A MAJOR PROJECT REPORT

ON

WEED CONTROL ROBOT USING COMPUTER VISION

Submitted in partial fulfilment for the award of the degree

Of

BACHELOR OF TECHNOLOGY

In

ELECTRONICS AND INSTRUMENTATION ENGINEERING

Submitted by

K. Akamsha Reddy	**17B81A1001**
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N. Tarun Reddy	**17B81A1054**

Under the Guidance of

DR. SANTOSH KUMAR SAHOO

Associate Professor, EIE.

Department of Electronics and Instrumentation Engineering

CVR COLLEGE OF ENGINEERING

(An UGC Autonomous Institution with NAAC ‘A’ Grade Accredited by NBA, AICTE)

Approved by AICTE & Affiliated to JNTU, Hyderabad, Mangalpalli(V),
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CERTIFICATE

This is to certify that the dissertation entitled "WEED CONTROL SYSTEM USING COMPUTER VISION" is a bonafide work done and submitted by

K. Akamsha Reddy	17B81A1001
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In partial fulfilment of requirement for the award of Bachelor of Technology degree in EIE CVR College of Engineering (Accredited by NBA, Approved by AICTE and Government of Andhra Pradesh and Affiliated to JNTU, Hyderabad).

Certified further that to the best of my knowledge the work in this dissertation has not been submitted to any other university or institute for the award of any degree.

Dr. Santosh Kumar Sahoo	**Dr. S. Harivardhagini**
(Project Guide)	(Head of department)

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ABSTRACT

Weed management is one of the most important aspects of crop productivity. The ordinary method for removing weeds (unwanted plants) in a field is to shower herbicides all over the estate. This results in defilement of the sustenance crops and the yield turns out to be less as a portion of the production plants pass on alongside the weeds. In this way, there is a requirement for a brilliant weed control framework. In this project, a weed control robot is made using the concepts of computer vision to automate the weed removal process and to increase productivity by spraying the herbicides only on the weeds but not all over the estate. Computer vision is a field of artificial intelligence that trains systems to recognize, process, and analyse images. The weed control robot recognises the weeds using an image segmentation algorithm and after recognizing the weeds, the herbicides are showered specifically and just on the weeds. R-CNN (Region-based Convolutional Neural Network) is trained to perform image segmentation on weeds. Once the weeds are recognized, a flag is sent from the raspberry pi to the motor driver which controls the motion of the robot and to the sprayer to shower the chemicals over the weeds.

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CHAPTER 1
INTRODUCTION

As the world population increases, so does the demand for food. Taking into account that land, water, and Labor are limited resources, it is estimated that the efficiency of agricultural productivity will increase by 25% by the year 2050. Therefore, it is crucial to focus on the problems faced by the agricultural industry. One of the significant effects of agribusiness is the control of weeds developing among the estate crops. At the exhibit, these sorts of plants are being expelled physically, in whatever place conceivable, or herbicides are being splashed consistently everywhere throughout the field to hold them in check. On an average, 34% of production is lost because weeds directly compete for nutrients, water, and sunlight. Furthermore, weeds are harder to detect due to their non-uniform presence and their overlap with other crops.

The oldest technique used to control weeds in crops is manual weeding. However, it is Labor and time-consuming, which makes it inefficient for large scale crops. Today, the agricultural industry has chemical weeding systems, and to a lesser extent, mechanical weeding systems, but in our context, 75% of the fruits produced, such as oranges, have manual weeding, which makes production even more inefficient and expensive. Moreover, there is a very high margin of error regarding weeding and these systems may end up damaging the plants.

Figure.1.1. Manual weeding

In customary weed control frameworks, herbicides are splashed consistently all over the field. This procedure is incompetent as pretty much 20% of the shower achieves the plant and under 1% of the synthetic really adds to weed control, prompting wastage, sullying of nature and wellbeing issues in individuals.

To maintain a strategic distance from these outcomes, a keen weed control framework ought to be utilized. These frameworks must be equipped for finding weeds in the field and herbicide sprayers are coordinated to splash ideal on the coveted specks. Additionally, it centres on decreasing the expensive work and limits the utilization of herbicides that damage the ordinary development of plants.

The machine vision keystone way utilizes surface, shape, shading and area-based highlights exclusively or in a mix of these to separate amongst unwanted plant and product. An imaging detector is a main part of any weed location and arrangement framework. Singular plant characterization has been effectively shown with either otherworldly or shading imaging. Weed regulation action is a basic problem and can essentially influence edit yield. Herbicides assume a vital part of weed control in any case, their utilization is condemned on the grounds that it is utilized exorbitantly and has possibly harmful impacts. Numerous examinations show that utilization of herbicides is lessened by fix showering. Manual exploring for fix showering requires extensive assets and isn't an attainable alternative.

Machine vision frameworks are appropriate for plant scale though remote detecting can be utilized on ideas proposed. Both of these frameworks basically need picture procurement and picture handling. The initial phase of recognizing weeds inside a picture includes grouping the pixels. The motivation behind portioning the picture into the plant and foundation pixels is to recognize the sum of plant material inside a particular zone.

In the event that the measure of plant material achieves a particular limit, that territory is focused on herbicidal spray application. A framework that could make utilization of the spatial appropriation data continuously and apply as it were the fundamental measures of herbicide to the weed-invaded region would be significantly more effective and limit natural harm. In this way, a high spatial determination, ongoing weed invasion recognition framework is by all accounts the answer for site-specific weed administration.

1.1. Problem statement:

Weeds are out of place and they cause economic losses by competing with crop plants for nutrients, water and space resulting in significant reduction in crop yields. Some of the problems faced due to weeds:

- The losses caused by weeds (34%) are more than losses caused by either disease (20%).
- Weeds require a lot of manual effort and time-consuming, which makes them inefficient and expensive.
- Around 20% of the crop is subjected to herbicides while spraying which in turn reduces the production.
- Spraying of excessive herbicides results in soil pollution and decreases future yields.

1.2. Objective:

- The main objective of this project is to reduce the human effort for removing the weeds by automatically detecting the weeds using computer vision.
- To increase the productivity of the crop by precisely spraying the herbicides only on the weeds but not on the crops.
- To reduce the abundant usage of herbicides by precise spraying and thus preventing soil pollution.
- To reduce the agricultural expenses by reducing the labour cost for weed management.

1.3. Thesis of organization:

- The first section gives an overview of the project, a brief introduction to the importance of weed control management, problem statement, and objective of the project.

- The next section describes system architecture, hardware components and its implementation, software part and simulation results.
- Last section describes literature survey, result of this experiment, future work scope, conclusion, references etc.

1.4 Conclusion:

Autonomous robotic weed control systems hold promise toward the automation of one of agriculture's few remaining unmechanized and dredging tasks, hand weed control. Robotic technology may also provide a means of reducing agriculture's current dependency on herbicides, improving its sustainability and reducing its environmental impact. This documentation describes the current status of the four core technologies (guidance, detection and identification, precision in-row weed control, and mapping) required for the successful development of a general-purpose robotic system for weed control. Of the four, detection and identification of weeds under the wide range of conditions common to agricultural fields remains the greatest challenge.

CHAPTER 2
LITERATURE REVIEW

In order to overcome the dynamic nature of weeds which causes many problems, the proposed system aims to develop a computer vision based robotic weed control system (WCS) for real-time control of weeds. This system will be able to identify weeds and selectively spray the right amount of the herbicides.

A. Smart Agricultural Machine with a Computer Vision-Based Weeding and VariableRate Irrigation Scheme:

Authors: Chung-Liang Chang and Kuan-Ming Lin.

This model proposes a scheme that combines computer vision and multi-tasking processes to develop a small-scale smart agricultural machine that can automatically weed and perform variable rate irrigation within a cultivated field. Image processing methods such as HSV (hue (H), saturation (S), value (V)) color conversion, estimation of thresholds during the image binary segmentation process, and morphology operator procedures are used to confirm the position of the plant and weeds, and those results are used to perform weeding and watering operations. Furthermore, the data on the wet distribution area of surface soil (WDAS) and the moisture content of the deep soil is provided to a fuzzy logic controller, which drives pumps to perform variable rate irrigation and to achieve water savings. The proposed system has been implemented in small machines and the experimental results show that the system can classify plants and weeds in real time with an average classification rate of 90% or higher. This allows the machine to do weeding and watering while maintaining the moisture content of the deep soil at 80 ± 10% and an average wedding rate of 90%.

B. A Deep Learning Approach for Weed Detection in Lettuce Crops Using Multispectral Images:

Authors: Kavir Osorio, Andreas Puerto, Cesar Pedraza, David Jamaica and Leonardo Rodriguez

Weed management is one of the most important aspects of crop productivity; knowing the amount and the locations of weeds has been a problem that experts have faced for several decades. This paper presents three methods for weed estimation based on deep learning image processing in lettuce crops, and we compared them to visual estimations by experts. One method is based on support vector machines (SVM) using histograms of oriented gradients (HOG) as feature descriptors. The second method was based in YOLOV3 (you only look once V3), taking advantage of its robust architecture for object detection, and the third one was based on Mask R-CNN (region based convolutional neural network) in order to get an instance segmentation for each individual. These methods were complemented with a NDVI index (normalized difference vegetation index) as a background subtractor for removing non photosynthetic objects. According to chosen metrics, the machine and deep learning methods had F1-scores of 88%, 94%, and 94% respectively, regarding crop detection.

Subsequently, detected crops were turned into a binary mask and mixed with the NDVI background subtractor in order to detect weed in an indirect way. Once the weed image was obtained, the coverage percentage of weed was calculated by classical image processing methods. Finally, these performances were compared with the estimations of a set from weed experts through a Bland–Altman plot, intraclass correlation coefficients (ICCs) and Dunn's test to obtain statistical measurements between every estimation (machine-human); we found that these methods improve accuracy on weed coverage estimation and minimize subjectivity in human-estimated data.

C. Robotic weed control using automated weed and crop classification:

Authors: Xiaolong Wu, Stéphanie Aravecchia, Philipp Lottes, Cyrill Stachniss, Cédric Pradalier.
Autonomous robotic weeding systems in precision farming have demonstrated their full potential to alleviate the current dependency on agrochemicals such as herbicides and pesticides, thus reducing environmental pollution and improving sustainability. However, most previous works require fast and constant-time weed detection systems to achieve real-time treatment, which forecloths the implementation of more capable but time-consuming algorithms, e.g., learning-based methods. In this paper, a non-overlapping multi-camera system is applied to provide flexibility for the weed control system in dealing with the indeterminate classification delays. The design, implementation, and testing of our proposed modular weed control unit with mechanical and chemical weeding tools are presented. A framework that performs naive Bayes filtering, 3D direct intra- and inter-camera visual tracking, and predictive control, while integrating state-of-the-art crop/weed detection algorithms, is developed to guide the tools to achieve high- precision weed removal. The experimental results show that our proposed fully operational weed control system is capable of performing selective mechanical as well as chemical in-row weeding with indeterminate detection delays in different terrain conditions and crop growth stages.

