (CW or CCW)
- Shaft Diameter and Length
- Enclosure Restrictions

4.1.3 Servo Motor

A servomotor is a rotary_actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors. Servomotors are not a specific class of motor, although the term servomotor is often used to refer to a motor suitable for use in a closed-loop control system. Servomotors are used in applications such as robotics, CNC machinery or automated_manufacturing.

A servomotor is a closed-loop servomechanism that uses position feedback to control its motion and final position. The input to its control is a signal (either analogue or digital) representing the position commanded for the output shaft.

All motors have three wires coming out of them. Out of which two will be used for Supply (positive and negative) and one will be used for the signal that is to be sent from the MCU.

Servo motor is controlled by PWM (Pulse with Modulation) which is provided by the control wires. There is a minimum pulse, a maximum pulse and a repetition rate. Servo motor can turn 90 degree from either direction form its neutral position. The servo motor expects to see a pulse every 20 milliseconds (ms) and the length of the pulse will determine how far the motor turns.

Fig 16 : Servo Motor

4.1.4 Wheels

Fig 17: Wheels

Arduino smart Car Robot Plastic Tire Wheel. The above figure is the wheel being used in our robot chassis. We used a 4 wheel chassis. There are front two tired controlled by one motor driver and the back two tires controlled by the other motor driver. 4 wheels give it easier support for the chassis to hold the components to move easily.

4.2 Electronic Hardware Requirements

4.2.1 Raspberry Pi 3b+

Fig 18: Raspberry Pi 3b+

The Raspberry Pi 3 B+ is the latest product in the Raspberry Pi 3 range, boasting an updated 64-bit quad core processor running at 1.4GHz with built-in metal heatsink, dual-band 2.4GHz and 5GHz wireless LAN, faster (300mbps) Ethernet, and PoE capability via a separate PoE HAT.

The Raspberry Pi is a fully-fledged mini computer, capable of doing whatever you might do with a computer. It comes with 4x USB, HDMI, LAN, built-in Bluetooth/WiFi support, 1GB RAM, 1.2GHz quad-core ARM CPU, 40 GPIO (General Purpose Input Output) pins, audio and composite video output, and more. Rather than not having many choices, instead, your options are staggeringly large.

4.2.2 Raspberry Pi Camera

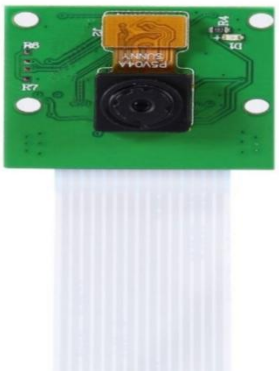


Fig 19 Raspberry Pi Camera

The high-definition 5MP camera delivers outstanding photos but can also shoot video, ideal for drones or a CCTV project. The lightweight camera module allows for it to be used in more practical roles, such as a hidden camera or even a camera for a Pi-phone, for example.

This Raspberry Pi Camera Module is a custom designed add-on for Raspberry Pi. It attaches to Raspberry Pi by way of one of the two small sockets on the board upper surface. This interface uses the dedicated CSI interface, which was designed especially for interfacing to cameras. The CSI bus is capable of extremely high data rates, and it exclusively carries pixel data.

The board itself is tiny, at around 25mm x 23mm x 8mm. It also weighs just over 3g, making it perfect for mobile or other applications where size and weight are important. It connects to Raspberry Pi by way of a short flexible ribbon cable. The camera connects to the BCM2835 processor on the Pi via the CSI bus, a higher bandwidth link which carries pixel data from the camera back to the processor. This bus travels along the ribbon cable that attaches the camera board to the Pi.

The sensor itself has a native resolution of 5 megapixels and has a fixed focus lens onboard. In terms of still images, the camera is capable of 2592 x 1944 pixel static images, and also supports 1080p30, 720p60 and 640x480p60/90 video.

No adapters required! This camera will plug directly into the Raspberry Pi 3 Model B camera port. This model is capable of taking pictures and vedio no sound.

4.2.3 Motor Drivers

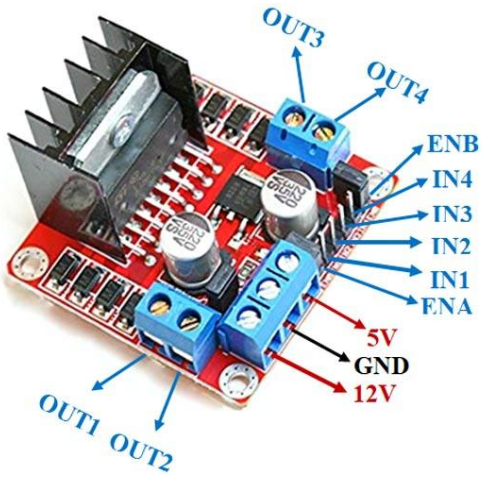


Fig 20 : L298 motor driver

L298N Motor Driver Module is a high power motor driver module for driving DC and Stepper Motors. This module consists of an L298 motor driver IC and a 78M05 5V regulator. L298N Module can control up to 4 DC motors, or 2 DC motors with directional and speed control. 12V input from DC power Source.5V Supplies power for the switching logic circuitry inside L298N IC

4.2.4 Power Supply

Fig 21 : 9V battery

9-volt battery, is a common size of **battery** that was introduced for the early transistor radios. It has a rectangular prism shape with rounded edges and a polarized snap connector at the top. This type is commonly used in walkie-talkies, clocks and smoke detectors. This battery is used to power on the arduino uno and the rasberry pi board. We have used 2 of these batteries with us to power on the device.

4.2.5 Raspberry Pi display

Fig 22: Raspberry Pi display

Compatible with Raspberry Pi-3.Good touch response.Large viewing angle.Fast response time.Support backlight control alone.Not only for Raspberry Pi.Not only for mini-PCs, but it can also work as a computer monitor.The product is shipped with a user guide and image.

Either we can directly power it on with the power supply or use the HDMI cable and connect it to our laptops and help in screen sharing process. There are various sizes available of this display. The one used here is the 5 inch display.

4.2.6 Bluetooth module

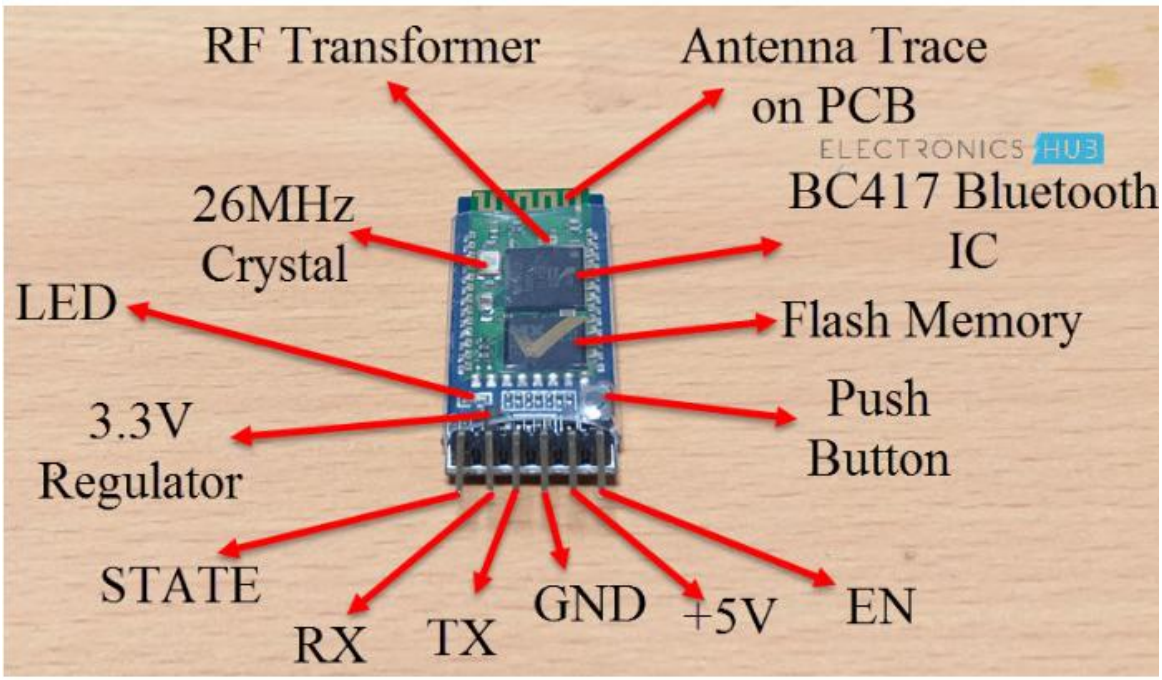


Fig 23: Bluetooth module

HC-05 is a bluetooth module which is designed for wireless comunication. this module can be used in a master or slave configuration.

