AGRIBOT

Bachelors of Science in Computer Engineering

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AGRIBOT

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In partial fulfillment of the requirement for degree of

Bachelors of Science in Computer Engineering

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This is to certify that the work presented in this project report, entitled *"AGRIBOT"* was conducted by **Muhammad Imtiaz, Muhammad Atif Ashraf, Muhammad Umair Malik** under the supervision of **Engr. Hammad Shahab and Engr. Dr. Muhammad Mohsin Waqas**.
This project report is submitted to the Department of Computer Engineering, Khwaja Fareed University of Engineering and Information Technology, Rahim Yar Khan in partial fulfillment of the requirements for the degree of Bachelors of Science in field of Computer Engineering.

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Abstract

Agricultural sector is definitely a vast source of living in Pakistan and other agricultural countries. Agriculture is a core part of the country's economy and massively contributes in the economic growth of any country. Matters concerns with farming have been continually restricting the progress of the country. In this article we have discussed our IoT and Computer Vision based precision herbicide spraying Agribot system that can perform precision spraying mechanism using raspberry pi 4 (model B). Our main task is to minimize the usage of herbicides and to reduce the labor cost. By doing this we will be able to overcome the massive usage of spray and will be able to minimize the labor required. An innovation in the agriculture sector is predicted, and an efficient agricultural robotic system is its section. Internet of Things technology has ability of giving significant data to agricultural businesses making this idea really arising. In our work, we planned a framework utilizing shrewd innovation, which can accomplish complex work without any problem. The framework planned in this work does precision spraying in the fields. Our system is capable of monitoring entire field using IoT technology on real time basis. Our work is not just focusing on precision spraying it should also be able to save the information in drive and utilize the data for additional investigation for taking exact actions against the received farm condition. The Agribot is being operated using a mobile Application that has the ability to control within the bluetooth range. Efficient agricultural systems with IoT and Computer vision have ability to maximize per acre yields in today's agricultural growth.

Keywords: Computer Vision, Precision Spraying, Internet of things.

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1 Introduction & Background

Agriculture sector is suffering from challenges every year, like rapid growth in human population and change in climate [1]. In this generation, we have progressed in practically every field aside from one field where there is still absence of innovation that is in agriculture sector in terms of technology [2].The contribution of Pakistan agriculture to GDP is about 21% and the yearly rate of growth is round about 2.7% [3]. Agribot is intended to limit the work of farmers as well as speeding up and precision of the work. It performs the basic techniques that are involved in the farming. In this project we will design a solar-powered agricultural robot that will automate farming Processes. The Agribot will be able to facilitate the farmers in most of the aspects like precision spraying and smart farm monitoring. Mostly agricultural country and its economic sustainability is widely dependent on the growth of agriculture sector [4]. However in Pakistan with the passage of time, area for agricultural land is shrinking. On the other hand, the demand for vegetables and fruits is rising exponentially to meet the nutritional requirements for such large ensemble of population. In order to cope with the rising demand of vegetables and fruits it is necessary to adopt modern farming techniques for high yield production. Farm automation is one of the modern farming techniques that provides controlled environment for high-yield crops in relatively. However, the lack of technical skills and inability to maintain pest free crop in farms results in significant loss in crop yield. Therefore, there is a rising demand of highly accurate system that will spray only the weeds for the desired production goals and using less amount of spray as compared to traditional methods. In this project, we have design a solar-powered agricultural robot (Agribot) that will automate the spraying in farms.

1.1 Literature Review (Existing System)

Latest technology usage in agriculture sectors are increasing rapidly. The efficiency of work regarding farming increase by using the latest technology [5]. This mean smart automation system is urgently needed in order to improve the productivity of the crops which will make us able to generate best rate of growth and also give us best solutions for food problem. Agriculture farming integrated with the IoT give us many benefits that include the precise use of the natural resources that are soil and water and many more. Internet of things helps to monitor the field status. The only way to make the farming steps more accurate, precise and exact is smart agricultural robotic system. The automated hardware is the major part that is used for the agricultural robotic system. In farming, there are different robots and sensors using IoT technology [6]. Advancement of the cultivating rules should not be applicable in numerous provincial areas. There are huge number of publications and articles that normally highlight the character of the robotics, like IoT and artificial intelligence. In the proposed project, we explain our robot, AGRIBOT is driven by two high torque DC gear motors, two wheels are powered while other two are free wheels and the chassis of the car is built as all-terrain vehicle. A solar power based robot, has ability to run in daytime on sun light, and is able to auto-charge the battery.

1.2 System Overview and Architecture

In this generation, the agricultural sectors are moving constantly towards the precision agriculture. In the proposed work, an agricultural robotic System is designed and developed by using the latest technologies like Machine learning, automation, IoT and robotics. Multiple portions of the work are integrated in this section. There is huge demand of agricultural precision spraying robotic system because it is only solution for gaining higher yields [7].

1.3 Overview of IoT

The report is proposed for IoT based agriculture system, which will update farmers by sending data of Humidity sensor (soil moisture) and temperature sensor (environment temperature) at low cost, with help of that live monitoring can be done. In the report chapter, I will cover overview of IoT technology and agricultural concepts. IoT means internet of things that provide unique identifiers and have the ability to transfer the data on any network without need of interaction between human and computer. Internet of things provides an online platform to user in order to access the required data using any application at any place [8]. Internet of things create a lot of easiness in work. In our project IoT helps to update the farmer regarding different status like during spraying, it give us the details about the remaining spray in the spray tank. We will monitor the throughout parameters of farm. We will integrate the raspberry pi with cam and using mobile application we can use it anywhere or at any place.

The internet of things biodiversity is based on smart gadget that normally use systems that are embedded like processors, textbooks and sensors in order to send collect and track the information that they receive in their environment. IoT gadgets share the sensory information they collect in conjunction with the role of IoT or another boundary gadget where information is normally sent from cloud should be sorted or demolished. locally gadgets have ability to do work left without human interfere even if people can contact the gadgets for example set them up give them directions or access information.