D. Automatic Weed Detection and Smart Herbicide Sprayer Robot

Authors: G.Y. Raja Vikhram1, Rakshit Agarwal2, Rohan Uprety3, V.N.S. Prasanth4

The ordinary method for murdering weeds (unwanted plants) in a harvest manor is to shower herbicides all over the estate. This results in defilement of the sustenance crops and furthermore the yield turns out to be less as a portion of the production plants pass on alongside the weeds. In this way, there is a requirement for a brilliant weed control framework. In this venture, a picture handling calculation is utilized to take pictures of the manor columns at consistent intervals and after recognizing the weeds in the captured image, the weed killer chemical is showered specifically and just on the weeds. The herbicide is put away in a compartment fitted with water pump engines joined to shower spouts. After the weeds are recognized, a flag is signaled from Raspberry Pi to the motor driver IC governing the water pump motors to shower the chemicals over the unwanted vegetation.

CHAPTER 3
BLOCK DIAGRAM FOR WEED CONTROL ROBOT

The construction blocks of weed control robot using computer vision is as followed below:

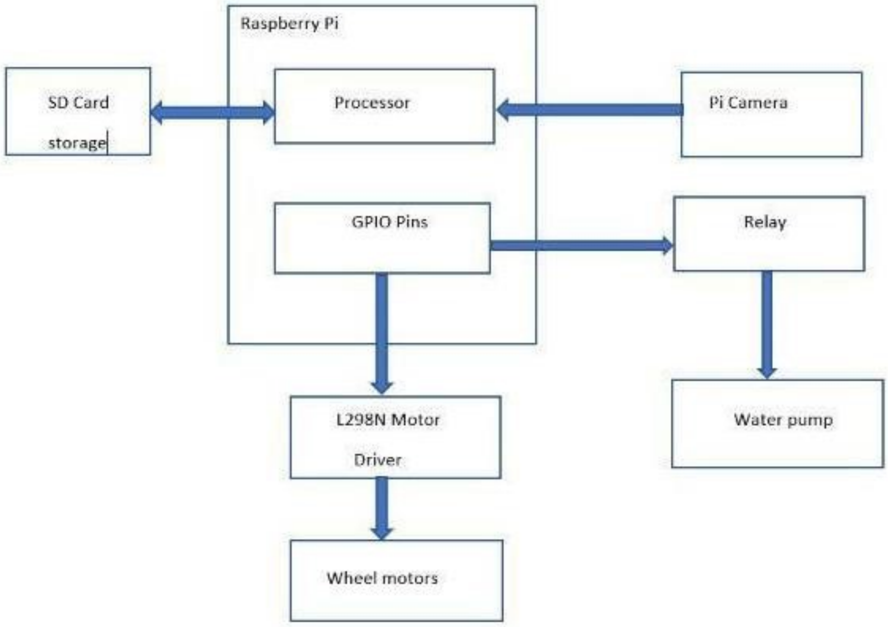

Fig.3.1. Block diagram for weed control

Operational Steps: -

- Load Raspbian OS into SD card and insert SD card into raspberry pi.
- Insert Pi camera into the camera interface of raspberry pi.
- Connect L298N motor driver to raspberry pi using GPIO pins.
- Connect the water pump to relay and power supply. ● Connect relay to raspberry pi using GPIO pins.

CHAPTER 4
INTRODUCTION TO HARDWARE COMPONENTS

The components which we have used in our project are:

1. Raspberry pi 3 B+
2. Pi Camera (5MP)
3. L298N Motor driver
4. 1 Channel 5v relay
5. DC Submersible water pump(3-6v)
6. Robot chassis and wheels
7. Batteries
8. Heatsink for raspberry pi
9. Power Bank

4.1 Raspberry pi b+:

Raspberry Pi is a series of small single-board computers developed in the United Kingdom by the Raspberry Pi Foundation in association with Broadcom. The Raspberry Pi project originally leaned towards the promotion of teaching basic computer science in schools and in developing countries. The original model became more popular than anticipated, selling outside its target market for uses such as robotics. It is widely used in many areas, such as for weather monitoring, because of its low cost, modularity, and open design. It is typically used by computer and electronic hobbyists, due to its adoption of HDMI and USB devices.

After the release of the second board type, the Raspberry Pi Foundation set up a new entity, named Raspberry Pi Trading, and installed Eben Upton as CEO, with the responsibility of developing technology. The Foundation was rededicated as an educational charity for promoting the teaching of basic computer science in schools and developing countries.

The Raspberry Pi is one of the best-selling British computers. As of December 2019, more than thirty million boards have been sold. Most Pis are made in a Sony factory in Pencoed, Wales, while others are made in China and Japan.

The Raspberry Pi is a low cost, credit-card sized computer that plugs into a computer monitor or TV and uses a standard keyboard and mouse. It is a capable little device that enables people of all ages to explore computing, and to learn how to program in languages like Scratch and Python. It's capable of doing everything you'd expect a desktop computer to do, from browsing the internet and playing high-definition video, to making spreadsheets, word-processing, and playing games. With a Quad-Core 64bit CPU, Wi-Fi & Bluetooth the Raspberry Pi 3 Model B is the third generation Raspberry Pi. This powerful credit-card sized single board computer can be used for many applications and supersedes the original Raspberry Pi Model B+ and Raspberry Pi 2 Model B.

Fig .4.1 Raspberry pi

4.1.1 Hardware of raspberry pi:

The Raspberry Pi hardware has evolved through several versions that feature variations in the type of the central processing unit, amount of memory capacity, networking support, and peripheral-device support.

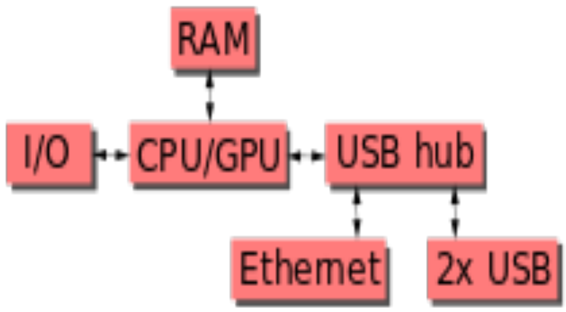

Fig. 4.2 Hardware of raspberry pi

This block diagram describes models B, B+, A and A+. The Pi Zero models are similar but lack the Ethernet and USB hub components. The Ethernet adapter is internally connected to an additional USB port. In Model A, A+, and the Pi Zero, the USB port is connected directly to the system on a chip (SoC). On the Pi 1 Model B+ and later models the USB/Ethernet chip contains a five-port USB hub, of which four ports are available, while the Pi 1 Model B only provides two. On the Pi Zero, the USB port is also connected directly to the SoC, but it uses a micro-USB (OTG) port. Unlike all other Pi models, the 40 pin GPIO connector is omitted on the Pi Zero, with solderable through-holes only in the pin locations. The Pi Zero WH remedies this.

Processor speed ranges from 700 MHz to 1.4 GHz for the Pi 3 Model B+ or 1.5 GHz for the Pi 4; on-board memory ranges from 256 MB to 1 GB random-access memory (RAM), with up to

8 GB available on the Pi 4. Secure Digital (SD) cards in MicroSD form factor (SDHC on early models) are used to store the operating system and program memory. The boards have one to five USB ports. For video output, HDMI and composite video are supported, with a standard 3.5 mm tip-ring-sleeve jack for audio output. Lower-level output is provided by a number of GPIO pins, which support common protocols like I²C. The B-models have an 8P8C Ethernet port and the Pi 3, Pi 4 and Pi Zero W have on-board Wi-Fi 802.11n and Bluetooth.

4.1.2 Processor of raspberry pi:

The Broadcom BCM2835 SoC used in the first-generation Raspberry Pi includes a 700 MHz ARM1176JZF-S processor, Video Core IV graphics processing unit (GPU), and RAM. It has a level 1 cache of 16 KB and a level 2 cache of 128 KB. The level 2 cache is used primarily by the GPU. The SoC is stacked underneath the RAM chip, so only its edge is visible. The ARM1176JZS is the same CPU used in the original iPhone, although at a higher clock rate, and mated with a much faster GPU. The earlier V1.1 model of the Raspberry Pi 2 used a Broadcom BCM2836 SoC with a 900 MHz 32-bit, quad-core ARM Cortex-A7 processor, with 256 KB shared L2 cache. The Raspberry Pi 2 V1.2 was upgraded to a Broadcom BCM2837 SoC with a 1.2 GHz 64-bit quad-core ARM Cortex-A53 processor, the same SoC which is used on the Raspberry Pi 3, but underclocked to the same 900 MHz CPU clock speed as the V1.1. The BCM2836 SoC is no longer in production as of late 2016.

The Raspberry Pi 3 Model B uses a Broadcom BCM2837 SoC with a 1.2 GHz 64-bit quadcore ARM Cortex-A53 processor, with 512 KB shared L2 cache. The Model A+ and B+ are 1.4 GHz. The Raspberry Pi 4 uses a Broadcom BCM2711 SoC with a 1.5 GHz 64-bit quadcore ARM Cortex-A72 processor, with 1 MB shared L2 cache. Unlike previous models, which all used a custom interrupt controller poorly suited for virtualisation, the interrupt controller on this SoC is compatible with the ARM Generic Interrupt Controller architecture 2.0, providing hardware support for interrupt distribution when using ARM virtualisation capabilities.The Raspberry Pi Zero and Zero W use the same Broadcom BCM2835 SoC as the first-generation Raspberry Pi, although now running at 1 GHz CPU clock speed. The Raspberry Pi Pico uses the RP2040 running at 133 MHz.