PIN DESCRIPTION

Fig 24: Pin description of Bluetooth module

Bluetooth serial modules allow all serial enabled devices to communicate with each other using Bluetooth.

It has 6 pins,

1. **Key/EN:** It is used to bring Bluetooth module in AT commands mode. If Key/EN pin is set to high, then this module will work in command mode. Otherwise by default it is in data mode. The default baud rate of HC-05 in command mode is 38400bps and 9600 in data mode.

HC-05 module has two modes,

1. **Data mode:** Exchange of data between devices.

2. **Command mode:** It uses AT commands which are used to change setting of HC-05. To send these commands to module serial (USART) port is used.

2. **VCC:** Connect 5 V or 3.3 V to this Pin.

3. **GND:** Ground Pin of module.

4. **TXD:** Transmit Serial data (wirelessly received data by Bluetooth module transmitted out serially on TXD pin)

5. **RXD:** Receive data serially (received data will be transmitted wirelessly by Bluetooth module).

6. **State:** It tells whether module is connected or not.

4.2.7 Arduino Uno

Fig 25: Arduino UNO

The Arduino UNO is the best board to get started with electronics and coding. If this is your first experience tinkering with the platform, the UNO is the most robust board you can start playing with. The UNO is the most used and documented board of the whole Arduino family.

4.3 Connection of Electronic Hardware

Fig 26 Connection of Raspberry Pi camera to Raspberry Pi

Connect the Raspberry Pi Camera Module to your Raspberry Pi and take pictures, record video, and apply image effects

Raspberry Pi computer with a Camera Module port

All current models of Raspberry Pi have a port for connecting the Camera Module.

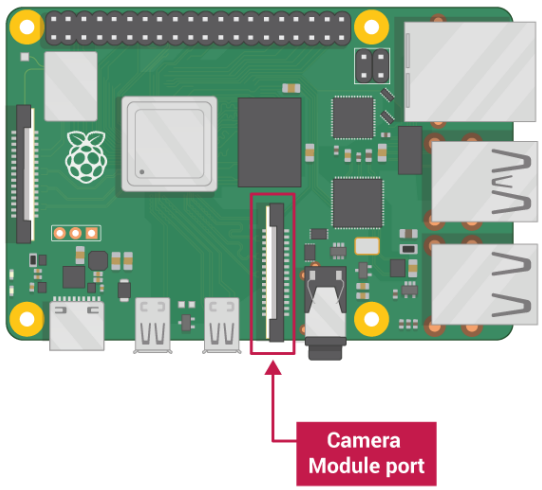


Fig 27: Raspberry Pi computer with a Camera Module port

If you want to use a Raspberry Pi Zero, you need a Camera Module ribbon cable that fits the Raspberry Pi Zero's smaller Camera Module port.

Connect the Camera Module

There are two versions of the Camera Module:

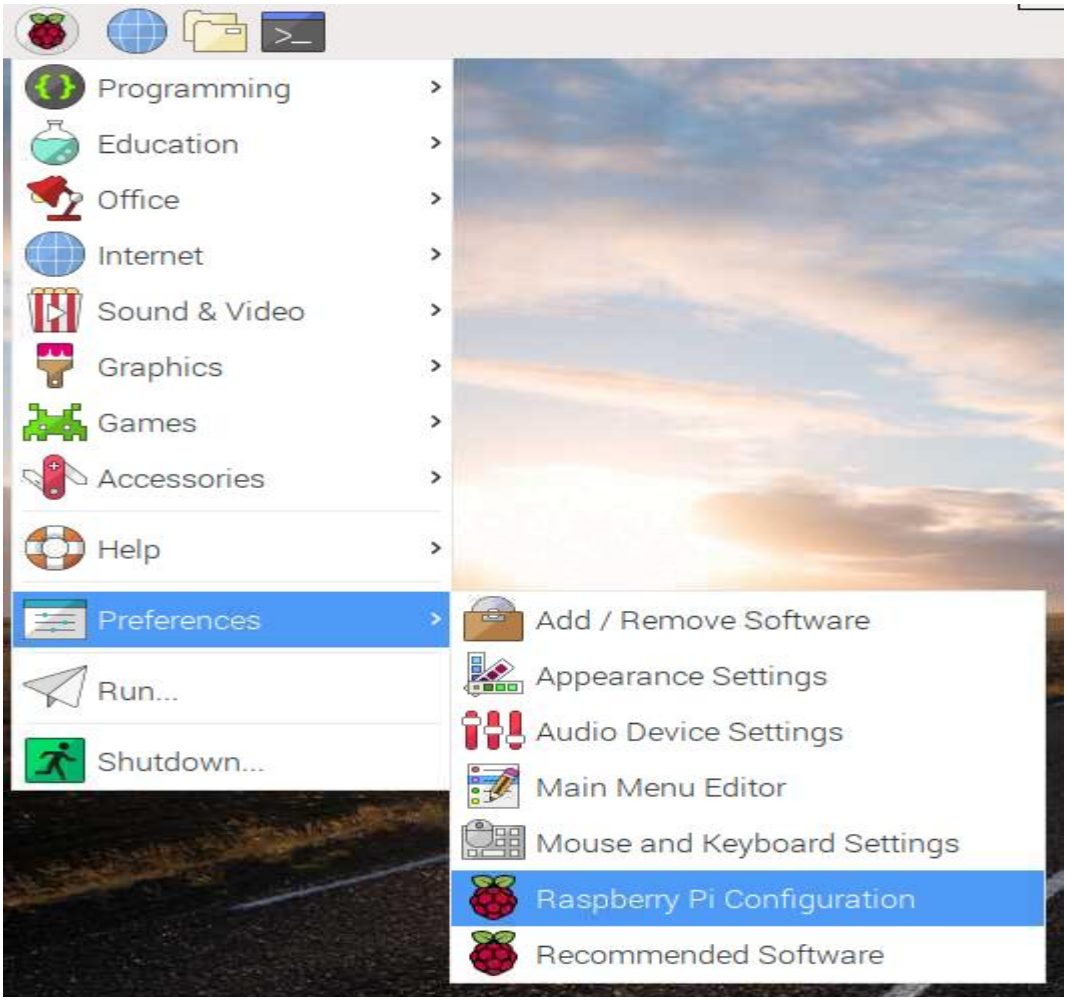
- The standard version, which is designed to take pictures in normal light
- The NoIR version, which doesn't have an infrared filter, so you can use it together with an infrared light source to take pictures in the dark

Ensure your Raspberry Pi is turned off.

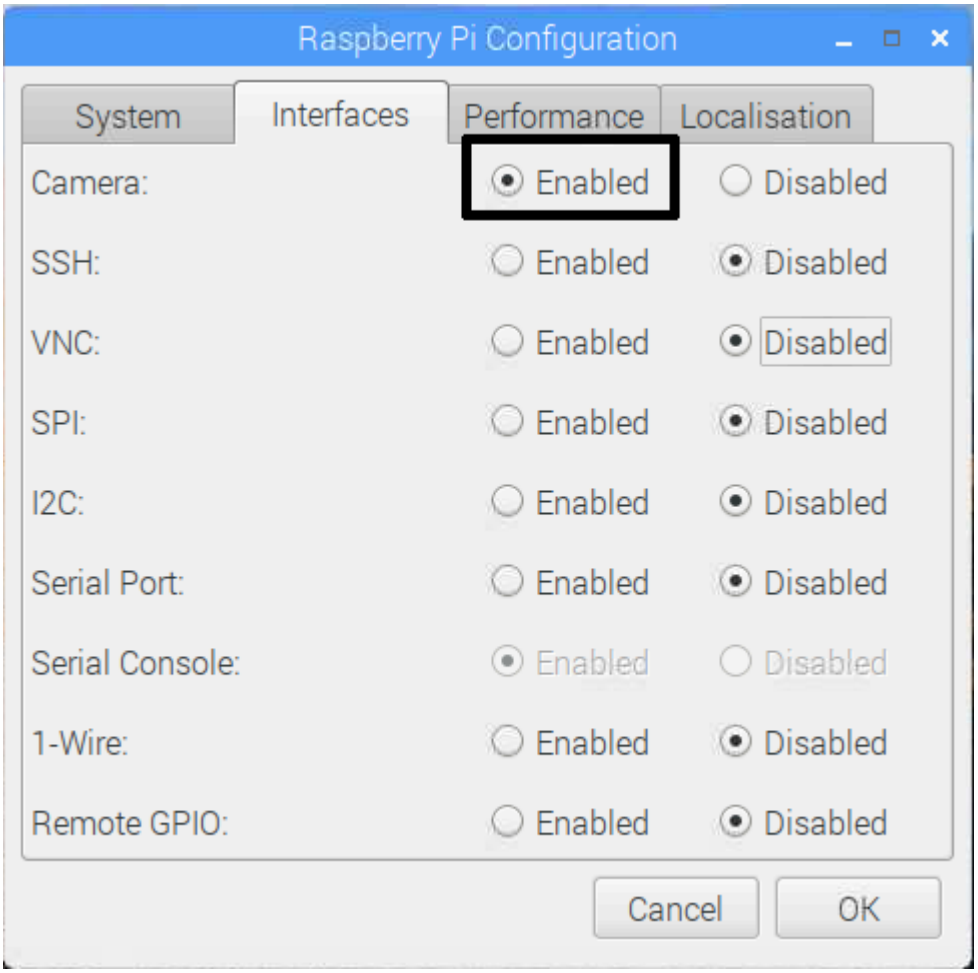
1. Locate the Camera Module port
2. Gently pull up on the edges of the port's plastic clip
3. Insert the Camera Module ribbon cable; make sure the cable is the right way round
4. Push the plastic clip back into place