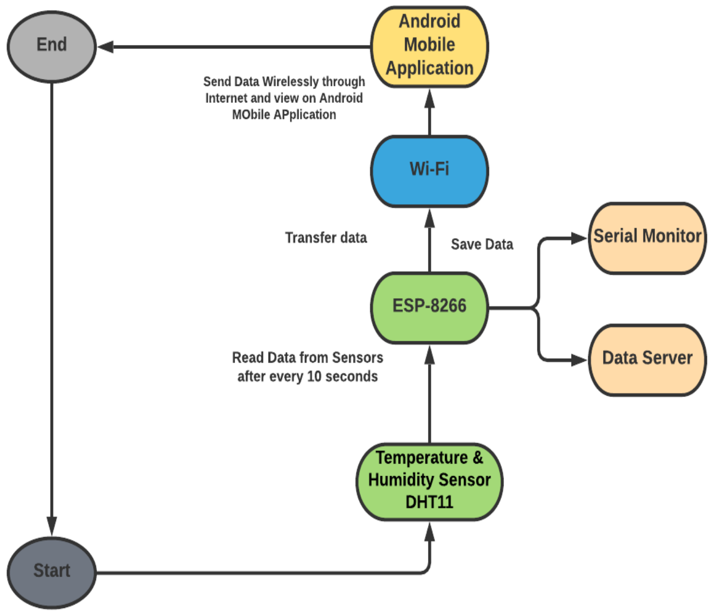

Figure 1.1 Flowchart of IoT System

1.4 IoT Based Smart Farming System

The Figure 1.1 shows IoT based SFS, which is consider as IoT module focused on the real time observation about the data of environment in case of humidity, temperature and other types depend on sensors that are integrated with it. The system provide the idea of " Plug and Sense " inside this, farmer should be able to easily use smart farming by just putting these systems on farm and get the real time data feeds on multiple gadgets like mobile phone applications etc. It also has ease to share the data about field at any time anywhere through its remote access. Figure 1.1 shows flowchart of IoT based SFS [9].

1.5 Benefits of IoT

1. Smart IoT system will reduced production cost nearly equal to zero.
2. Efficiency level increased in term of soil, fertilizer, water, pesticides etc.
3. IoT systems have some factor for protection of environment.

4. IoT is the core part Smart Farming because it provides accurate, exact and fast results regarding farm. Farmer is able to increase the production of food up to 70% [10].

1.6 IoT Application in Agriculture

As industries, homes, and cities will adopt IoT, everything will become smart and intelligent it will elevate the agriculture sector. In the present era, IoT is becoming necessity for farmers. Farmer are using IoT in managing the water for crops, precise agriculture, management or control of integrated pest, food production and other projects implemented till date. In the agriculture sector, the water is main asset so its wastage cannot be ignored. Therefore, in IoT based agriculture system water wastage is nearly equal to zero. In the weather prediction, high accuracy is required. If the weather update got earlier the chance of crop damage becomes minimum.

Agricultural IoT system satisfied the farmer by giving live data about plant health, water requirement and Temperature and humidity sensor, level of pets. Hence, proper care of crop could be planned by adopting the IoT based system. Therefore, food productivity and safety can be 100%.

2 Material and Methods/Model and Equations/Modelling

2.1 Methodology

The methodology of complete project is explained in the below section. Agribot system consist of multiple segments:

2.1.1 RC Vehicle (Agribot)

Figure 2.1 shows the working of bluetooth controlled remote control vehicle. The Robotic vehicle can move all over the field. We used two DC 12v windshield wiper motors having high torque. We used this kind of motors because they are capable of carrying and pulling heavy weight. One motor carry up to 20kg weight so, by using this type of motor that have high torque help robot to move throughout the field without facing issue. For the sake of suspension, we used locally available motorbike rear shocks. These shocks helps robot to move over the field in smooth way. These shocks work properly and provide excellent suspension on irregular surface. We can control the robot through mobile application. The robot is the main component of the entire project that is used for spraying on the field. The combination of wheels and motors of the robot is chosen wisely so that robot can move easily on the field. Solar panel is placed on the roof of the robot. Solar panel makes it possible for the robot to work in day light without any external power. However, battery backup is available in order to work in the field in morning and evening hours. Raspberry Pi is suspended below the solar panel and is facing downward. It is necessary to adjust raspberry pi in proper angle. Spray module is also placed below the solar panel for spraying. Like other agricultural robots, our Agribot is also able to perform the entire fieldwork easily without any operational problem. The only issue is that, if we want to implement the product on large scale then we have to upgrade the entire product like dc gear motors, chassis, battery backup and controlling mechanism.

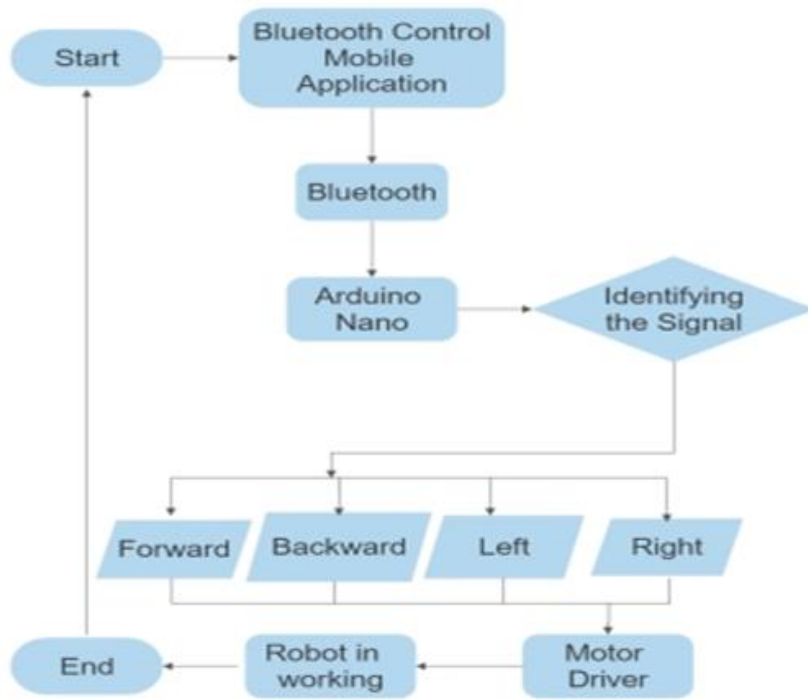

Figure 2.1 Flowchart of Bluetooth control Robot

2.1.2 Body Dimensions

The dimensions of the robot have great impact on the throughout chassis of the robot [11]. Therefore, it is important to select the dimensions more carefully. Because the stability of the robot depends on the dimensions of the robot. Figure 2.2 shows the pictorial view of AGRIBOT. In our case, the dimensions are given below:

Height of the robot: 45 cm

Length of the robot: 40 cm

Width of the robot: 40 cm

Figure 2.2 Agribot Body

2.1.3 Wheel Dimensions

The dimensions of the wheels also have great impact on the functionality of the robot. Wheels are of large diameter and heavy enough to work properly in the field without any hindrance. The wheels have enough grip on field for smooth operation.