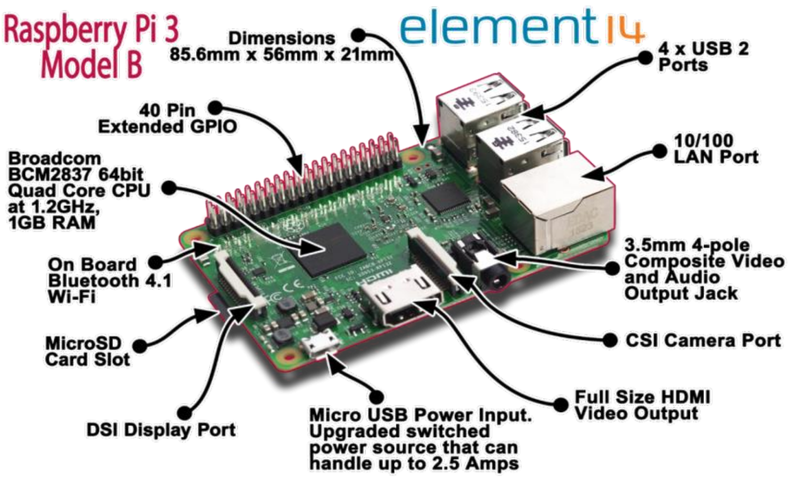

Fig.4.3 berry pi3 elementRasp

4.1.3 Overclocking of raspberry pi:

Most Raspberry Pi systems-on-chip could be overclocked to 800 MHz, and some to 1000 MHz There are reports the Raspberry Pi 2 can be similarly overclocked, in extreme cases, even to 1500 MHz (discarding all safety features and over-voltage limitations). In the Raspbian Linux distro the overclocking options on boot can be done by a software command running "sudo raspi-config" without voiding the warranty. In those cases, the Pi automatically shuts the overclocking down if the chip temperature reaches 85 °C (185 °F), but it is possible to override automatic over-voltage and overclocking settings (voiding the warranty); an appropriately sized heat sink is needed to protect the chip from serious overheating.

Newer versions of the firmware contain the option to choose between five overclock presets that, when used, attempt to maximise the performance of the SoC without impairing the lifetime of the board. This is done by monitoring the core temperature of the chip and the CPU load, and dynamically adjusting clock speeds and the core voltage. When the demand is low on the CPU or it is running too hot, the performance is throttled, but if the CPU has much to do and the chip's temperature is acceptable, performance is temporarily increased with clock speeds of up to 1 GHz, depending on the board version and on which of the turbo settings is used.

The overclocking modes are:

- none; 700 MHz ARM, 250 MHz core, 400 MHz SDRAM, 0 overvolting,
- modest; 800 MHz ARM, 250 MHz core, 400 MHz SDRAM, 0 overvolting,
- medium; 900 MHz ARM, 250 MHz core, 450 MHz SDRAM, 2 overvolting,
- high; 950 MHz ARM, 250 MHz core, 450 MHz SDRAM, 6 overvolting,
- turbo; 1000 MHz ARM, 500 MHz core, 600 MHz SDRAM, 6 overvolting,
- Pi 2; 1000 MHz ARM, 500 MHz core, 500 MHz SDRAM, 2 overvolting,
- Pi 3; 1100 MHz ARM, 550 MHz core, 500 MHz SDRAM, 6 overvolting. In system information the CPU speed appears as 1200 MHz When idling, speed lowers to 600 MHz.

In the highest mode the SDRAM clock speed was originally 500 MHz, but this was later changed to 600 MHz because of occasional SD card corruption. Simultaneously, in high mode the core clock speed was lowered from 450 to 250 MHz, and in medium mode from 333 to 250 MHz.The CPU of the first- and second-generation Raspberry Pi board did not require cooling with a heatsink or fan, even when overclocked, but the Raspberry Pi 3 may generate more heat when overclocked.

4.1.4 Ram of raspberry pi:

The early designs of the Raspberry Pi Model A and B boards included only 256 MB of randomaccess memory (RAM). Of this, the early beta Model B boards allocated 128 MB to the GPU by default, leaving only 128 MB for the CPU. On the early 256 MB releases of models A and B, three different splits were possible. The default split was 192 MB for the CPU, which should be sufficient for standalone 1080p video decoding, or for simple 3D processing. 224 MB was for Linux processing only, with only a 1080p framebuffer, and was likely to fail for any video or 3D. 128 MB was for heavy 3D processing, possibly also with video decoding. In comparison, the Nokia 701 uses 128 MB for the Broadcom Video Core IV.

The later Model B with 512 MB RAM, was released on 15 October 2012 and was initially released with new standard memory split files with 256 MB, 384 MB, and 496 MB CPU RAM, and with 256 MB, 128 MB, and 16 MB video RAM, respectively. But about one week later, the foundation released a new version of start. Elf that could read a new entry in config.txt (gpu_mem=*xx*) and could dynamically assign an amount of RAM to the GPU, obsoleting the older method of splitting memory, and a single start. Elf worked the same for 256 MB and 512 MB Raspberry Pis. The Raspberry Pi 2 has 1 GB of RAM. The Raspberry Pi 3 has 1 GB of RAM in the B and B+ models, and 512 MB of RAM in the A+ model. The Raspberry Pi Zero and Zero W have 512 MB of RAM. The Raspberry Pi 4 is available with 2, 4 or 8 GB of RAM. A 1 GB model was originally available at launch in June 2019 but was discontinued in March 2020, and the 8 GB model was introduced in May 2020.

4.1.5 Networking of raspberry pi:

The Model A, A+ and Pi Zero have no Ethernet circuitry and are commonly connected to a network using an external user-supplied USB Ethernet or Wi-Fi adapter. On the Model B and B+ the Ethernet port is provided by a built-in USB Ethernet adapter using the SMSC LAN9514 chip. The Raspberry Pi 3 and Pi Zero W (wireless) are equipped with 2.4 GHz Wi-Fi 802.11n (150 Mbit/s) and Bluetooth 4.1 (24 Mbit/s) based on the Broadcom BCM43438 Fullam chip with no official support for monitor mode (though it was implemented through unofficial firmware patching) and the Pi 3 also has a 10/100 Mbit/s Ethernet port. The Raspberry Pi 3B+ features dual-band IEEE 802.11b/g/n/ac Wi-Fi, Bluetooth 4.2, and Gigabit Ethernet (limited to approximately 300 Mbit/s by the USB 2.0 bus between it and the SoC). The Raspberry Pi 4 has full gigabit Ethernet throughput is not limited as it is not funnelled via the USB chip.General purpose input-output (GPIO) connector.

Raspberry Pi 1 Models A+ and B+, Pi 2 Model B, Pi 3 Models A+, B and B+, Pi 4, and Pi Zero, Zero W, and Zero WH GPIO J8 have a 40-pin pinout. Raspberry Pi 1 Models A and B have only the first 26 pins.

In the Pi Zero and Zero W, the 40 GPIO pins are unpopulated, having the through-holes exposed for soldering instead. The Zero WH (Wireless + Header) has the header pins pre installed.

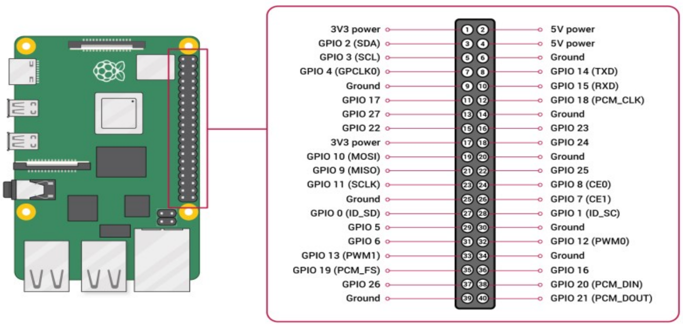

Fig.4.4 Pin Diagram of raspberry pi

4.1.6 Operating system used in raspberry pi:

The Raspberry Pi Foundation provides Raspberry Pi OS (formerly called Raspbian), a Debianbased (32-bit) Linux distribution for download, as well as third-party Ubuntu, Windows 10 IoT Core, RISC OS, and LibreELEC (specialised media centre distribution). It promotes Python and Scratch as the main programming languages, with support for many other languages. The default firmware is closed source, while unofficial open source is available. Many other operating systems can also run on the Raspberry Pi. Third-party operating systems available via the official website include Ubuntu MATE, Windows 10 IoT Core, RISC OS and specialised distributions for the Kodi media centre and classroom management. The formally verified microkernel seL4 is also supported.

4.1.7 OS installation of raspberry pi:

Your Raspberry Pi doesn't come with an operating system pre-installed. This means you can choose from a wide range of OSs, each of which can be flashed to your Raspberry Pi's SD card. Here's how to get a new OS installed and running on your Raspberry Pi, using Windows, macOS, or Linux. This resource explains how to install a Raspberry Pi operating system image on an SD card. You will need another computer with an SD card reader to install the image. Using Raspberry Pi Imager. Raspberry Pi has developed a graphical SD card writing tool that works on Mac OS, Ubuntu 18.04 and Windows, and is the easiest option for most users as it will download the image and install it automatically to the SD card.

- Download the latest version of Raspberry Pi Imager and install it.If you want to use Raspberry Pi Imager on the Raspberry Pi itself, you can install it from a terminal using sudo apt install rpi-imager.
- Connect an SD card reader with the SD card inside.
- Open Raspberry Pi Imager and choose the required OS from the list presented.
- Choose the SD card you wish to write your image to.
- Review your selections and click 'WRITE' to begin writing data to the SD card.

Note: if using the Raspberry Pi Imager on Windows 10 with Controlled Folder Access enabled, you will need to explicitly allow the Raspberry Pi Imager permission to write the SD card. If this is not done, Raspberry Pi Imager will fail with a "failed to write" error.

Using other tools, most other tools require you to download the image first, then use the tool to write it to your SD card. Alternative distributions are available from third-party vendors. You may need to unzip .zip downloads to get the image file (. image) to write to your SD card.

Note: The Raspberry Pi OS with desktop image contained in the ZIP archive is over 4GB in size and uses the ZIP64 format. To uncompress the archive, an unzip tool that supports ZIP64 is required. The following zip tools support ZIP64:

Boot your new OS, you can now insert the SD card into the Raspberry Pi and power it up. For the official Raspberry Pi OS,if you need to manually log in, the default user name is pi, with password raspberry. Remember the default keyboard layout is set to the UK. You should change the default password straight away to ensure your Raspberry Pi is secure.

4.1.8 Specifications:

The Raspberry Pi 3 Model B is the earliest model of the third-generation Raspberry Pi. It replaced the Raspberry Pi 2 Model B in February 2016. See also the Raspberry Pi 3 Model B+, the latest product in the Raspberry Pi 3 range.

- Quad Core 1.2GHz Broadcom BCM2837 64bit CPU
- 1GB RAM
- BCM43438 wireless LAN and Bluetooth Low Energy (BLE) on board
- 100 Base Ethernet
- 40-pin extended GPIO
- 4 USB 2 ports
- 4 Pole stereo output and composite video port
- Full size HDMI
- CSI camera port for connecting a Raspberry Pi camera
- DSI display port for connecting a Raspberry Pi touchscreen display
- Micro SD port for loading your operating system and storing data
- Upgraded switched Micro USB power source up to 2.5A
- Additionally, it adds wireless LAN & Bluetooth connectivity making it the ideal solution for powerful connected designs.