- Start up your Raspberry Pi.

- Go to the main menu and open the Raspberry Pi Configuration tool.



- Select the Interfaces tab and ensure that the camera is enabled:



- Reboot your Raspberry Pi.

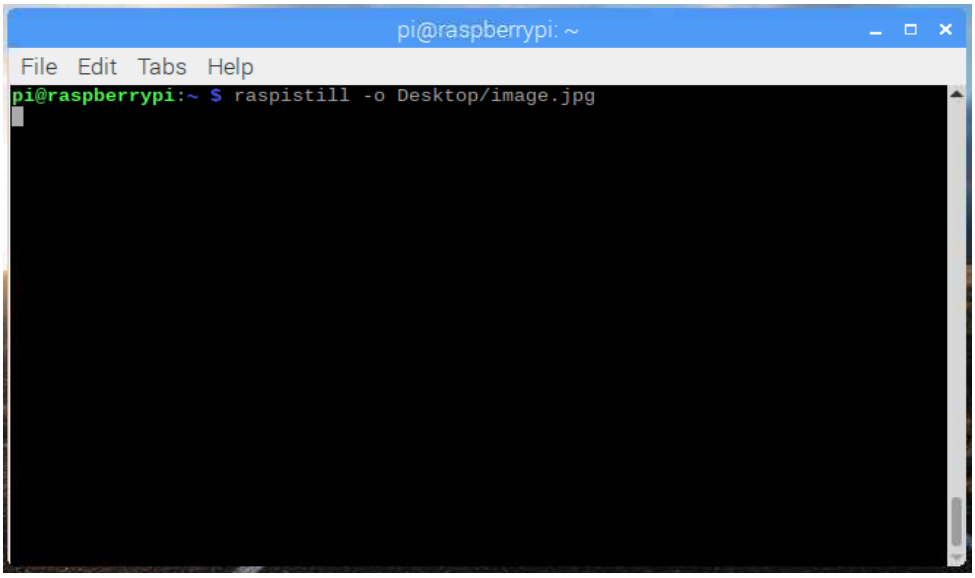
Controlling the Camera Module via the command line

Now your Camera Module is connected and the software is enabled, try out the command line tools raspistill and raspivid.

- Open a terminal window by clicking the black monitor icon in the taskbar:

- Type in the following command to take a still picture and save it to the Desktop:

```
raspistill -o Desktop/image.jpg
```



- Press Enter to run the command.

When the command runs, you can see the camera preview open for five seconds before a still picture is taken.

- Look for the picture file icon on the Desktop, and double-click the file icon to open the picture.

By adding different options, you can set the size and look of the image the raspistill command takes.

- For example, add -h and -w to change the height and width of the image:

```
raspistill -o Desktop/image-small.jpg -w 640 -h 480
```

- Now record a video with the Camera Module by using the following raspivid command:

```
raspivid -o Desktop/video.h264
```

- In order to play the video file, double-click the video.h264 file icon on the Desktop to open it in VLC Media Player.

Take still pictures with Python code

Now use the Camera Module and Python to take some still pictures.

- Amend your code to add a camera.capture() line:

```
camera.start_preview()
sleep(5)
camera.capture('/home/pi/Desktop/image.jpg')
camera.stop_preview()
```

  Note: it's important to sleep for at least two seconds before capturing an image, because this gives the camera's sensor time to sense the light levels.
- Run the code.

You should see the camera preview open for five seconds, and then a still picture should be captured. As the picture is being taken, you can see the preview briefly adjust to a different resolution.

Your new image should be saved to the Desktop.

- Now add a loop to take five pictures in a row:

```
camera.start_preview()
for i in range(5):
    sleep(5)
    camera.capture('/home/pi/Desktop/image%s.jpg' % i)
camera.stop_preview()
```

  The variable i counts how many times the loop has run, from 0 to 4. Therefore, the images get saved as image0.jpg, image1.jpg, and so on.
- Run the code again and hold the Camera Module in position.

The camera should take one picture every five seconds. Once the fifth picture is taken, the preview closes.

- Look at your Desktop to find the five new pictures.
    - If all goes as expected you should have an image displayed on your screen:

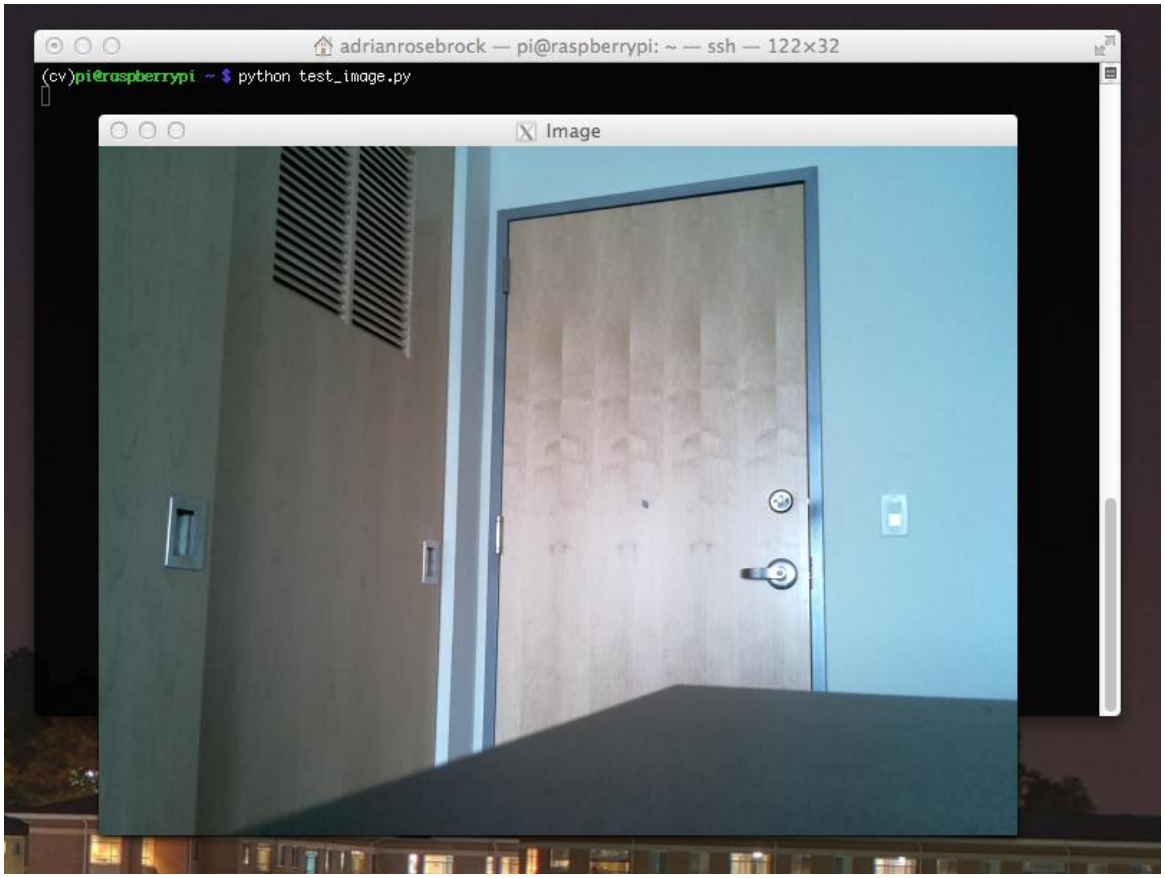


Fig 28: Display on LCD of the figure in front of camera

CHAPTER 5
SOFTWARE

5.1 Rasbian OS

Raspberry Pi OS is the recommended operating system for normal use on a Raspberry Pi.