Front wheel circumference: 20cm

Back Wheel circumference: 16 cm

2.1.3 Solar Panel

Solar panel is the main source of power for robot in the day time. Throughout the day robot operates on solar system while the batteries should be charging during the sun light. We used solar panel capable of giving 12 volts and 20-watt power. Figure 2.3 shows the Solar Panel used. The dimensions of the solar panel are given below.

Length of solar panel: 45cm

Width of solar panel: 35cm

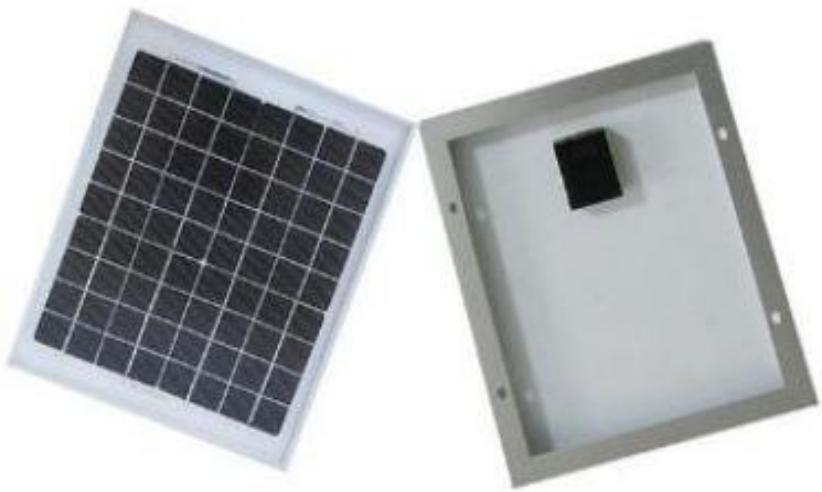

Figure 2.3 Solar Panel

2.1.4 Setting up Raspberry pi

In the software part, we used raspberry pi for the purpose of object detection. For setting up Raspberry Pi 4, we installed Rasbian the preferred OS on pi then installed required software like python, Anaconda, Opencv. After installing these software we can do object detection using Raspberry Pi 4 and Pi camera [12]. Figure 2.4 shows the block diagram of Raspberry Pi working.

We followed following steps respectively:

- Installing Rasbian
- Setting up python 3
- Installing opencv_python==4.1.1.26
- Installing tensor_flow==2.3.0rc0
- Setting up Pi Camera 5 mp

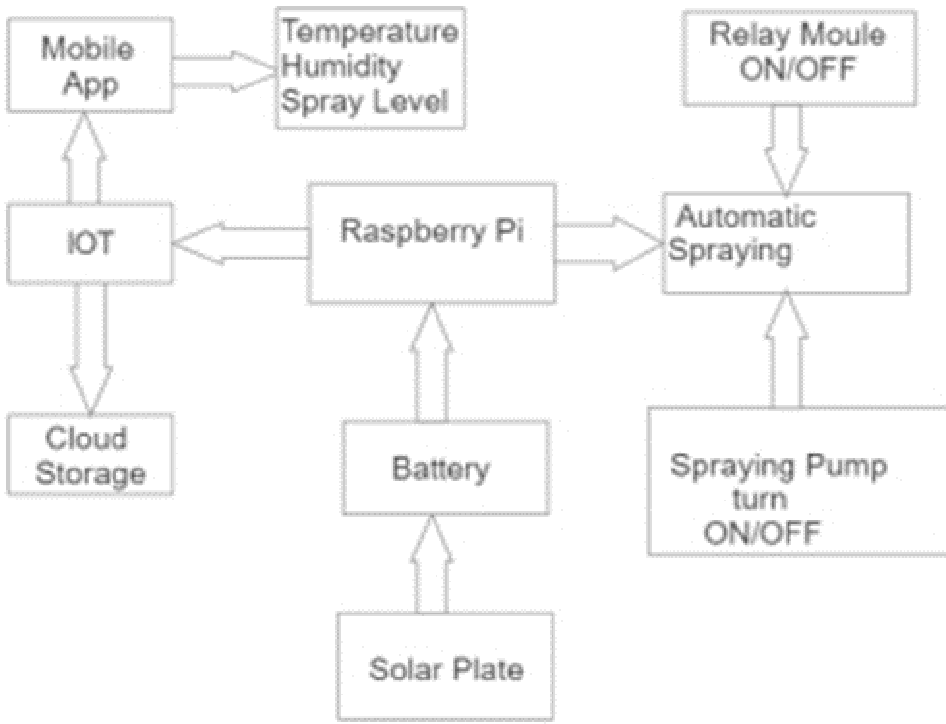

Figure 2.4 Block Diagram of Raspberry Pi Working

2.2 Sensors and Micro-Processor

We used temperature sensor and humidity sensor for obtaining the vital parameters like temperature and humidity. These sensors get real time values and send to mobile application using raspberry pi. We used raspberry pi 4 (Model B+) for precision spraying.

2.2.1 Raspberry Pi

Raspberry Pi are single-board computers SBCs [13]. Raspberry Pi is the series of SBCs available in more than 13 variants with different specifications. Raspberry pi is a portable computer like a smart phone. Window 8.1 can be install on raspberry pi. Arduino and Raspberry pi have same size but Raspberry Pi has more computational power and no analog to digital converter required to integrate different sensor. Almost all models of raspberry pi have built-in Wi-Fi. Raspberry Pi’s are mostly used in technical project.