4.1.9 Applications of raspberry pi:

- Raspberry Pi as Desktop
- Home Automation System Based on Raspberry Pi
- Raspberry Pi Based Camcorder
- The Zero Phone – Raspberry Pi Based Smartphone
- Xbox
- Zero – Raspberry Pi Based Xbox Controller
- Raspberry Pi Based Google AI Assistant
- Raspberry Pi Based Home Arcade System

4.2 Pi CAMERA (5MP):

The Pi camera module is a portable lightweight camera that supports Raspberry Pi. It communicates with Pi using the MIPI camera serial interface protocol. RPI CAMERA BOARD plugs directly into the CSI connector on the Raspberry Pi. It's able to deliver a crystal clear 5MP resolution image, or 1080p HD video recording at 30fps with latest v1.3. Board features a 5MP (2592 × 1944 pixels) Omni vision 5647 sensor in a fixed focus module. The module attaches to Raspberry Pi, by way of a 15 pin Ribbon Cable, to the dedicated 15 pin MIPI Camera Serial Interface (CSI), which was designed especially for interfacing to cameras. The CSI bus is capable of extremely high data rates, and it exclusively carries pixel data to the BCM2835 processor.

- Compatible all models of Raspberry Pi 1, 2 and 3

- 5MP Omni vision 5647 camera module
- Still picture resolution of 2592 x 1944
- Video supports 1080p at 30fps, 720p at 60fps and 640x480p 60/90 recording
- 15 pin MIPI camera serial interface plugs directly into the Raspberry Pi Board
- Size is 20mm x 25mm x 9mm
- Weight of 3g
- Fully compatible with the ModMyPi Raspberry Pi Case

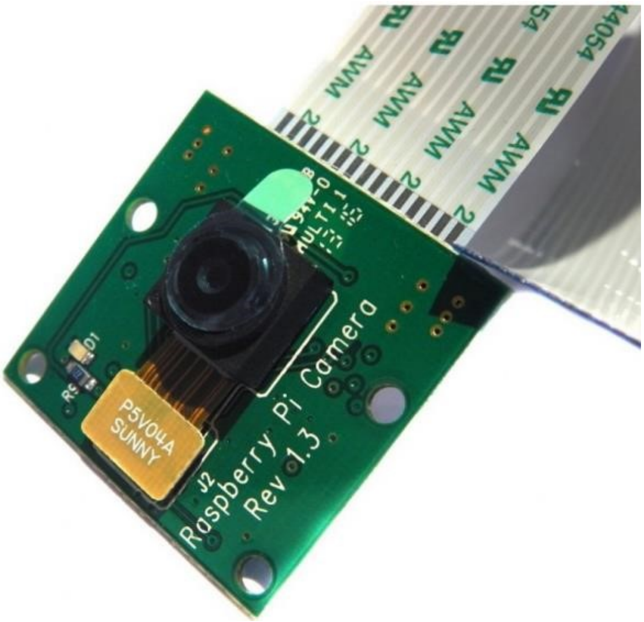

Fig.4.5 Pie Camera

The Raspberry Pi Camera Board is a custom designed add-on module for Raspberry Pi hardware. It attaches to Raspberry Pi hardware through a custom CSI interface. The sensor has a 5-megapixel native resolution in still capture mode. In video mode it supports capture resolutions up to 1080p at 30 frames per second.

4.2.1 Applications of pi camera :

There are four applications provided: raspistill, raspivid, raspiyuv and raspividyuv. raspistill and raspivid are very similar and are intended for capturing images; rasped and raspvidyuv are for capturing video. Imaging, Video & Vision, Compatible with Raspberry Pi Model A/B/B+.

4.3. L298N motor driver:

This 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.

The L298N Motor Driver module consists of an L298 Motor Driver IC, 78M05 Voltage Regulator, resistors, capacitor, Power LED, 5V jumper in an integrated circuit.

The L298N is a dual H-Bridge motor driver which allows speed and direction control of two DC motors at the same time. The module can drive DC motors that have voltages between 5 and 35V, with a peak current up to 2A. This depends on the voltage used at the motors VCC.

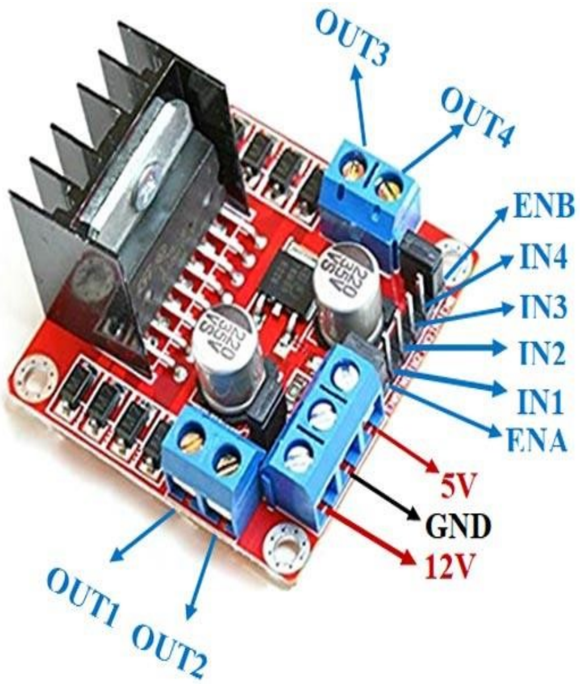

Fig.4.6. Motor Driver

L298N Module Pin Configuration:

Table.1 Motor pin configuration

Pin Name	**Description**
IN1 & IN2	Motor A input pins. Used to control the spinning direction of Motor A
IN3 & IN4	Motor B input pins. Used to control the spinning direction of Motor B
ENA	Enables PWM signal for Motor A

ENB	Enables PWM signal for Motor B
OUT1 & OUT2	Output pins of Motor A
OUT3 & OUT4	Output pins of Motor B
12V	12V input from DC power Source
5V	Supplies power for the switching logic circuitry inside L298N IC

78M05 Voltage regulator will be enabled only when the jumper is placed. When the power supply is less than or equal to 12V, then the internal circuitry will be powered by the voltage regulator and the 5V pin can be used as an output pin to power the microcontroller. The jumper should not be placed when the power supply is greater than 12V and separate 5V should be given through a 5V terminal to power the internal circuitry.ENA & ENB pins are speed control pins for Motor A and Motor B while IN1& IN2 and IN3 & IN4 are direction control pins for Motor A and Motor B.

Internal circuit diagram of L298N Motor Driver module is given below:

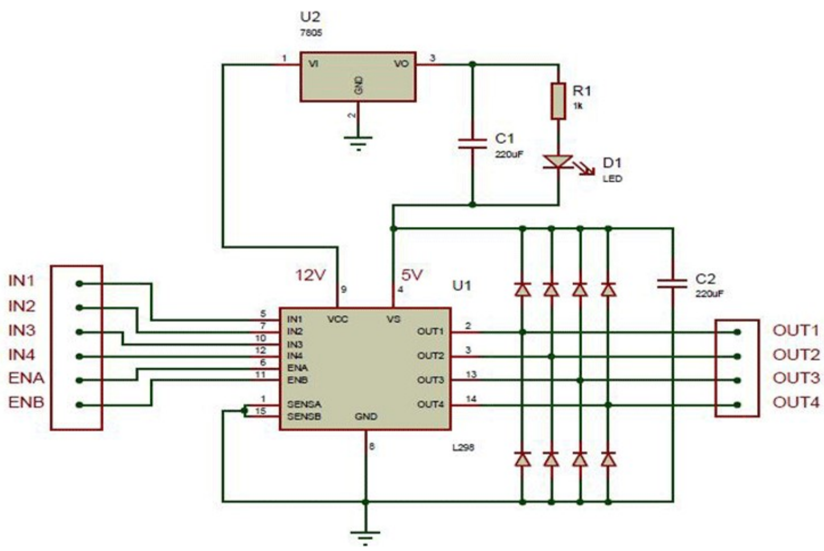

Fig.4.7 Circuit of motor driver

4.3.1 L298 features:

- Driver Model: L298N 2A
- Driver Chip: Double H Bridge L298N
- Motor Supply Voltage (Maximum): 46V
- Motor Supply Current (Maximum): 2A
- Logic Voltage: 5V
- Driver Voltage: 5-35V
- Driver Current:2A

- Logical Current:0-36mA
- Maximum Power (W): 25W
- Current Sense for each motor
- Heatsink for better performance
- Power-On LED indicator

4.3.2 Applications of L298 motor:

- Drive DC motors.
- Drive stepping motors
- In Robotics

4.4. 1 Channel 5v relay:

The 1 Channel 5V Relay Module provides a single relay that can be controlled by any 5V digital output from your microcontroller. The relay is accessible using screw terminals and can handle up to 2A of current. A handy LED indicates the status of the relay. This module provides a standard 3 pin Signal/Voltage/Ground male header and a 4 pin "Grove" connector.

Fig.4.8 Channel 5v relay

4.4.2 Uses of relay:

Connect the Signal (S) pin to a digital output line on your microcontroller, the Voltage (V) pin to a 5V operating voltage and the Ground (G) pin to a common ground. Then wire onto the relay using the screw terminals. The relay works like a common SPDT Single Pole Double Throw switch and has Normally Open (NO), Normally Closed (NC) and Common (COM) screw terminals. When the digital Signal (S) pin is HIGH, the relay will be switched on (closed), otherwise it will be switched off (opened).

Table 2. Relay characteristics

Relay Characteristics	
Contact Form	SPDT
Maximum Switch Current	2 A

Maximum Switch AC Voltage	120 V AC
Maximum Switch DC Voltage	24 VDC
Power Supply and Consumption	
Operating Voltage	5 V

The Single Channel Relay Module is a convenient board which can be used to control high voltage, high current load such as motor, solenoid valves, lamps and AC load. It is designed to interface with microcontroller such as Arduino, PIC and etc

Triggering the relay operates the normally open or normally closed contacts. It is frequently used in an automatic control circuit. To put it simply, it is an automatic switch to control a high-current circuit with a low-current signal. 5V relay signal input voltage range, 0-5V. VCC power to the system.

4.5 DC Submersible water pump(3-6v):

A mini submersible water pump is a centrifugal water pump, which means that it uses a motor to power an impeller that is designed to rotate and push water outwards. The motor is located in a waterproof seal and closely connected to the body of the water pump which it powers.

Micro DC 3-6V Micro Submersible Pump Mini water pump For Fountain Garden Mini water circulation System DIY project. This is a low cost, small size Submersible Pump Motor which can be operated from a 3 ~ 6V power supply. It can take up to 120 litres per hour with very low current consumption of 220mA. Just connect the tube pipe to the motor outlet, submerge it in water and power it. Make sure that the water level is always higher than the motor. Dry run may damage the motor due to heating and it will also produce noise.