Raspberry Pi OS is a free operating system based on Debian, optimised for the Raspberry Pi hardware. Raspberry Pi OS comes with over 35,000 packages: precompiled software bundled in a nice format for easy installation on your Raspberry Pi.

Raspberry Pi OS is a community project under active development, with an emphasis on improving the stability and performance of as many Debian packages as possible.

Step 1: Download the Required Software and Files

You need to download 2 software and 1 OS i.e. Raspbian for this complete process.

1st software: The first software is Win32 Disk Imager.

https://sourceforge.net/projects/win32diskimager/

2nd software: Second software is SD Card Formatter.

https://www.sdcard.org/downloads/formatter_4/

Raspbian OS: This is the Main operating system of the Pi.

https://www.raspberrypi.org/downloads/raspbian/

Extract all files to the desktop.

Step 2: Get the SD Card and the Card Reader

Get a minimum 8GB class 10 SD card with a card reader. Insert that card into the card reader and plug that to the USB port.

Step 3: Check the Drive in Which the SD Card Is Mounted

Go to my computer or My PC and find the drive name where the SD card is mounted.

Step 4: Format the SD Card

Open SD Card Formatter and select the drive you noticed in the previous step.

Click on format and don't alter any other options.

When formatting is completed, click on OK.

Step 5: Write the OS on the SD Card

Open win32diskimager.

Browse the .img file of Raspbian OS that was extracted from the downloaded file.

Click on open and then click on Write. If any warning pops up then ignore those by clicking OK.

Step 6: Eject the SD Card

Now your OS in installed on your Raspberry Pi.

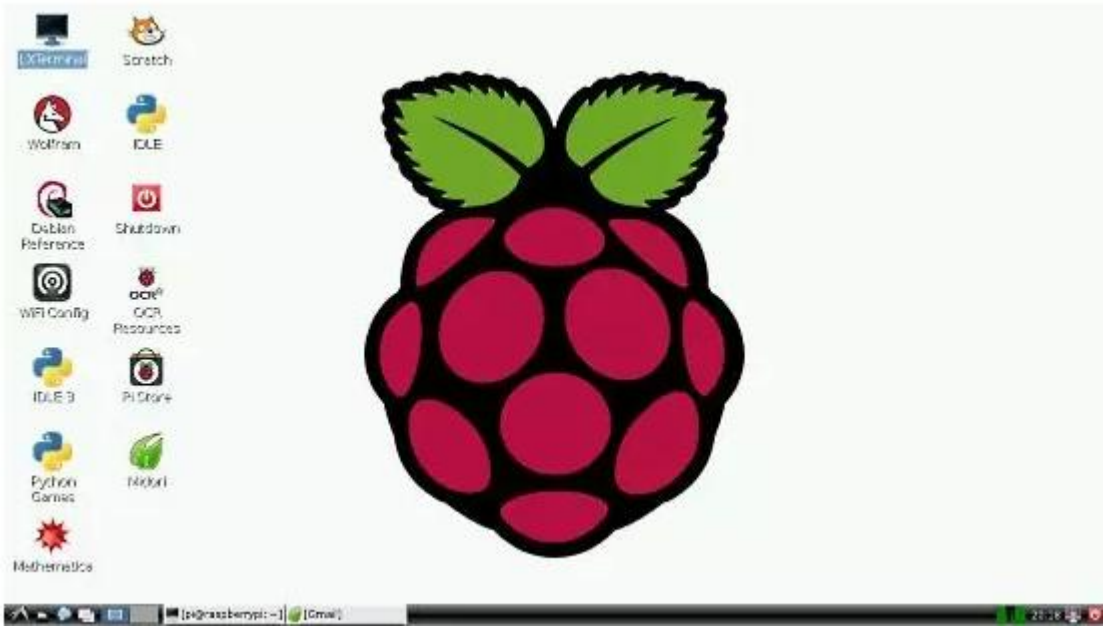


Fig 29: Rasbian OS on the PC

5.2 PYTHON PROGRAMMING

Python is a wonderful and powerful programming language that's easy to use (easy to read and write) and, with Raspberry Pi, lets you connect your project to the real world. Python syntax is very clean, with an emphasis on readability, and uses standard English keywords.

OpenCV (Open Source Computer Vision Library: http://opencv.org) is an open-source BSD-licensed library that includes several hundreds of computer vision algorithms. The document describes the so-called OpenCV 2.x API, which is essentially a C++ API, as opposed to the C-based OpenCV 1.x API (C API is deprecated and not tested with "C" compiler since OpenCV 2.4 releases). To use the OpenCV library you have two options: Installation by Using the Pre-built Libraries or Installation by Making Your Own Libraries from the Source Files .

OpenCV has a modular structure, which means that the package includes several shared or static libraries. The following modules are available:

- Core functionality (core) - a compact module defining basic data structures, including the dense multi-dimensional array Mat and basic functions used by all other modules.
- Image Processing (imgproc) - an image processing module that includes linear and non-linear image filtering, geometrical image transformations (resize, affine and perspective warping, generic table-based remapping), color space conversion, histograms, and so on.
- Video Analysis (video) - a video analysis module that includes motion estimation, background subtraction, and object tracking algorithms.
- Camera Calibration and 3D Reconstruction (calib3d) - basic multiple-view geometry algorithms, single and stereo camera calibration, object pose estimation, stereo correspondence algorithms, and elements of 3D reconstruction.
- 2D Features Framework (features2d) - salient feature detectors, descriptors, and descriptor matchers.
- Object Detection (objdetect) - detection of objects and instances of the predefined classes (for example, faces, eyes, mugs, people, cars, and so on).
- High-level GUI (highgui) - an easy-to-use interface to simple UI capabilities.
- Video I/O (videoio) - an easy-to-use interface to video capturing and video codecs.
- ... some other helper modules, such as FLANN and Google test wrappers, Python bindings, and others.

5.3 ARDUINO IDE

Arduino development environment:
The Arduino Integrated Development Environment (IDE) is a cross-platform application (for Windows, macOS, Linux) that is written in functions from C and C++. It is used to write and upload programs to Arduino compatible boards, but also, with the help of 3rd party cores, other vendor development boards.

Developer(s): Arduino Software
Written in: C, C++, Java
Platform: IA-32, x86-64, ARM

The Arduino board is connected to a computer via USB, where it connects with the Arduino development environment (IDE). The user writes the Arduino code in the IDE, then uploads it to the microcontroller which executes the code, interacting with inputs and outputs such as sensors, motors, and lights.