2.2.1.1 Raspberry Pi 4 Model B Configuration

Raspberry Pi 4 model B has BMC2711 Broadcom chip. BCM2711 chip’s architecture is upgraded as compared to the chips in SoCs in earlier Pi models. It has quad-core CPU design as in BCM2837 chip but uses ARM A72 core, which is more powerful. The frequency of ARM cores is 1.5 GHz which make Pi 4 fifty percent more faster than Raspberry Pi 3B+. Raspberry Pi 4 model B+ can handle more memory than previous models as the ARM core is 64-bit and the VideoCore is 32-bit therefore new memory management unit was needed, So raspberry Pi 4 model B comes with faster and more efficient memory management unit. Raspberry Pi 4 model B has 2 GB LPDDR SDRAM it is power efficient and is mostly used in mobile computers. It has 2.4 GHz IEEE 802.11ac wireless Wi-Fi and 5.0 GHz BLE Bluetooth. It comes with a Gigabit Ethernet and 4 USB ports, 2 USB 2.0 ports and 2 USB 3.0 ports. The GPIOs are same as the previous models, standard 40-pin GPIO header. It has 2 micro-HDMI ports with 4kp60 supported. It has two 2-lane MIPI ports, one DSI display port and second CSI camera port. It uses OpenGL ES 3.1 and Vulkan 1.0 APIs for 2D and 3D graphics on embedded system. For loading operating system and data, storage there is Micro-SD card slot. Raspberry Pi Model B takes 5V DC via USB-C connector and GPIO header. It has operating temperature of 0 – 50 degrees C ambient. Figure 2.5 shows the pin configuration and parts of Raspberry Pi 4 model B.

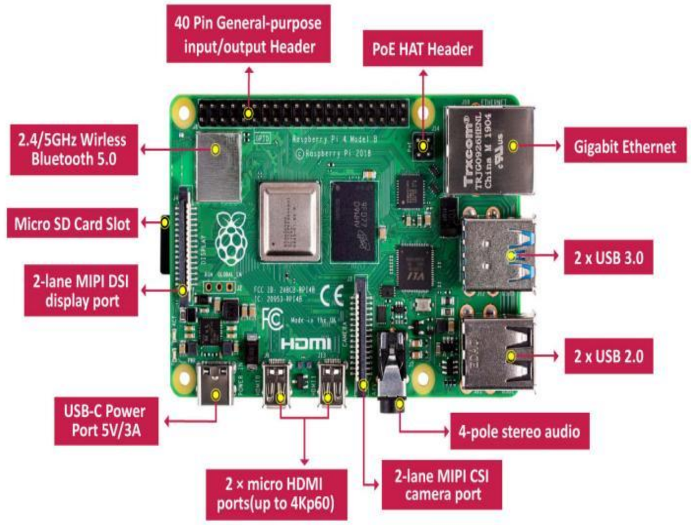

Figure 2.5 Raspberry Pi 4 (Model B plus)

2.2.1.2 Raspberry Pi Variants

Raspberry Pi was launched in 2012 with its first variant called as Raspberry Pi model B it had BCM2835 Broadcom chip with 256 MB RAM with Ethernet port. There was no wireless connection option it had 26 GPIOs. In the year, 2013 Raspberry Pi released its model A with same SoC but without Ethernet port. Later they released B+ and A+ models with 256 MB RAM and B+ model but in compact sizes. In 2015, they introduced Raspberry Pi 2 model B with BCM2836/7 Broadcom chip it had 1 GB RAM and an Ethernet port. With the release of Raspberry Pi 2 they released Raspberry Pi Zero in two models Zero and W/WH with BCM2835 Broadcom chip it had 512 MB RAM. The model Zero came without option of wireless connection whereas W/WH model came with option of wireless connection. In year 2016 Raspberry Pi introduced Raspberry Pi 3 model B with BCM2837A0/B0 Broadcom chip with 1 GB RAM, with Ethernet port, and wireless connectivity option. In 2018 they introduced A+ and B+ models of Raspberry Pi 3 with BCM2837B0 Broadcom chip, model A+ has 512 MB RAM without Ethernet port and with wireless connectivity, whereas model B+ has 1 GB RAM and with

Ethernet port and wireless connectivity option. In 2021 Raspberry Pi introduced Raspberry Pi 4 model B with BCM2711 Broadcom chip available in 1 GB, 2 GB,4 GB and 8 GB RAM, with Ethernet port and wireless connectivity option. With the release of Raspberry Pi 4 model B Raspberry Pi released model 400 with same SoC and with 4 GB RAM with Ethernet and wireless connectivity option. In 2021 Raspberry Pi released Raspberry Pi Pico with RP2040 Broadcom chip with 264 KB RAM without Ethernet port and without wireless connectivity option. Table 2.1 contains the data of different variants in tabular form.

Table 2.1 Raspberry pi Variants

Family	**Model**	**SoC**	**Memory**	**Form Factor**	**Wireless**	**Released**
Raspberry Pi	B	BCM2835	256 MB	Standard	No	2012
	A					2013
	B+		512 MB			2014
	A+			Compact		2014
Raspberry Pi 2	B	BCM2836 /7	1 GB	Standard	No	2015
Raspberry Pi Zero	Zero	BCM2835	512 MB	Zero	No	2015
	W/WH				Yes	2017
Raspberry Pi 3	B	BCM2837 A0/B0	1 GB	Standard	Yes	2016
	A+	BCM2837 B0	512 MB	Compact		2018
	B+		1 GB	Standard		2018
Raspberry Pi 4	B	BCM2711	1 GB	Standard	Yes	2019
			2 GB			
			4 GB			
			8 GB			2020
	400 (4 GB)		4 GB	Keyboard		
Raspberry Pi Pico	N/A	RP2040	264 KB	Pico	No	2021

2.2.2 Arduino UNO

Arduino is a micro-controller device that is based on ATmega328.Arduino has digital Input-output pins that are 14 and analog inputs are 6 and also has crystal oscillators having frequency of 16 MHz USB type port, Power jack and reset button is also available on board. Figure 2.6 shows the Arduino uno board.