Fig.4.9 Water Pump

The key to sizing a submersible well pump is to calculate the gallons per minute of water required during peak periods. Smith recommends sizing a submersible well pump based on fixture count, which involves counting the fixtures and faucets in a home.it works like any other pump set with the only difference being the solar energy used instead of non-renewable energy for its operation. When sunlight falls on the solar panels it produces direct current (DC) which then feeds the motor to pump out the water.

4.5.1 Specifications of water pump:

- Operating Voltage: 3 ~ 6V
- Operating Current: 130 ~ 220mA
- Flow Rate: 80 ~ 120 L/H
- Maximum Lift: 40 ~ 110 mm
- Continuous Working Life: 500 hours
- Driving Mode: DC, Magnetic Driving
- Material: Engineering Plastic
- Outlet Outside Diameter: 7.5 mm
- Outlet Inside Diameter: 5 mm

4.6. Robot chassis and wheels:

4-Wheel Robot Chassis Kit, an easy to assemble and use robot chassis platform. The Chassis kit provides you with everything you need to give your robot a fast four-wheel drive platform with plenty of room for expansion to add various sensors and controllers. Just add your electronics - Arduino/Raspberry Pi and Motor Driver and you can start programming your robot. It offers a large space with predrilled holes for mounting sensors and electronics as per your requirement. This robot chassis lets you get your mechanical platform ready in minutes and QuickStart your robot building process.

Wheeled Robots are the most popular robot platforms and are easy to run, maintain and use. Simple to build and program, this kit is the simplest robot platform. Highly recommended for beginners and novice users. Building robots using this wheeled kit is fun and a great learning experience too. The 4WD Kit lets you go faster, carry more weight, and carry a bigger load compared to the 2WD Kit. You can build line following robots, obstacle avoiding robots, and other robots using this kit.

Features of 4-Wheel Robot Chassis Kit:

- Simple mechanical structure, easy for installation.

- Adopts 4 DC motors for better power, speed and load capacity ● Large and stable Chassis, easy for expansion.
- Easy interface with Arduino development platform
- Enormous space between middle & bottom chassis
- This kit is great for DIY Learning, Academic Research, Hobby Projects and Robot Competitions
- Made from Laser cut 3mm Acrylic Sheet
- Multiple slots for mounting extra electronics easily
- Compatible with Ultrasonic distance sensor
- Arduino compatible boards can be mounted inside as well as on top.

4WD Smart Robot Car Chassis Kit

Fig 4.10 Robot car Chassis Kit

Specifications:

- Operating Voltage: 3-6V DC
- Length: about 25.3cm
- Width: about 14.8cm
- Tyre Diameter: 6.5cm

Package Includes:

- 2 x 4WD Robot Car Chassis (Acrylic)
- 4 x High Power DC Motor
- 4 x Wheels
- 8 x Fastener
- 6x M3 6mm Screw
- 4x M2.5 25mm Screw
- 4x 2.5 20mm Screw
- 14 x M3 nuts
- 6 x L30+6 spacer
- 8 X M3 30mm screw

- **Applications:**

- Many types of autonomous and manual controlled robots.

4.7 BATTERIES:

A battery is a power source consisting of one or more electrochemical cells with external connections for powering electrical devices such as flashlights, mobile phones, and electric cars. When a battery is supplying electric power, its positive terminal is the cathode and its negative terminal is the anode. The terminal marked negative is the source of electrons that will flow through an external electric circuit to the positive terminal. When a battery is connected to an external electric load, a redox reaction converts high-energy reactants to lowerenergy products, and the free-energy difference is delivered to the external circuit as electrical energy. Historically the term "battery" specifically referred to a device composed of multiple cells; however, the usage has evolved to include devices composed of a single cell.

Primary (single-use or "disposable") batteries are used once and discarded, as the electrode materials are irreversibly changed during discharge; a common example is the alkaline battery used for flashlights and a multitude of portable electronic devices. Secondary (rechargeable) batteries can be discharged and recharged multiple times using an applied electric current; the original composition of the electrodes can be restored by reverse current. Examples include the lead-acid batteries used in vehicles and lithium-ion batteries used for portable electronics such as laptops and mobile phones.

Batteries come in many shapes and sizes, from miniature cells used to power hearing aids and wristwatches to small, thin cells used in smartphones, to large lead acid batteries or lithiumion batteries in vehicles, and at the largest extreme, huge battery banks the size of rooms that provide standby or emergency power for telephone exchanges and computer data centres.

Battery life can be extended by storing the batteries at a low temperature, as in a refrigerator or freezer, which slows the side reactions. Such storage can extend the life of alkaline batteries by about 5%; rechargeable batteries can hold their charge much longer, depending upon type. To reach their maximum voltage, batteries must be returned to room temperature; discharging an alkaline battery at 250 mA at 0 °C is only half as efficient as at 20 °C. Alkaline battery manufacturers such as Duracell do not recommend refrigerating batteries.

4.7.1 Cell types:

Many types of electrochemical cells have been produced, with varying chemical processes and designs, including galvanic cells, electrolytic cells, fuel cells, flow cells and voltaic piles.

Wet cell:
A wet cell battery has a liquid electrolyte. Other names are flooded cell, since the liquid covers all internal parts or vented cell, since gases produced during operation can escape to the air. Wet cells were a precursor to dry cells and are commonly used as a learning tool for electrochemistry. They can be built with common laboratory supplies, such as beakers, for demonstrations of how electrochemical cells work. A particular type of wet cell known as a concentration cell is important in understanding corrosion. Wet cells may be primary cells (non-rechargeable) or secondary cells (rechargeable). Originally, all practical primary batteries such as the Daniell cell were built as open-top glass jar wet cells. Other primary wet cells are

the Leclanche cell, Grove cell, Bunsen cell, Chromic acid cell, Clark cell, and Weston cell. The Leclanche cell chemistry was adapted to the first dry cells. Wet cells are still used in automobile batteries and in industry for standby power for switchgear, telecommunication or large uninterruptible power supplies, but in many places batteries with gel cells have been used instead. These applications commonly use lead–acid or nickel–cadmium cells.

Dry cell:
Further information: Dry cell

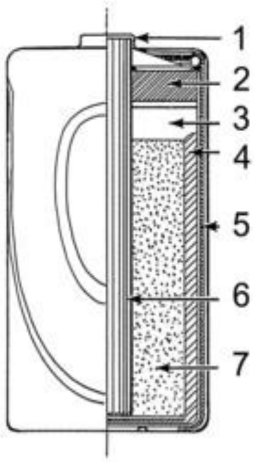

Fig.4.11 Battery

Line art drawing of a dry cell:

1. Brass cap

2. Plastic seal

3. Expansion space

4. Porous cardboard

5. Zinc can

6. Carbon rod

7. Chemical mixture.

A dry cell uses a paste electrolyte, with only enough moisture to allow current to flow. Unlike a wet cell, a dry cell can operate in any orientation without spilling, as it contains no free liquid, making it suitable for portable equipment. By comparison, the first wet cells were typically fragile glass containers with lead rods hanging from the open top and needed careful handling to avoid spillage. Lead–acid batteries did not achieve the safety and portability of the dry cell until the development of the gel battery. A common dry cell is the zinc–carbon battery, sometimes called the dry Leclanché cell, with a nominal voltage of 1.5 volts, the same as the alkaline battery (since both use the same zinc–manganese dioxide combination). A standard dry cell comprises a zinc anode, usually in the form of a cylindrical pot, with a carbon cathode in the form of a central rod. The electrolyte is ammonium chloride in the form of a paste next to the zinc anode. The remaining space between the electrolyte and carbon cathode is taken up by a second paste consisting of ammonium chloride and manganese dioxide, the latter acting as a depolariser. In some designs, the ammonium chloride is replaced by zinc chloride.

Molten salt

Molten salt batteries are primary or secondary batteries that use a molten salt as electrolyte. They operate at high temperatures and must be well insulated to retain heat.

Reserve

A reserve battery can be stored unassembled (inactivated and supplying no power) for a long period (perhaps years). When the battery is needed, then it is assembled (e.g., by adding electrolyte); once assembled, the battery is charged and ready to work. For example, a battery for an electronic artillery fuze might be activated by the impact of firing a gun. The acceleration breaks a capsule of electrolyte that activates the battery and powers the fuze's circuits. Reserve batteries are usually designed for a short service life (seconds or minutes) after long storage (years). A water-activated battery for oceanographic instruments or military applications becomes activated on immersion in water.

Cell performance

A battery's characteristics may vary over load cycle, over charge cycle, and over lifetime due to many factors including internal chemistry, current drain, and temperature. At low temperatures, a battery cannot deliver as much power. As such, in cold climates, some car owners install battery warmers, which are small electric heating pads that keep the car battery warm.

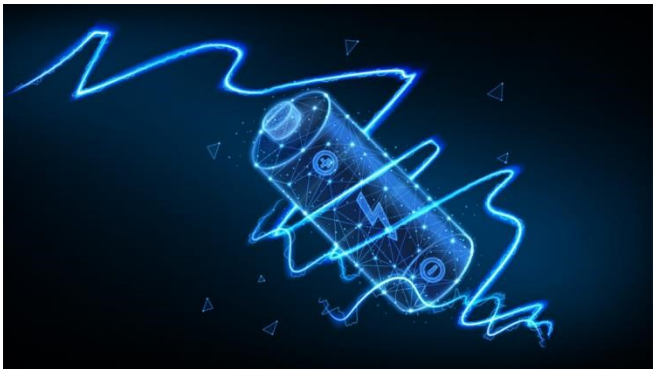

Fig.4.1Cell Performance

4.8 Heatsink for raspberry pi:

Heat sinks should be installed at least on the two main components of the Raspberry Pi: the CPU and the LAN Chip.Under normal conditions, the Raspberry Pi 4 runs great without any sort of external heatsink and the software throttling keeps everything within safe operating temperatures.

4.8.1 Heat sink installation:

we must install heat sinks on two components:

–The processor, which is in the Center of the board.

– The network chip, which is close to USB ports.

The bigger heat sink will go to the CPU in the Center and the other to the LAN chip. The orientation of the heat sink does not matter, try to Center it on the CPU so that the heat can smoothly flow over the entire surface. To install the first heat sink, follow these simple steps:

1. Take the first heat sink (the larger of the two).
2. Peel off the adhesive pad underneath.
3. Place it on the processor (1).
4. Press lightly to make sure it is properly attached.