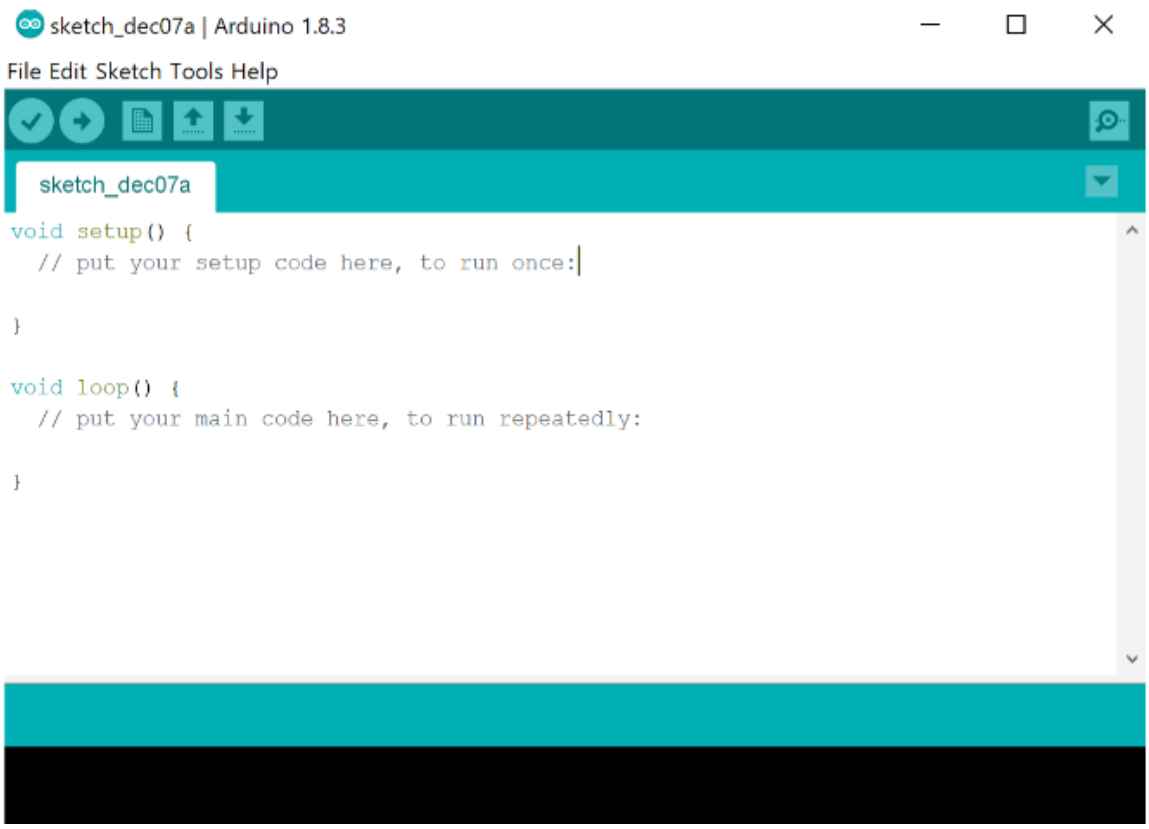


Fig 30: Arduino IDE

5.4 ARDUINO BLUETOOTH RC

Bluetooth Communication is a 2.4GHz frequency based RF Communication with a range of approximately 10 meters. It is one of the most popular and most frequently used low range communication for data transfer, audio systems, handsfree, computer peripherals etc.

Make the connections and power on the Bluetooth Module. If this is the first time you are using your Bluetooth Module, then the LED will blink rapidly. In order to pair the module with your phone, open Bluetooth Settings in your phone and connect to "HC-05" with pin "1234". If 1234 doesn't work, try "0000".

Once the Bluetooth Module is paired with your phone, you can start using the App. Open the Bluetooth Controller App and click on scan. A list of Bluetooth Devices will appear on the screen. Select HC-05.

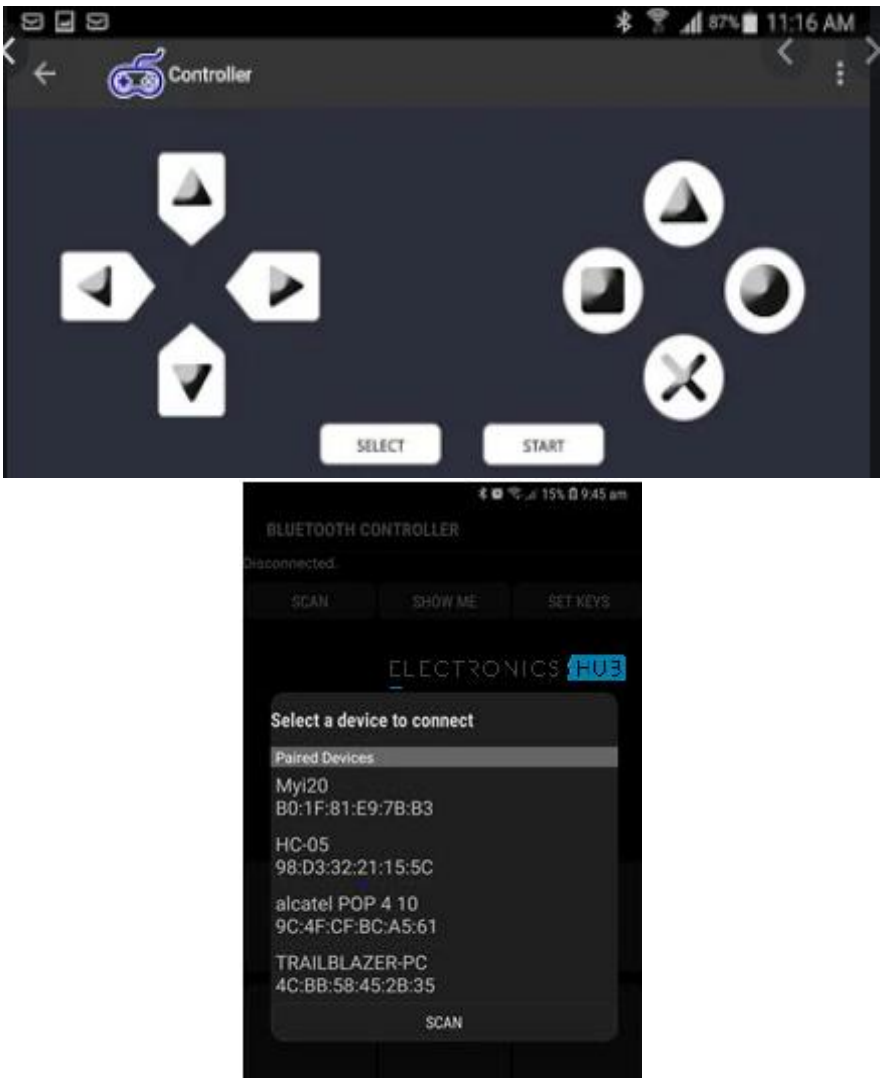


Fig 31:HC-05 bluetooth when connected to phone to control robot movement

CHAPTER 6

TESTING

6.1 Hardware Testing

6.1.1 DC Motor for controlled Motion

```
char t;

void setup() {
pinMode(13,OUTPUT);   //left motors forward
pinMode(12,OUTPUT);   //left motors reverse
pinMode(11,OUTPUT);   //right motors forward
pinMode(10,OUTPUT);   //right motors reverse
pinMode(6,OUTPUT);   //left motors forward
pinMode(5,OUTPUT);   //left motors reverse
pinMode(4,OUTPUT);   //right motors forward
pinMode(3,OUTPUT);   //right motors reverse
Serial.begin(9600);

}

void loop() {
if(Serial.available()){
  t = Serial.read();
  Serial.println(t);
}

if(t == 'S'){                //move forward(all motors
rotate in forward direction)
  digitalWrite(13,LOW);
  digitalWrite(12,HIGH);
  digitalWrite(11,HIGH);
  digitalWrite(10,LOW);
  digitalWrite(6,HIGH);
  digitalWrite(5,LOW);
  digitalWrite(4,HIGH);
  digitalWrite(3,LOW);
}

else if(t == 'W'){          //move reverse (all motors
rotate in reverse direction)
  digitalWrite(13,HIGH);
  digitalWrite(12,LOW);
  digitalWrite(11,LOW);
  digitalWrite(10,HIGH);
```

```
  digitalWrite(6,LOW);
  digitalWrite(5,HIGH);
  digitalWrite(4,LOW);
  digitalWrite(3,HIGH);
}

else if(t == 'D'){       //turn right (left side motors
rotate in forward direction, right side motors doesn't
rotate)
  digitalWrite(13,LOW);
  digitalWrite(12,HIGH);
  digitalWrite(11,LOW);
  digitalWrite(10,HIGH);
  digitalWrite(6,LOW);
  digitalWrite(5,HIGH);
  digitalWrite(4,HIGH);
  digitalWrite(3,LOW);

}

else if(t == 'A'){       //turn left (right side motors
rotate in forward direction, left side motors doesn't
rotate)
  digitalWrite(13,HIGH);
  digitalWrite(12,LOW);
  digitalWrite(11,HIGH);
  digitalWrite(10,LOW);
  digitalWrite(6,HIGH);
  digitalWrite(5,LOW);
  digitalWrite(4,LOW);
  digitalWrite(3,HIGH);
}

else
{                        //STOP (all motors stop)
  digitalWrite(13,LOW);
  digitalWrite(12,LOW);
  digitalWrite(11,LOW);
  digitalWrite(10,LOW);
  digitalWrite(6,LOW);
  digitalWrite(5,LOW);
  digitalWrite(4,LOW);
  digitalWrite(3,LOW);
}
delay(100);
}
```