Figure 2.6 Arduino uno

2.2.2.1 Arduino Uno Specifications

The microcontroller used in Arduino uno is Microchip ATmega328P. The operating voltage of Arduino board is 5 V. The input voltage is 7 to 20 Volts. It consists of 14 Input Output pins. Analog pins present are A0 – A5, two serial pins that are Rx and Tx used for transmitting and receiving serial data. There are two external interrupts 2, 3 that are used to trigger an interrupt, two TWI pins A4 and A5 that are used for TWI communication. For SPI communication, there are four pins 10, 11, 12 and 13. It gives 40 mA DC current on I/O pins. Flash memory of Arduino board is 32

KB, SRAM is of 2 KB and EEPROM 1 KB. The clock speed of Arduino board is 16 MHz. Figure 2.7 shows the pin configuration and labeled parts of Arduino.

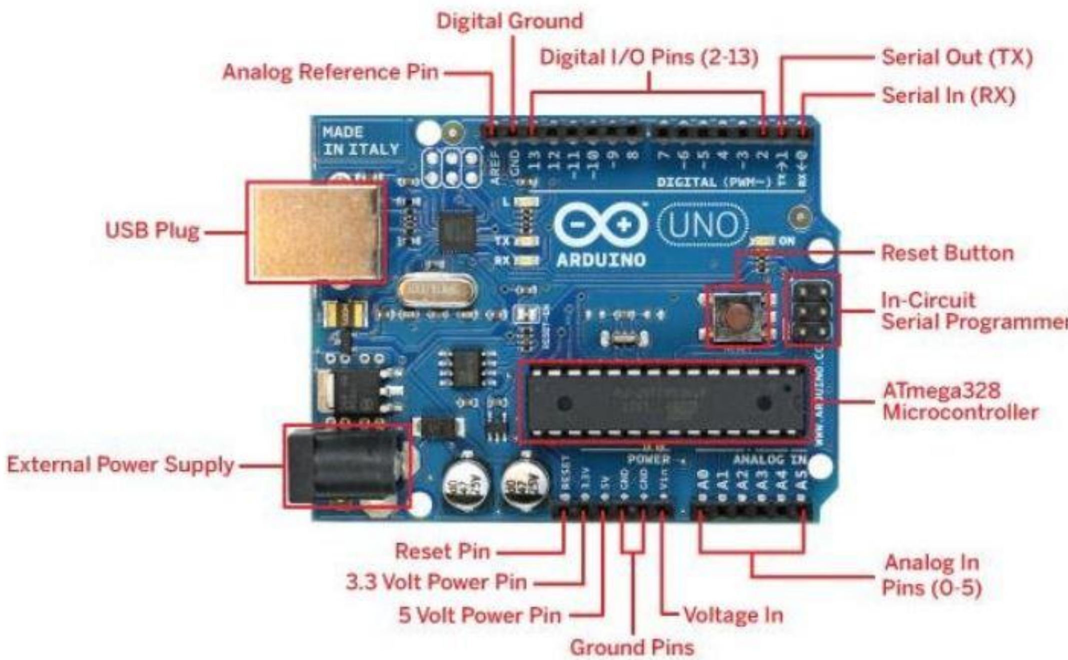

Figure 2.7 Arduino Board's Pin configuration

2.2.3 Temperature and Humidity Sensor- DHT11

In order to monitor the real time temperature of the field we use temperature sensor. The sensor has 64 bit serial code that give permission to multiple **DHT11** 20s to perform their functionality at the same time on a single wire bus without any delay. Humidity sensor is used to detect the moisture level of the soil. This sensor has 2 exposed pad that act like a variable resistor. These kind of sensors are mostly used for the purpose of giving water to plants.

2.3 Components

2.3.1 Solar Charging Mechanism

As we know in these days solar operated gadgets make work more cost effective and time saving. Agribot is solar based robot having ability of self-charging. A 12v solar panel is placed on the roof of the robot. The solar charging and operating system make robot more much cost effective for use. There is no need of fuel and external power source for operating the robot.

2.3.2 ESP32

In Figure 2.8, ESP32 is a system on chip and very low cost module. ESP32 has RF integrated components like antenna switch, receiver and power amplifier and filters. If we use this module then we need just few components that are more external.

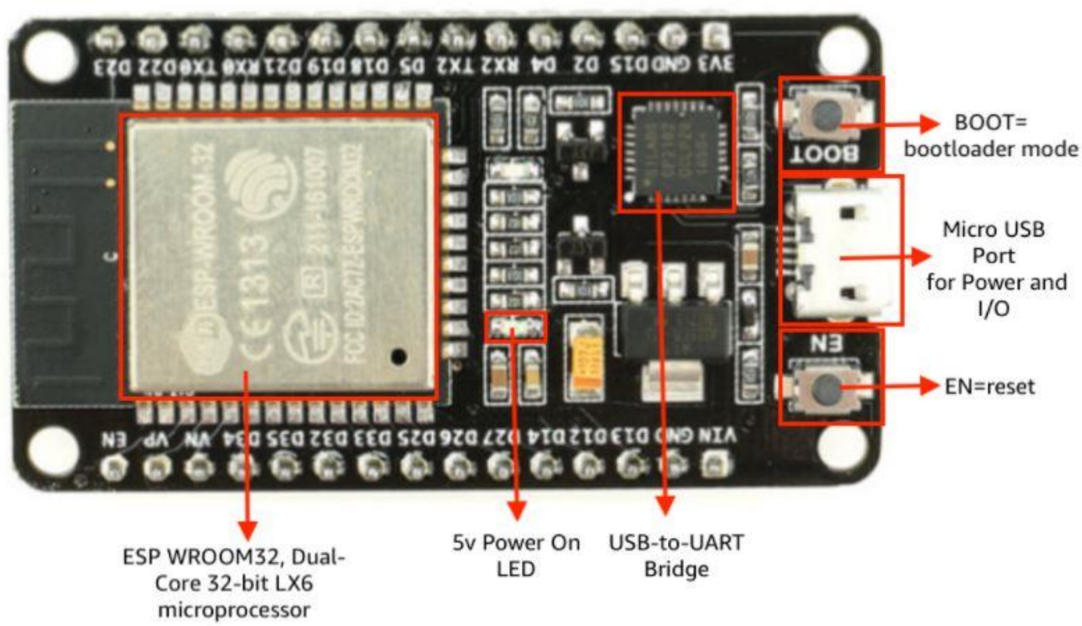

Figure 2.8 ESP 32

2.3.2.1 Specifications of ESP32

1. ESP32 comes with 16 KB SRAM and 448 KB ROM.
2. Having both single and dual core microprocessor.
3. Total 34 GPIOs are programmable.
4. One host controller and one slave controller.
5. It contains flash Encryption.
6. ESP32 comes with enable button for reset.