Repeat the same steps with the second heat sink, sticking it this time on the network chip .You can take the raspberry in your hands and slightly tighten the heat sinks between thumb and index to complete the operation.Monitor your CPU temperature.To go further on this topic, we will see how to check the temperature of your processor to ensure that it stays in the recommended range.What is the maximum safe temperature?The lower the CPU temperature is, the more efficient it will beThe Raspberry Pi will start to run slower over 85 ° C, and it is not recommended going higher because you risk CPU damage. So, we will see how to know the temperature of the CPU at any time to ensure that it is well below this limit.

Fig.4.13. Heat Sink

How to get the current CPU temperature?

If you are on the Raspberry desktop, you can add the current temperature in your taskbar by following these steps:

- Right-click on the taskbar.
- Then Add/Remove Panel Items.
- Click on the Add button in the right menu.
- Choose the Temperature monitor in the list.
- Then Add.

4.9 POWER BANK:

Power banks are commonplace and with our increasing use of battery powered equipment: everything from mobile phones to battery powered headphones, portable speakers, MP3 players can be charged via a power bank. They are effectively a portable charger. All they need is a USB charging interface.

Power banks come in a variety of shapes and sizes and to suit many different people and their needs. In recent years, the use of power banks has risen significantly as they provide a very convenient and easy method of charging smartphones and other devices when away from mains power. Wireless charging power banks have also been introduced for those devices that can be charged wirelessly. Power banks, sometimes speed as power banks, can be defined as portable batteries that use circuits to control any power in and power out. They can charge up using a USB charger when power is available, and then used to charge battery powered items like mobile phones and a host of other devices that would normally use a USB charger.

The name power bank can be likened to a financial bank where funds can be deposited, stored, and withdrawn when needed. These items are also often referred to as portable chargers, as they can charge items like mobile phones without the need to be connected to the mains during charging, although they will need to be charged, and this normally requires a mains charger.

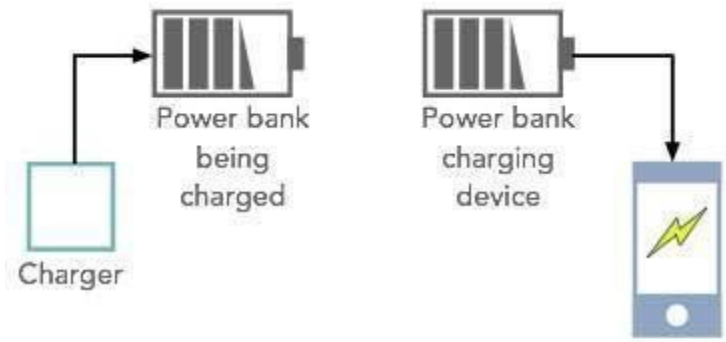

Fig.4.14 Power Bank

4.9.1 Types of power bank

There are a few different types of power bank portable charger that can be bought. Obviously, size is one of the main criteria, but there are some other categories that can be considered.
The main types of USB power banks include the following:

- Universal or standard power bank: These are the normal power bank portable chargers which are available in the stores and online. They are charged from the normal USB sources like USB chargers.

- These power banks are normally charged from a standard USB charger and there is some indication on the power bank as to its state of charge. This may be a row of small LED lamps or a simple alphanumeric display that indicates the charge level as a percentage of full charge. Typically, a micro-USB connector is used as the power in connection.

- Once fully charged the power bank can be used to charge other devices. There may be one or more Type A USB sockets (dependent upon the particular power bank) that can deliver charge to the devices needing charging.

- Solar power bank: As the name indicates, these solar power banks can use sunlight to charge up. To do this they have photovoltaic panels. These are really only able to trickle-charge the internal battery when placed in sunlight because the solar cells are relatively small, but nevertheless this can be a very useful function, but really only in very sunny or bright conditions.
- A solar powered power bank, it can also be charged in the normal way, using the solar power for a slow trickle charge

- As the solar charging is slow, they can also be charged from a USB charger as well. The solar charging is a useful back-up, especially if you are travelling away from mains power. To ensure that the maximum amount of solar energy can be converted, some of the more advanced solar power banks have solar panels that fold out to present a larger area to the Sun. Even so, it can take over 24 hours to charge some, and as there obviously isn't bright sun at night, or even all day, it can take a considerable while to charge. As charge times, capacities, etc vary considerably, it is always best to take a close look at the figures, if there is a possibility of buying one.

- Like the standard wired power bank, these solar powered ones have standard Type A USB connectors for the output or outputs and a micro-USB for the input from a USB charger.

- Wireless power bank: With many gadgets like phones, ear-pods and the like now having the capability to be charged wirelessly, this concept has been adopted by the power bank industry.

- It is possible to obtain power banks that are themselves charged from a standard USB source, but they are able to charge phones and other wireless charging compatible electronic devices wirelessly.

Fig.4.15 Power Bank

- These power banks use the Qi standard that has been adopted by virtually all electronic devices that can be charged wirelessly. The electronic device to be changed is placed on the power bank - orientation is often important, so check with the instructions, a button typically has to be pressed to turn on the wireless charging capability, and then it all proceeds until the device is charged.
- It is best to turn off the wireless charging power bank once the charging is complete and then the wireless charging circuitry is disabled and the power bank will not be discharged unnecessarily.

CHAPTER 5
METHODOLOGY APPLIED

The working of the robot comprises four principal steps.

A. The process starts by capturing the image using a pi-camera which is connected to the raspberry-pi.
B. The image obtained is processed to detect the weeds using the inbuilt functions in the OpenCV library.
C. The motion of the robot is controlled to reach the detected weeds using the inbuilt robot class from gpiozero library.
D. When the robot reaches the weeds the sprayer motor turns ON for 4 seconds which in turn is controlled using the gpiozero library.

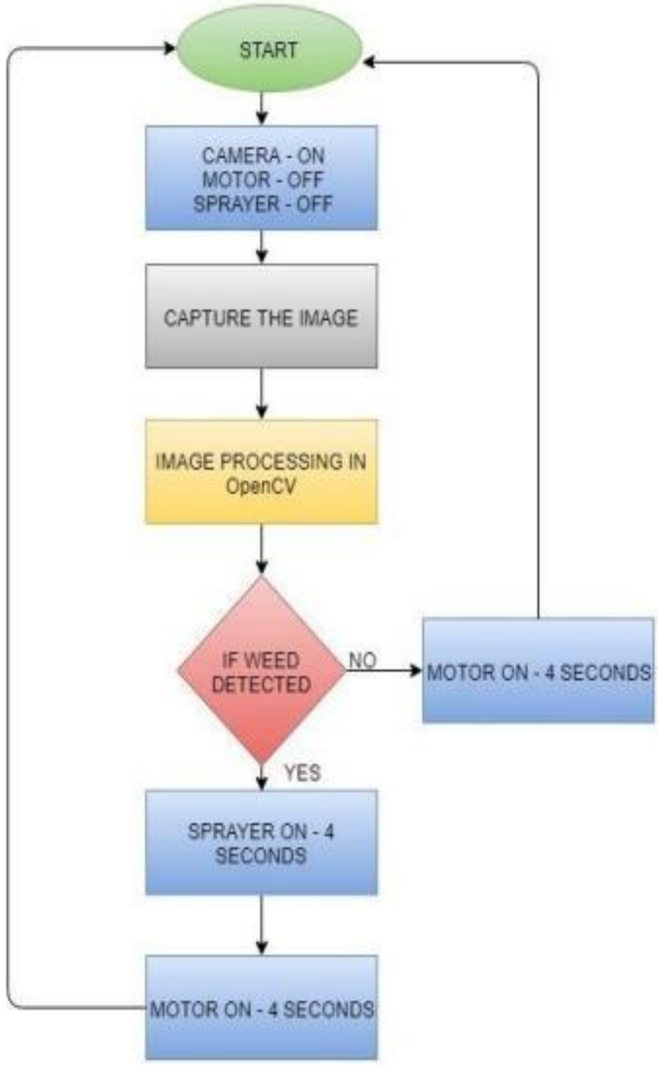

Fig.5.1 Methodology

5.1 Algorithm for weed detection:

The process is set about by capturing the image from Raspberry-Pi Camera. The image captured is in RGB representation which is then converted to HSV (hue, saturation, value) representation using cvtColor() of OpenCV. HSV is an alternative colour representation that is frequently used instead of the RGB (Red Green Blue) colour model.

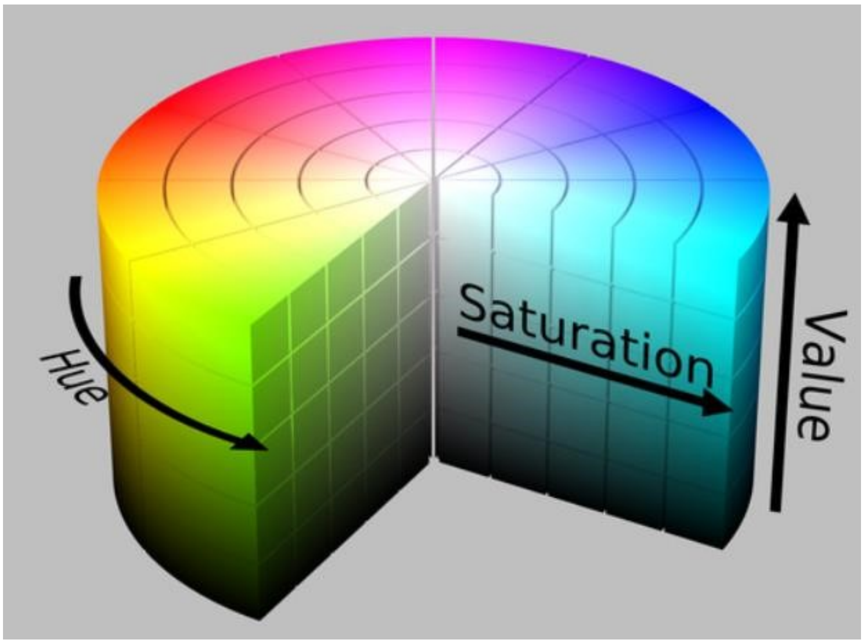

Fig.5.2 Algorithm

We need to select an appropriate HSV (hue, saturation, value) value to identify weeds. Then we mask the image to green by giving a masking range of (25,0,0) (45, 255, 255) in the cv2.inRange() function. After doing this we only get the green part of the image. Then the image will by default be converted to black and white image where black pixels represent background image and white pixels represent green image i.e weeds.

OpenCV has a find Contour () function that helps in extracting the contours from the image. Contours are defined as a rectangular box joining all the points along the boundary of an image that are having the same intensity which comes in handy to find out the area and coordinates of the weeds.