6.2 Software Testing

```
import tkinter as tk
import cv2
from PIL import Image, ImageTk
import numpy as np
import picamera

cap = cv2.VideoCapture(0)                    # capture from
pi camera
width  =  cap.get(cv2.CAP_PROP_FRAME_WIDTH)  #get  the
captured image width
height  =  cap.get(cv2.CAP_PROP_FRAME_HEIGHT)  #get  teh
captured image height
height  =  int(height)  #  convert  the  height  value  to
integer
width  =  int(width)   ##  convert  the  width  value  to
integer
global    red,    green,    blue,    average_rgb_value,
colour_frame # global variables diclared
colour_frame    =    np.zeros((height,    width,    3),
dtype=np.uint8)    #  create  a  color_frame  variable
initialised to zeros to store colour data


def    compute_average_image_color(display_image):    #
function  to  calculate  the  average  each  pixel  colour
value present in the image
    global width, height
    r_total = 0
    g_total = 0
    b_total = 0
    print(width, height)
    count = 0
    for x in range(0, 80):
        for y in range(0, 48):
            rgb_value = display_image.getpixel((x, y))
            r_total += rgb_value[0]
            g_total += rgb_value[1]
            b_total += rgb_value[2]
            count += 1

    return int(r_total / count), int(g_total / count),
int(b_total / count) # returns the average value of RGB
```

```
def colour_frame_update():        # function to update
the colour frame after every capture
    global colour_frame, average_rgb_value, red, green,
blue
    red, green, blue = average_rgb_value
    print(red,green,blue)
    colour_frame[ : : ] = red, green, blue


def display_loop():        # main loop that runs to
capture the frame and calculates averages of RGB pixel
values individually
    if not cap.isOpened():  # checks for the opening of
camera
        print("cant open the camera")
    flag, frame = cap.read()
    if flag is None:
        print("Major error!")
    global average_rgb_value, colour_frame

    pic = cv2.cvtColor(frame.copy(), cv2.COLOR_BGR2RGB)
# convert the image from BGR to RGB
    captured_image = Image.fromarray(pic)
    captured_image   =   captured_image.resize((80,48),
Image.ANTIALIAS) #Resize the image to 80x48 to reduce
calculations else will slow down the process
    average_rgb_value                                  =
compute_average_image_color(captured_image)      #calls
the function to calculate the average
    colour_frame_update()                              #
Updates the frame colour after calculating the average
    img  =  Image.fromarray(colour_frame)              #
creates the image from the colour frame
    img_resize = img.resize((800,480), Image.ANTIALIAS)
# resize to the size of the output screen to fill with
same colour
    render_1   =   ImageTk.PhotoImage(image=img_resize)
# render the iamge
    screen_1.render_1 = render_1
    screen_1.configure(image=render_1)
    screen_1.after(2, display_loop)                #Loop
to repeat


window = tk.Tk()  # assigning root variable for Tkinter
as tk
```

```
screen_1 = tk.Label(master=window) # assign the screen
1 to the window
screen_1.grid(row=1, column=0, padx=0, pady=0)
window.title("color")  # you can give any title
coordinate = str(width) + 'x' + str(height) # match the
size of the window to the image size
window.geometry(coordinate)  # size of window , x-axis,
y-axis
display_loop() # calling the main loop
window.attributes('-fullscreen', True) # fullscreen the
application to cover the entire screen
window.mainloop()    # keeps the application in an
infinite loop so it works continuously
cap.release()
```

CHAPTER 7

RESULT

After applying all the available techniques and further evaluation of the code, below model is obtained.

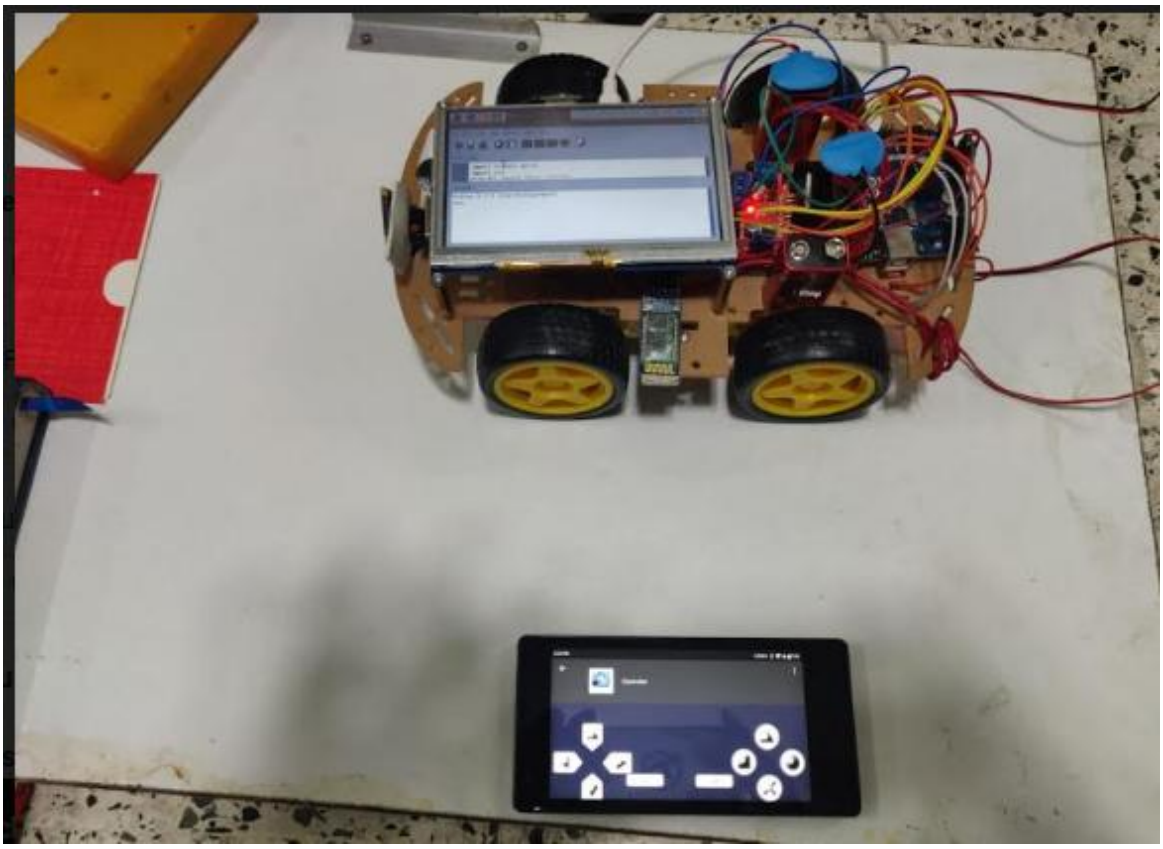


Fig 32 : Working Model

The Arduino Bluetooth RC app as shown in the above picture is used to manually control the robot and move it as we need. It is capable of identifying the colour present in front of the pi camera. With this bluetooth connectivity we operate it. Below are the images which demonstrate the camouflge technique.