2.3.3 Bluetooth Module

We used Bluetooth module hc05 that is in the figure 2.9. We can use this Bluetooth module in order to make a communication link between two different microcontrollers .We can control any device using RC Bluetooth mobile application. We can create a link between Arduino and mobile application. Therefore, by using the application we can easily send or receive data through Bluetooth module that helps in controlling the device. By using the mode of command, we can easily configure the default values.

2.3.3.1 Pinout Configuration of HC-05

Pin configuration of the Bluetooth module is given below in Figure 2.9:

1. Vcc pin is used for giving power to module. Any 5 volt power supply is connected to module.
2. Enable pin is used for toggling between AT mode and data mode.
3. Ground pin is used for connecting to the system ground.
4. State pin is used for feedback in order to check the Bluetooth module functionality.
5. Rx pin is used for broadcasting all type of serial data using Bluetooth technology.

6. Tx pin is used for transmitting serial data

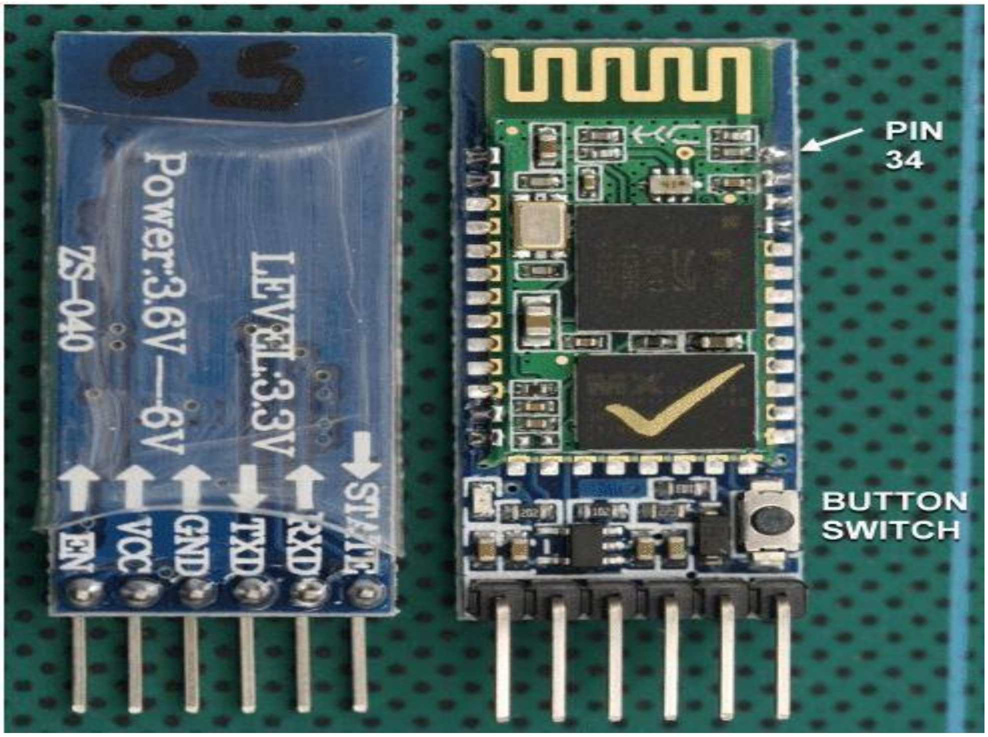

Figure 2.9 Bluetooth hc-05

2.3.3.2 Specification of hc05

1. Bluetooth module works on the frequency of 2.45 GHz.
2. The operating voltages of module is 4 to 6 volts (Normally 5 volts).
3. The range of module is about 100 m.
4. Operating current is round about 30 mA.

2.3.4 Pi Camera

Figure 2.10 shows a Pi camera. Pi cam is able to deliver the clear 5mp resolution images and HD recording with 1080p at 30 frame per second.

2.3.4.1 Specification of Pi Camera

1. The resolution of picture is 2592x1944.
2. Total pins are 15 and are connect directly to Raspberry Pi.
3. Size of the cam is around 20x25x9 mm.

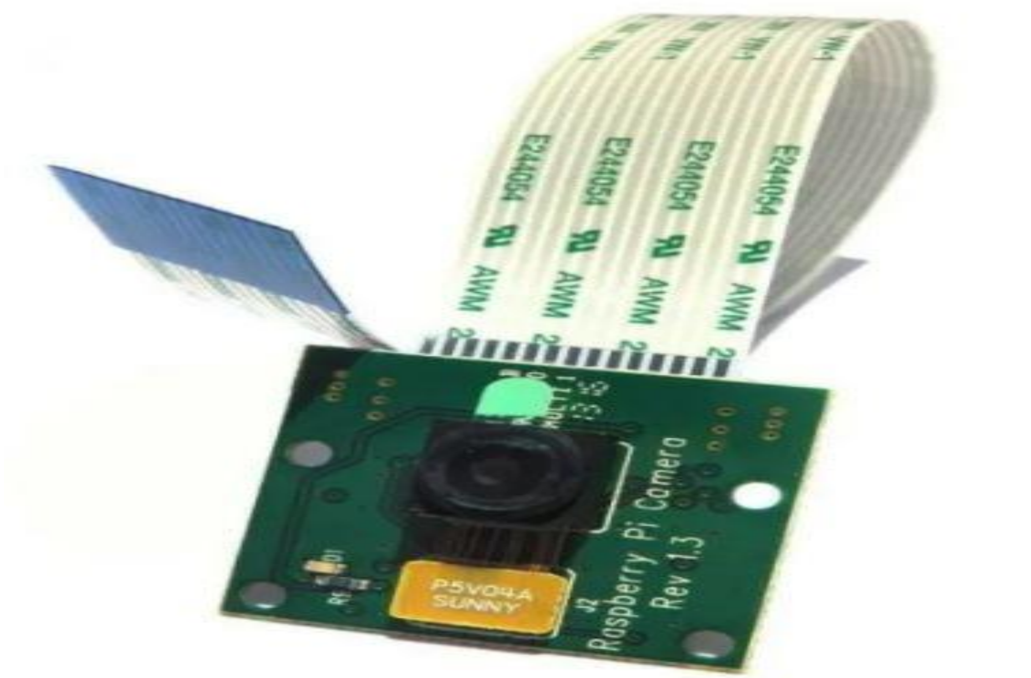

Figure 2.10 Pi Camera

2.3.5 Wind shield wiper motor

Windshield wiper motors are mostly used in cars. We use these motors because they produce high torque. This motor is capable of pulling heavy weights up to 20kg without any problem. It has three speeds and we have option to set it on any level according to our requirement and need. This motor is powerful enough to move heavy object easily. Figure 2.11 shows a Windshield Wiper Motor.