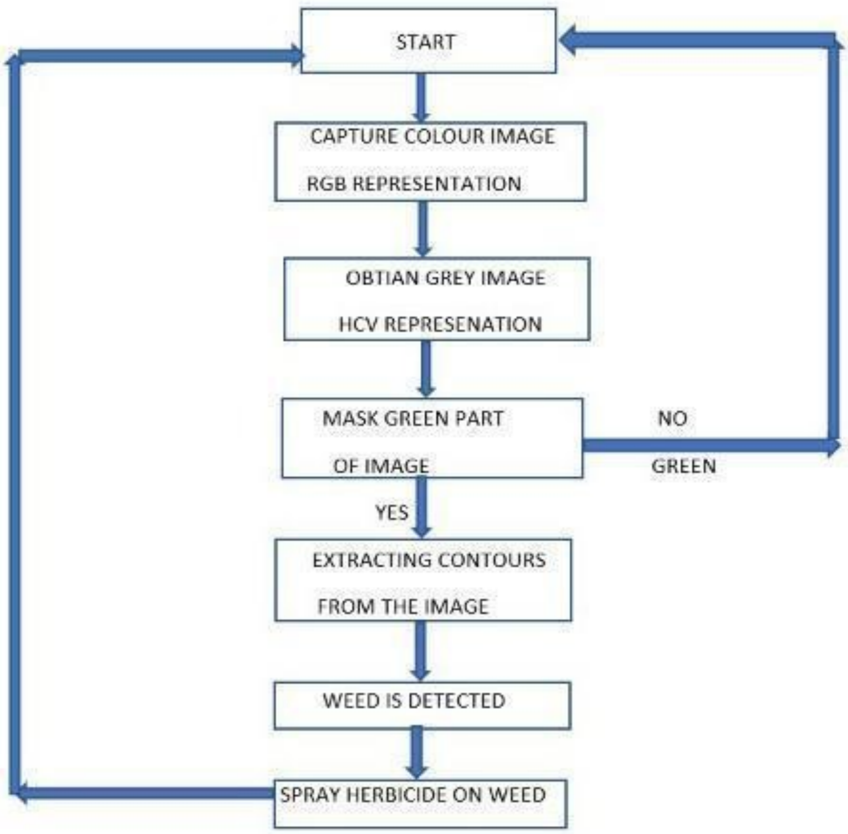

Fig.5.3 Algorithm for the program

5.1.2 Technologies used:

A. Python

Python is a popular general-purpose programming language that can be used for a wide variety of applications. It includes high-level data structures, dynamic typing, dynamic binding, and many more features that make it as useful for complex application development as it is for scripting or "glue code" that connects components together. It can also be extended to make system calls to almost all operating systems and to run code written in C or C++. Due to its ubiquity and ability to run on nearly every system architecture, Python is a universal language found in a variety of different applications like Artificial Intelligence and Machine Learning, web development, Game development etc.

Python is a useful language to learn as it is widely used in computer science and machine learning. Python is the language that is used with the Raspberry Pi. This makes it highly relevant to robotics because you can use a Raspberry Pi to control a robot.

B. OpenCV

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.

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.

C. GPIO Zero

GPIO Zero is a zero-boilerplate Python library that makes physical computing with Python more accessible. GPIO Zero started out as a friendly API on top of the GPIO library, but later extended it to allow other pin libraries to be used. The pigpio library is supported, and that includes the ability to remotely control GPIO pins over the network.

GPIO Zero is installed by default in the Raspberry Pi OS desktop image, available from raspberrypi.org. To install on Raspberry Pi OS Lite or other operating systems, including for PCs using remote GPIO, see the Installing chapter.

5.1.3 Code for weed detection:

```
from picamera.array import PiRGBArray
from picamera import PiCamera
import time
import cv2
import numpy as np

# initialize the camera and grab a reference to the raw camera capture
camera = PiCamera()
camera.resolution = (640, 480)
camera.framerate = 32
rawCapture = PiRGBArray(camera, size=(640, 480))

while True:
    while True:
        try:
            hue_value = int(input("Hue value between 10 and 245: "))
            if (hue_value < 10) or (hue_value > 245):
                raise ValueError
        except ValueError:
            print("That isn't an integer between 10 and 245, try again")
        else:
            break

    lower_red = np.array([hue_value-10,100,100])
    upper_red = np.array([hue_value+10, 255, 255])

    for frame in camera.capture_continuous(rawCapture, format="bgr", use_video_port=True):
        image = frame.array

        hsv = cv2.cvtColor(image, cv2.COLOR_BGR2HSV)

        color_mask = cv2.inRange(hsv, lower_red, upper_red)

        result = cv2.bitwise_and(image, image, mask= color_mask)

        cv2.imshow("Camera Output", image)
        cv2.imshow("HSV", hsv)
        cv2.imshow("Color Mask", color_mask)
        cv2.imshow("Final Result", result)

        rawCapture.truncate(0)

        k = cv2.waitKey(5) #& 0xFF
        if "q" == chr(k & 255):
            break
```

5.1.4 Code for sprayer:

```
#sprayer.py
from gpiozero import LED
from time import sleep


def spray():
    spray = LED(21)
    spray.on()
    sleep(4)
    spray.off()
```

5.1.5 Complete code:

from sprayer import * from pi

camera.array import PiRGBArray from pi

camera import Pi Camera from time

import sleep import cv2 import numpy as

np import gpiozero camera = PiCamera()

image_width = 640 image_height = 480

camera.resolution = (image_width, image_height) camera.frame rate =

32 rawCapture = PiRGBArray(camera, size=(image_width,

image_height)) center_image_x = image_width / 2 center_image_y =

image_height / 2 minimum_area = 250 maximum_area = 100000 robot

= gpiozero.Robot(left= (22,27), right= (17,18)) forward_speed = 1.0

turn_speed = 0.8

HUE_VAL = 35 temp=0 lower_color = np.array([HUE_VAL-10,100,100]) upper_color =

np.array([HUE_VAL+10, 255, 255]) for frame in camera.capture_continuous(rawCapture,

format="bgr",use_video_port=True):

image = frame.array   hsv = cv2.cvtColor(image,

cv2.COLOR_BGR2HSV)   color_mask = cv2.inRange(hsv,

lower_color, upper_color)   contours, hierarchy =

```
cv2.findContours(color_mask, cv2.RETR_LIST,
cv2.CHAIN_APPROX_SIMPLE)
 object_area = 0
object_x = 0  object_y
= 0 for contour in
contours:
        x, y, width, height = cv2.boundingRect(contour)
found_area = width * height         center_x = x +
(width / 2)         center y = y + (height / 2)         if
object_area < found_area:             object_area =
found_area             object_x = center_x
object_y = center y     if object_area > 0:
        ball_location   =   [object_area,   object_x,   object_y]
else:
        ball_location = None  if ball_location:         if (ball_location[0] >
minimum_area) and (ball_location[0] < maximum_area):             temp=0             if
ball_location[1] > (center_image_x + (image_width/3)):
                robot.right(turn_speed)
print ("Turning right")           elif
ball_location[1] < (center_image_x -
(image_width/3)):

                robot.left(turn_speed)
print ("Turning left")             else:
                robot.forward(forward_speed)
print("Forward")         elif (ball_location[0]
< minimum_area):
            temp=0             robot.forward(0.5)
print ("Target isn't large enough, searching")
else:
            robot.stop()             temp+=1
print ("Target large enough, stopping")
if(temp==15):
```

Print (“Robot is spraying”) spray

()

else:

robot.forward(0.5) print

("Target not found, searching")

rawCapture.truncate(0)

5.1.6. Circuit diagram:

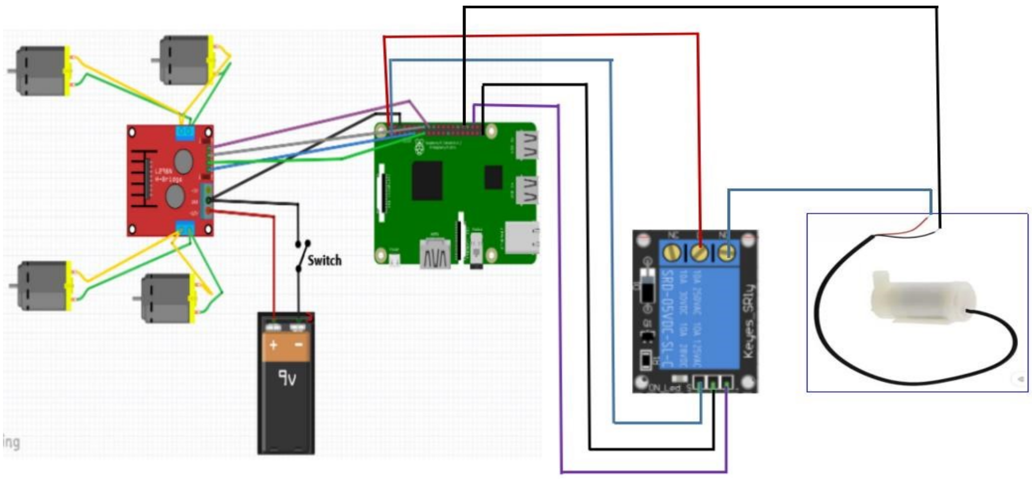

Fig.5.1.3 Circuit Diagram

5.1.7 Pin configuration:

L298N Motor Driver:

- Motor Driver IN1 – GPIO BCM22
- Motor Driver IN2 – GPIO BCM27
- Motor Driver IN3 – GPIO BCM17
- Motor Driver IN4 – GPIO BCM18
- 12V – Battery +Ve
- GND – Battery -Ve ● GND – GPIO BOARD 6

5V Relay:

- Vcc – GPIO BOARD 1 (+3.3V)
- Ground - GPIO BOARD 39 (GND)
- SIGNAL – GPIO BCM21
- Normally Open (NO) – Spray Motor +Ve
- Common (C) - GPIO BOARD 2 (+5 V)
- Spray Motor –Ve – GPIO BOARD 30 (GND)

5.2 Developed model:

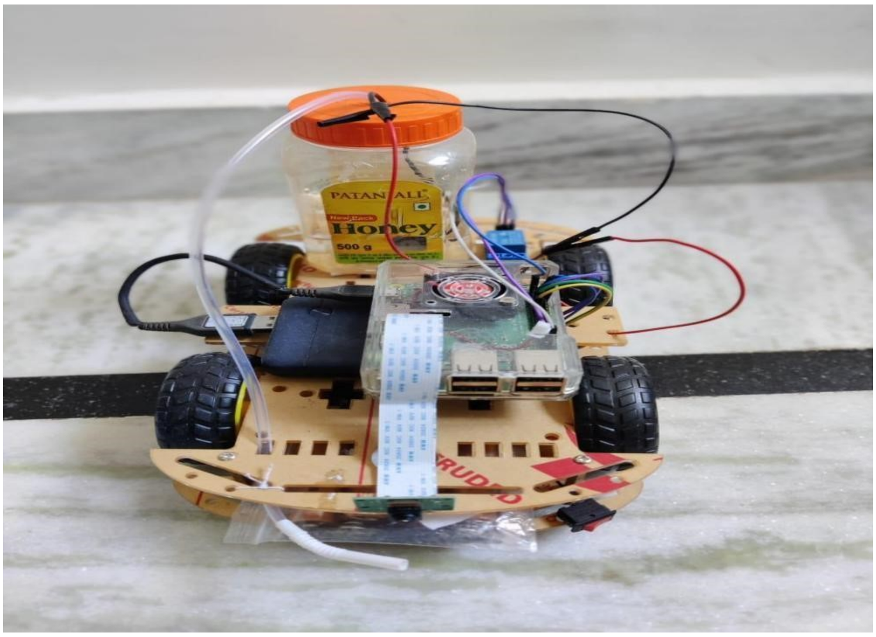

Fig5.4 constructed model 1

The main objective of our project is to identify the weeds and spray Herbicides only on the weeds but not on the crop.