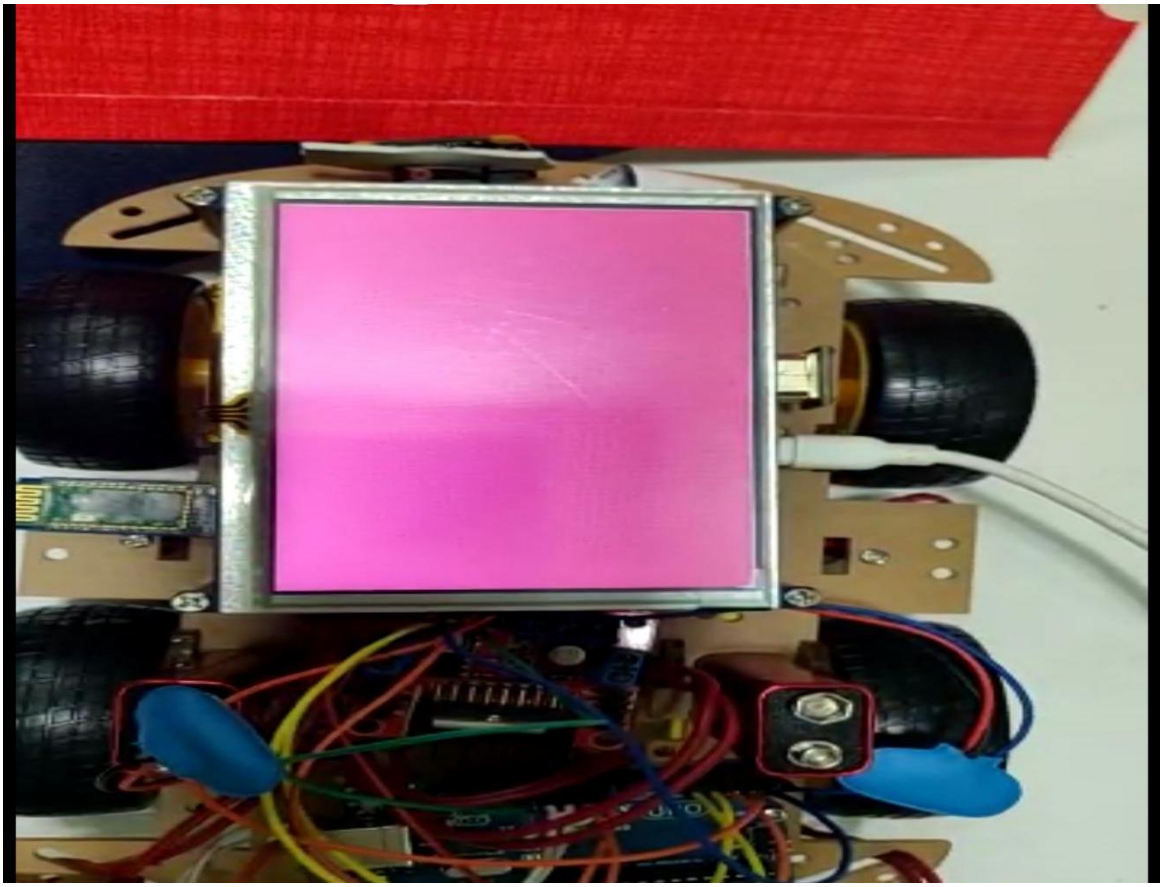


Fig 33: Red colour camouflage

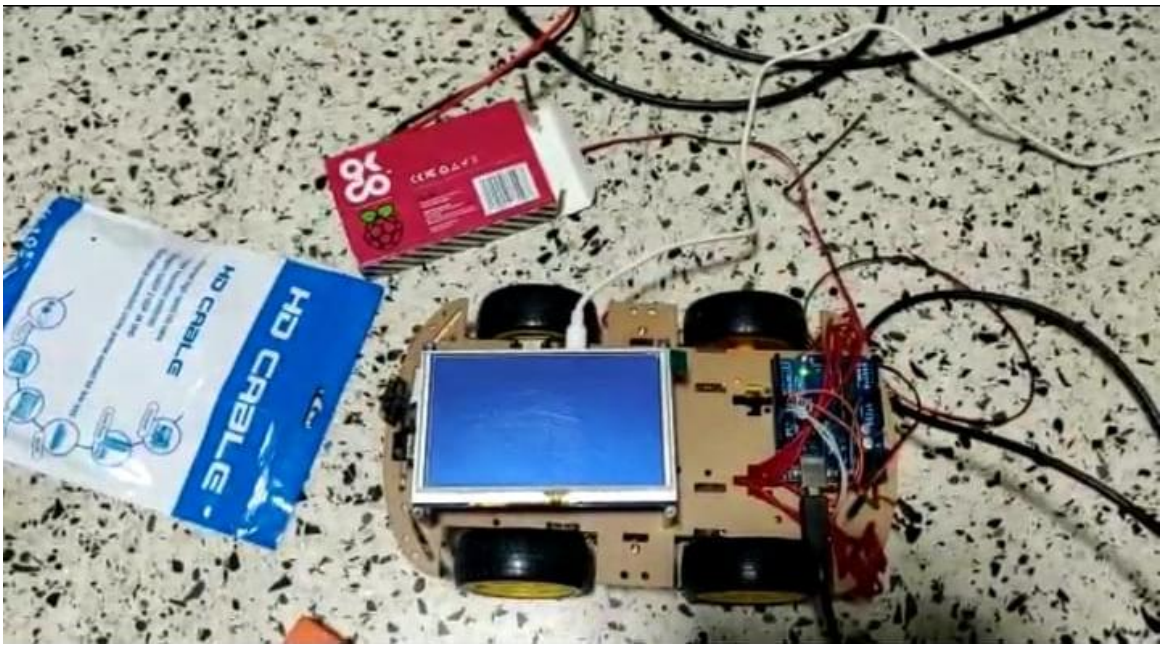


Fig 34: Blue colour camouflage

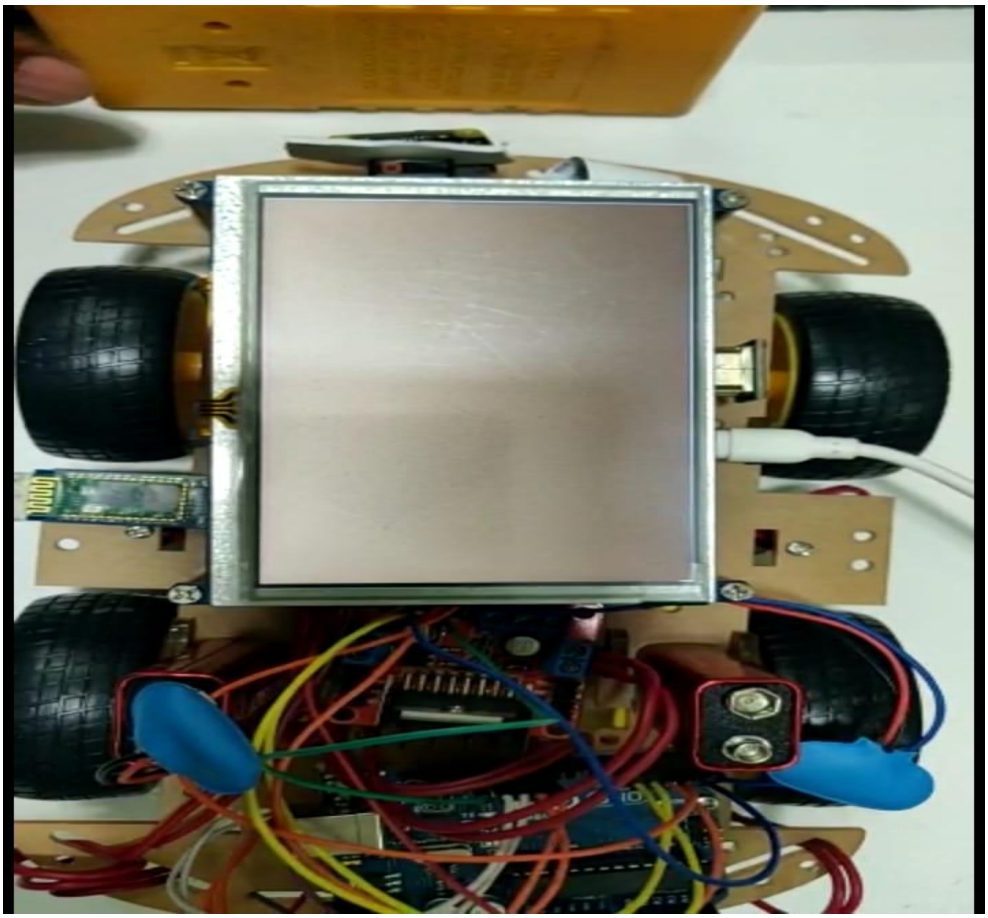


Fig 35 : Yellow coloured camouflage

On placing any object in front of the camera we can successfully make a camouflage.On using a E-ink display the work would be even more better. Thus we can move and control it within the limited range.

CHAPTER 8

ADVANTAGES AND DISADVANTAGES

ADVANTAGES

1. Army robots (Robotic soldiers) will not hesitate to kill any enemy, they have no emotions, so, they can't be scared or intimidated, they can be sent into places that humans can't go to such as nuclear waste areas or to extremely hot or cold places,
2. Army robots can make faster decisions than humans, they are unaffected by anger, revenge, hunger, fear, fatigue, or stress
3. They are easily replaceable at a cost, unlike human life
4. Robots can endure damage done by bombs or other types of weaponry that would otherwise destroy the human body.
5. Robots can report problems and sound alarms to scare away intruders, and everything will be in the hands of humans
6. Robot soldier can navigate on his own once he has learned his round, He gets around obstacles
7. Robots can see & hear better than humans, they don't get tired (at least between recharges), they don't get bored
8. can make decisions faster and better than a human

DISADVANTAGE

1. Army robots could be hacked by the enemy and can be used against you, They can malfunction and turn against you or explode in front of you, they can't tell right from wrong meaning it could kill civilians as well as rebel allies if it sees them
2. Humans fear robots, Robots could take over the world, and they might take over our jobs
3. Robots have limited capabilities, despite their capabilities in terms of object recognition and navigation
4. As the range of the Bluetooth Communication is limited (a maximum of 10 meters for class 2 devices for example) the control range of Bluetooth Controlled Robot is also limited.
5. Make sure that sufficient power is provided to all the modules especially the Bluetooth Module. If the power is not sufficient, even though the Bluetooth Module powers on, it cannot transmit data or cannot be paired with other Bluetooth devices.