Figure 2.11 Windshield Wiper Motor

2.3.5.1 Specifications of Motor

The gear motor for windshield wiper works on two speeds, the nominal or prescribed voltages for the smooth running of the motor is 12 - 24 volts and the testing voltage is 13.5 - 27 volts. These motors draw 2 - 1.5 ampere current at normal working while running at speed I, and draw 2.5 - 1.5 ampere current at normal working running at speed II. In extreme loads, the motors draw 12 - 10-

ampere current while running at speed I, and draw 15 - 13-ampere current while running at speed II. When there is no load on motor it gives 30 RPM while running at speed I, and gives 30 - 45 RPM while running speed II. At normal condition, motors produce torque of Four Nm at both speeds and with load, the starting torque or highest torque produced is 40 Nm while running at speed I and 35 – 40 Nm while running at speed II. The gear ratio of the windshield wiper motor is 2/110. The approximate weight of the motors is 1.2 kilogram. Table 2.2 shows the data in tabular form.

Table 2.2 Windshield Wiper Motor specification

Gear motor for windshield wipers MRT62 – 43	I Speed		II Speed	
Nominal Voltage (V)	12	24	12	24
Testing Voltage (V)	13.5	27	13.5	27
Nominal Current (A)	2	1.5	2 / 2.5	1.5 / 2
Max. Current (A)	12	10	12 / 15	10 / 13
No Load Speed (RPM)	30	30	30 / 45	30 / 45
Nominal Torque (Nm)	4	4	4	4
Gear Ratio	2 / 110			
IP Grade	40			
Weight (Kg)	1.2			

2.3.6 Motor Driver

Motor driver is the module used for driving motors .We use dual motor driver for operating the two motors. Motor driver is the core component for driving any kind of motors. Figure 2.12 shows a ZK-5 motor driver. We use ZK-5 ampere motor driver because it can bear up to 5 ampere current, which is enough for the motors that we are using.

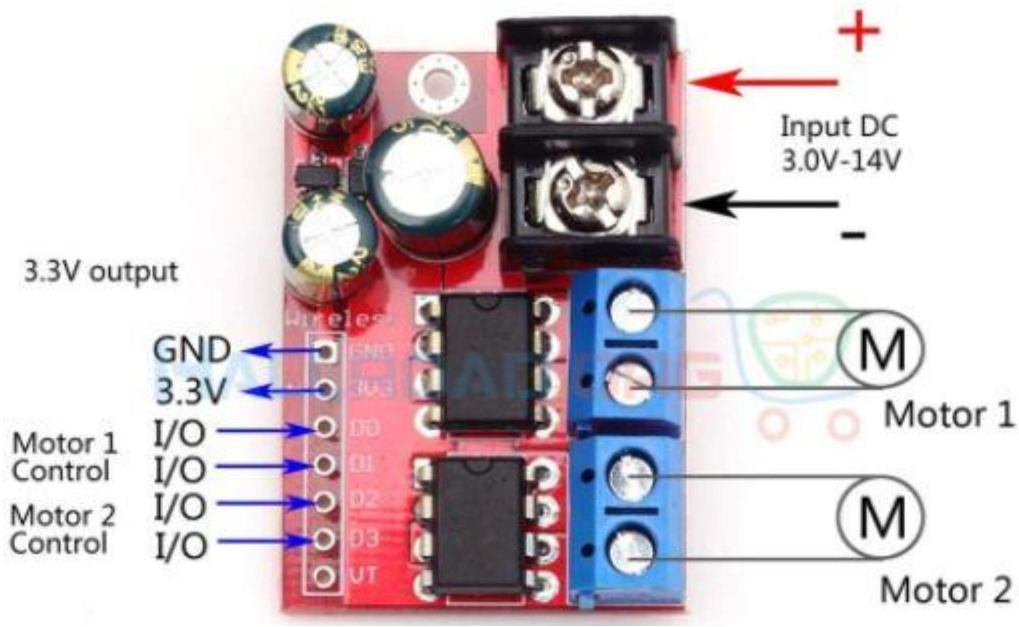

Figure 2.12 Motor Driver ZK-5A

2.3.6.1 Specifications of motor driver

1. The driven current is 5 Ampere.
2. The input signal voltage is 2.2-6 volt.
3. It provide 3.3 output voltage.
4. The working voltage is 3-14 volts DC.

2.3.7 DC Spray Pump

A Spray pump is used for spraying purposes. Figure 2.13 shows a DC spray pump. We used 12-volt DC spray pump. It is a brushless Spray pump. The flow rate of spray pump is nearly equal to 12 liters per minute, so it is ideal for quick or jet spraying.