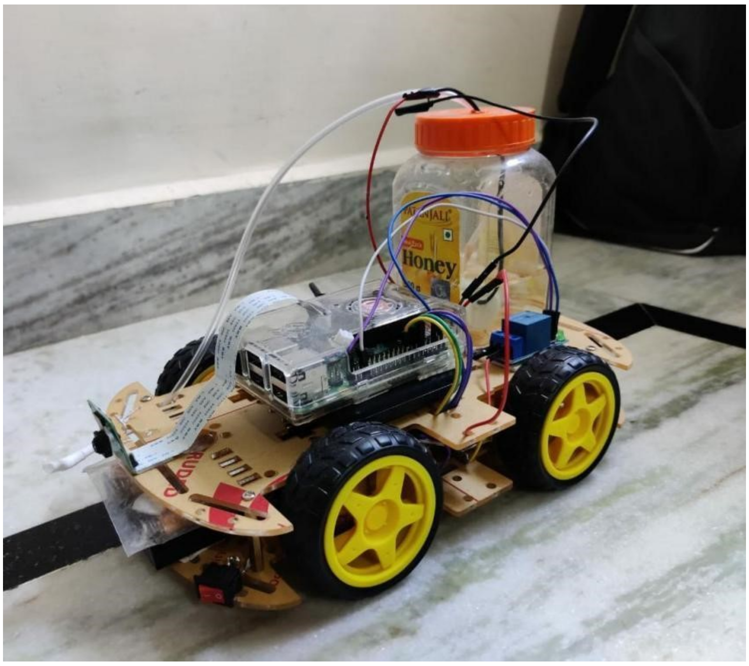

Fig5.5 constructed model

2

5.2.1 Simulation results:

CAMERA

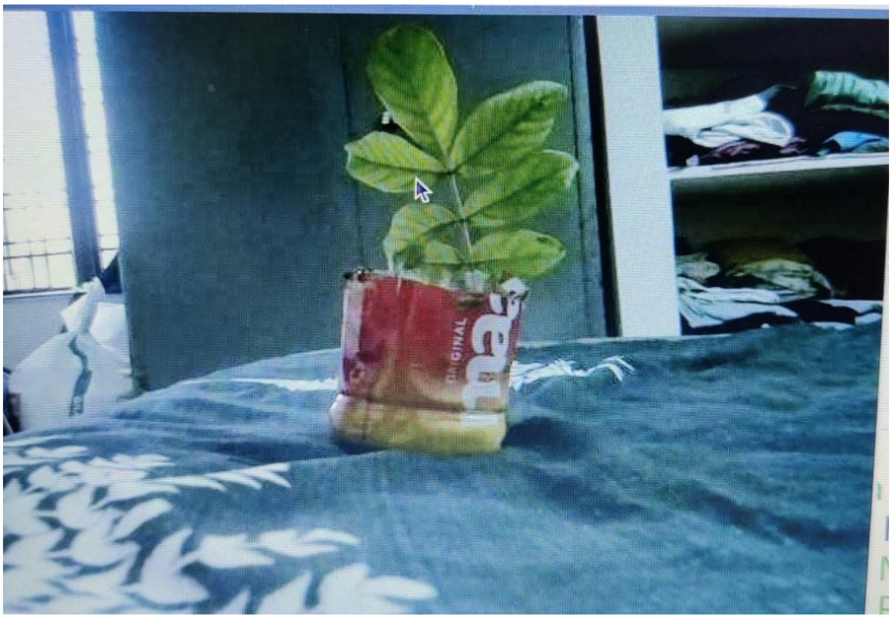
Fig 5.6.Camera representation

HSV REPRESENTATION

Fig 5.7.HSV Representation

PORTION OF FRAMES THAT MATCH HUE VALUE

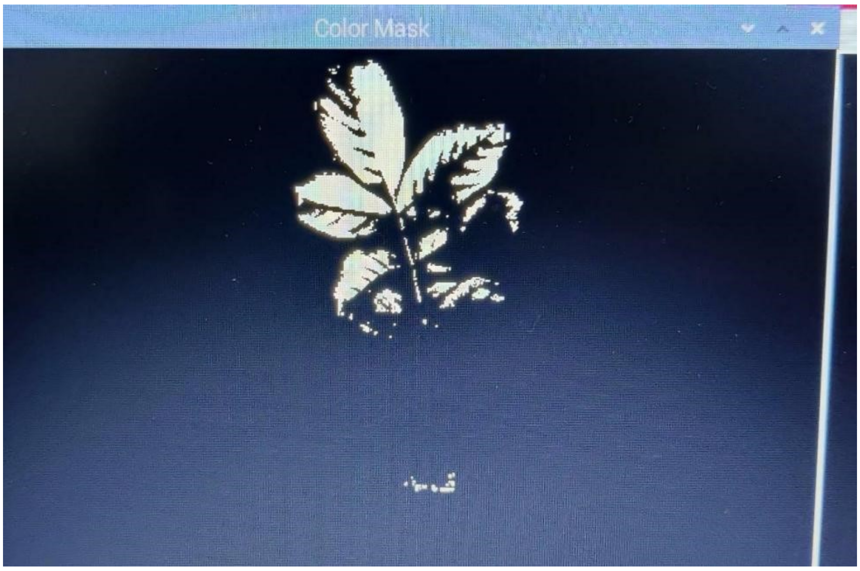

Fig.5.8. Portion of frames

ENTIRE FRAME MINUS ALL PORTION THAT DO NOT MATCH GIVEN HUE VALUE

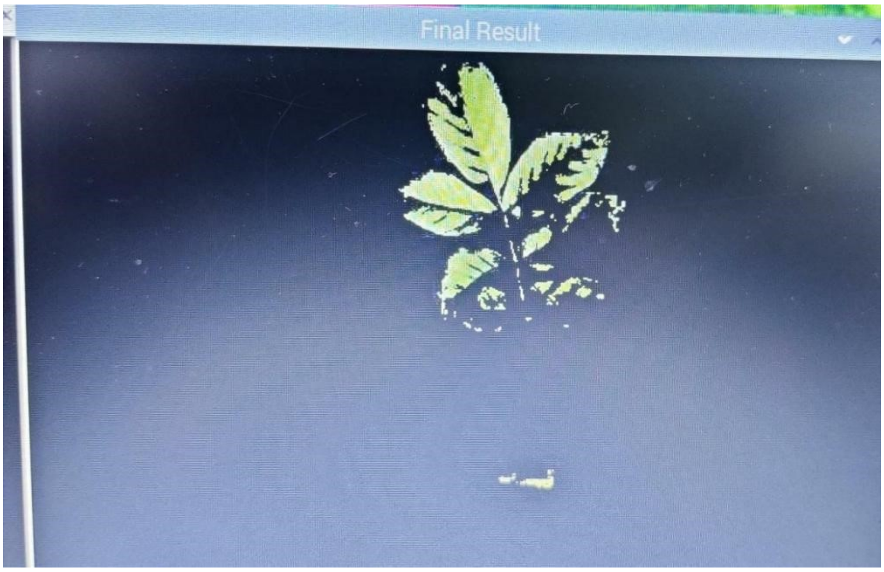

Fig.5.9 Hue Plant

6.SCOPE FOR FUTURE WORK AND CONCLUSION:

A robot to recognize weeds among estates was effectively created and a model of the Automatic Weed Detection and Smart Herbicide Sprayer i.e., Weed control Robot was outlined and actualized effectively with an accuracy of 95%. The robot involved equipment that can bolster and adequately splash herbicides on the identified weeds progressively. A sample course was planned with a column of plants in orange fields. The weeds were effectively-recognized and showered against by the robot and this procedure takes roughly 4 seconds. All the weed plants were distinguished legitimately, with a few orange leaves falling on the ground whose hue value is equal to the weeds being recognized as weeds. The weed detection can be further enhanced by employing algorithms like YOLO (You Only Look Once), SVM (Support Vector machines) for the classification of weeds from the crop. And to have more spouts to splash the chemicals. It can be transformed into an exceptional robot by employing solar panels for its power supply. The image handling algorithm can be modified further, with the goal that the recognition turns out to be more non-crop specific.

7. BIBLIOGRAPHY

A. B. C. Fenner, “New delta robot picks up the pace,” Industrial Robot, vol. 32, no. 1, pp. 1–2, 2005.

B. Y. Divya and C. P. Kumar, “Machine vision-based colour recognition by robotic arm using Lab VIEW,” CVR Journal of Science & Technology, vol. 18, no. 1, pp. 100–104, 2020.

C. T. Dewi, S. Nurmaini, PRisma, Y. Oktarina and M. Roriz, “Inverse kinematic analysis of 4 DOF pick and place arm robot manipulators using fuzzy logic controllers,” International Journal of Electrical and Computer Engineering (IJECE), vol. 10, no. 2, pp. 1376–1386, 2020.

D. X. Liu and S. Jin, “Multi-target visual recognition and positioning methods for sorting robots,” IOP Conf. Series: Materials Science and Engineering, vol. 892, The Third International Workshop on Materials Science and Mechanical Engineering (IWMSME 2020), Hangzhou, China, pp. 1–7, 2020.

E. Vaughan, R. N. Sumpter, A. Frost, and S. Cameron. "Experiments in Automatic Flock Control." Edinburgh, UK, 1998.

F. R. Grabowski, L. Navarro-Serment, and P. Khosla. "An Army of Small Robots." SciAm Online May 2004.

G. Moravec, Hans. "Robots, After All." Communications of the ACM. October 2003. Vol. 46, No.
10.