CHAPTER 9

APPLICATIONS

1. Low range Mobile Surveillance Devices
2. Military Applications (no human intervention)
3. Assistive devices (like wheelchairs)
4. Home automation
5. Spy Robot
6. Human detection

CHAPTER 10

CONCLUSION

The proposed system provides a helping hand to our security forces in detection of intruders. The robot can also be used in high altitude areas where human cannot survive. Moreover, the camouflaging feature makes it difficult to detect the robot by naked human eye. There is scope to improve the system by configuring it with multicolor camouflaging. This robot can be placed inside the room inorder to monitor things.Thus the main aim should be less involvement of humans for their safety.

Future Scope

Once a high definition kind of camouflage is obtained then we can completely hide the robot from human eye. Use of the new technology of e-ink based displays or any other good non-reflective display would give us a helping hand to our defense.

Use of this to act as a spy robot in warefare areas or in any place inorder to have a complete survillance of the surroundings.

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APPENDIX A

Arduino Uno

Arduino Uno R3 Front *Arduino Uno R3 Back*

Arduino Uno R2 Front *Arduino Uno SMD* *Arduino Uno Front* *Arduino Uno Back*

Overview

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.
The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.
Revision 2 of the Uno board has a resistor pulling the 8U2 HWB line to ground, making it easier to put into DFU mode.
Revision 3 of the board has the following new features:

- 1.0 pinout: added SDA and SCL pins that are near to the AREF pin and two other new pins placed near to the RESET pin, the IOREF that allow the shields to adapt to the voltage provided from the board. In future, shields will be compatible both with the board that use the AVR, which operate with 5V and with the Arduino Due that operate with 3.3V. The second one is a not connected pin, that is reserved for future purposes.
- Stronger RESET circuit.
- Atmega 16U2 replace the 8U2.

"Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduino, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform; for a comparison with previous versions, see the index of Arduino boards.

Summary

Microcontroller	ATmega328
Operating Voltage	5V

Overview

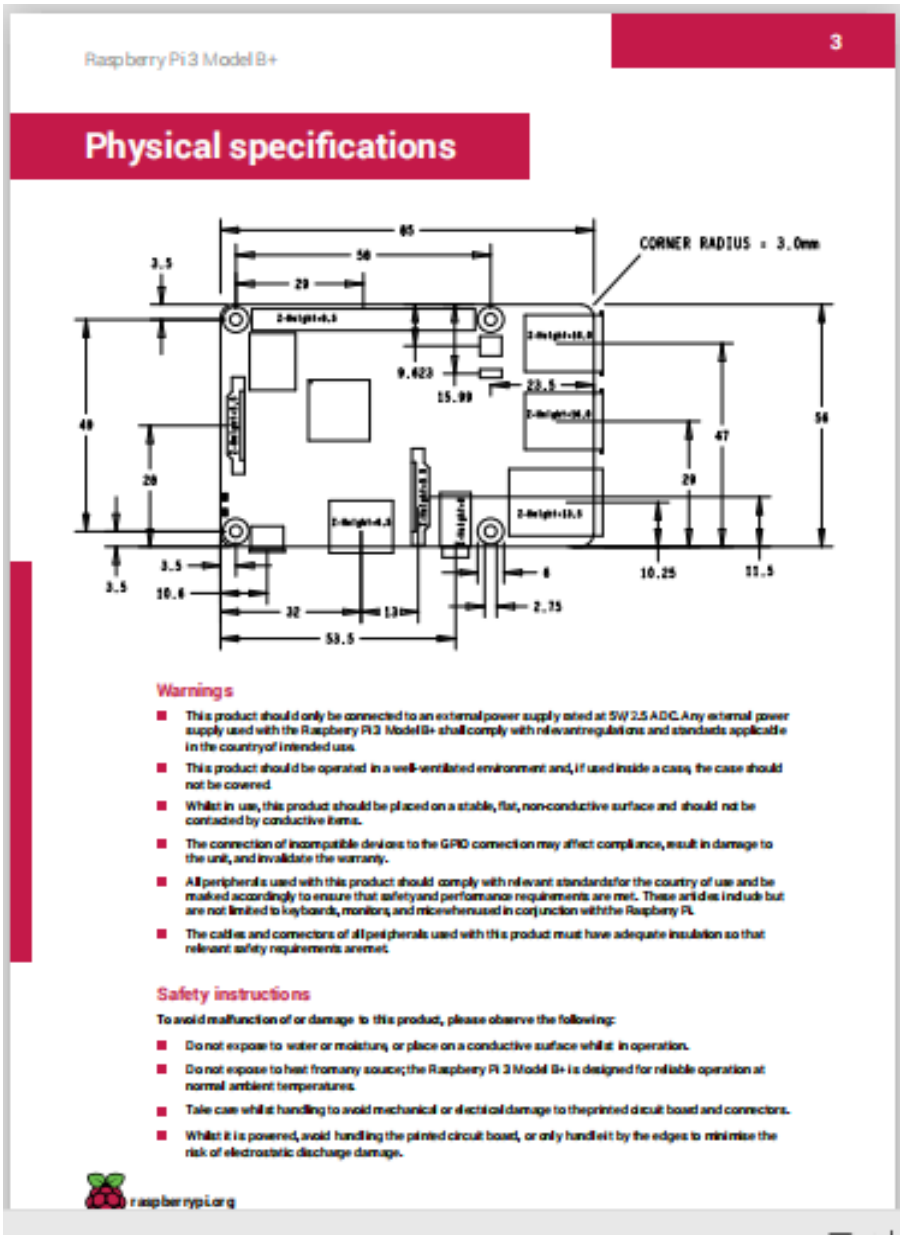
The Raspberry Pi 3 Model B+ is the latest product in the Raspberry Pi 3 range, boasting a 64-bit quad core processor running at 1.4GHz, dual-band 2.4GHz and 5GHz wireless LAN, Bluetooth 4.2/BLE, faster Ethernet, and PoE capability via a separate PoE HAT

The dual-band wireless LAN comes with modular compliance certification, allowing the board to be designed into end products with significantly reduced wireless LAN compliance testing, improving both cost and time to market.

The Raspberry Pi 3 Model B+ maintains the same mechanical footprint as both the Raspberry Pi 2 Model B and the Raspberry Pi 3 Model B.

Specifications

Processor:	Broadcom BCM2837B0, Cortex-A53 64-bit SoC @ 1.4GHz
Memory:	1GB LPDDR2 SDRAM
Connectivity:	■ 2.4GHz and 5GHz IEEE 802.11.b/g/n/ac wireless LAN, Bluetooth 4.2, BLE ■ Gigabit Ethernet over USB 2.0 (maximum throughput 300Mbps) ■ 4 × USB 2.0 ports
Access:	Extended 40-pin GPIO header
Video & sound:	■ 1 × full size HDMI ■ MIPI DSI display port ■ MIPI CSI camera port ■ 4 pole stereo output and composite video port
Multimedia:	H.264, MPEG-4 decode (1080p30); H.264 encode (1080p30); OpenGL ES 1.1, 2.0 graphics
SD card support:	Micro SD format for loading operating system and data storage
Input power:	■ 5V/2.5A DC via micro USB connector ■ 5V DC via GPIO header ■ Power over Ethernet (PoE)–enabled (requires separate PoE HAT)
Environment:	Operating temperature, 0–50°C
Compliance:	For a full list of local and regional product approvals, please visit www.raspberrypi.org/products/raspberry-pi-3-model-b+
Production lifetime:	The Raspberry Pi 3 Model B+ will remain in production until at least January 2023.



Raspberry Pi 3 Model B+ 3

Physical specifications

Warnings

- This product should only be connected to an external power supply rated at 5V/2.5A DC. Any external power supply used with the Raspberry Pi 3 Model B+ shall comply with relevant regulations and standards applicable in the country of intended use.
- This product should be operated in a well-ventilated environment and, if used inside a case, the case should not be covered.
- Whilst in use, this product should be placed on a stable, flat, non-conductive surface and should not be contacted by conductive items.
- The connection of incompatible devices to the GPIO connection may affect compliance, result in damage to the unit, and invalidate the warranty.
- All peripherals used with this product should comply with relevant standards for the country of use and be marked accordingly to ensure that safety and performance requirements are met. These articles include but are not limited to keyboards, monitors, and mice when used in conjunction with the Raspberry Pi.
- The cables and connectors of all peripherals used with this product must have adequate insulation so that relevant safety requirements are met.

Safety instructions

To avoid malfunction of or damage to this product, please observe the following:

- Do not expose to water or moisture, or place on a conductive surface whilst in operation.
- Do not expose to heat from any source; the Raspberry Pi 3 Model B+ is designed for reliable operation at normal ambient temperatures.
- Take care whilst handling to avoid mechanical or electrical damage to the printed circuit board and connectors.
- Whilst it is powered, avoid handling the printed circuit board, or only handle it by the edges to minimise the risk of electrostatic discharge damage.

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