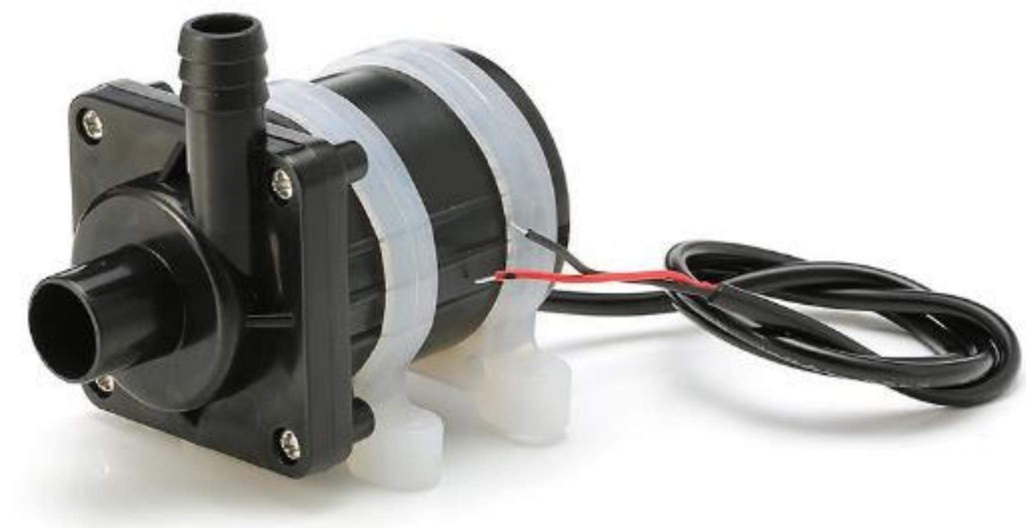

Figure 2.13 DC Spray Pump

2.3.7.1 Specifications of the spray pump

1. Operating voltages are 12 volt DC.

2. The power of the water pump is 8 watt.

3. The maximum flow rate of Spray is 12 Liters per minute.

4. Its working current is 667 mA.

2.3.8 Shock Absorbers

The Figure 2.14 shows the shocks that we used in our robot for the sake of suspension. The core part of the robot chassis are shocks that makes robot stable and comfortable while moving in the fields. As we know that farms are irregular, that is why we need comfortable suspension system for the proper working of robot on field. For the purpose of suspension, we used motorcycle rear shocks and installed soft spring instead of hard spring because we need smooth working. As we know that, all heavy machineries and robots have effective suspension system that enable robots to move freely. These shocks enables robot to cross any kind of hurdle without any problem.

Figure 2.14 Shock Absorbers

2.4 Weed Detection Using YOLO V4

The YOLO object detection technique is used for detecting objects in an images as well as video streaming by using the concept of deep learning, Python and OpenCV.

By applying object detection techniques, we will not only be able to just find what is in an image, but also where a given object lies in an image. In the previous five years, methods and techniques for the purpose of detection are classified into different classes that are non-digital and digital image sensors based [7].

2.4.1 YOLO Object Detection

R-CNNs were very accurate, but there is a huge problem with the speed of R-CNN family they were very slow, and able to just obtaining only 5 FPS on a GPU [14].

Redman introduces first neural network in 2015. Their first paper was, YOLO that is Unified, Detection of object in real time give the details of an object detector that is capable for object detection on real-time and obtained 45 FPS on a GPU.

In the earliest a small variant of their purposed model was introduced that is called ‘Fast YOLO’ that is able to achieve almost 155 FPS on a GPU [15].

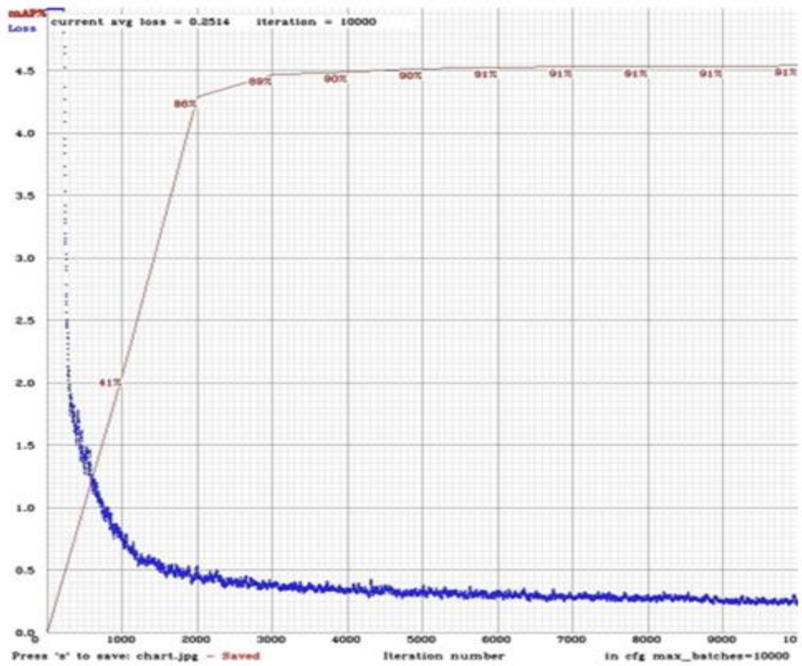

Figure 2.15 Training Graph

The above graph represents the average loss with respect to number of iterations during the training, as the model is being trained, the average loss gradually decrease after every iteration the model becomes more and more accurate. The check is applied after every 1000 iterations to check for the mAP% as the intervals or epochs pass the mAP% increases as the model becomes more accurate after every 1000 intervals. At a certain point, the mAP% is constant or gradually decreases as compared to the last iteration at that point the system stops the training process and saves the weights as the best weights in the backup folder of google drive. Figure 2.15 shows the training graph.

2.4.2 Object Detection Steps

- Gathering Data (Raw images)
- Labeling images
- Creating data set
- Training data set

2.4.2.1 Gathering Data (raw images)

As our approach is to target the local crops of our region so it is impossible to search for a bigger and annotated data set on google images. Therefore, the team visited local farms and video of the targeted farms were recorded. After the videos were collected then required frames from the video were separated using different tools. The specification of the collected videos having width of frame is 1920, height of the frame is 1080 and the rate of frame is 30. The specifications of the extracted frames are Width 2592 Height 1520.In the start of the project. first we record the images of the field by using camera. Then, we convert the recorded video of field into images to make them able for labeling.

2.4.2.2 Labeling Images

Tool used for image labeling is Label master. After separating the desired frames from the video data, the images are then to be labeled with respect to the classes defined. Each bounding box or region must represent a class. The label master tool is used for the detection of the objects in any image. The core purpose of this tool is to give access to its users to capture or highlight the specific objects in any picture. The purpose of highlighting the images is to make images readable for the computers or machines. Image annotation and labeling are mostly used for machine learning and artificial intelligence. Figure 2.16 shows the usage of the Labelling Image master tool for labelling.

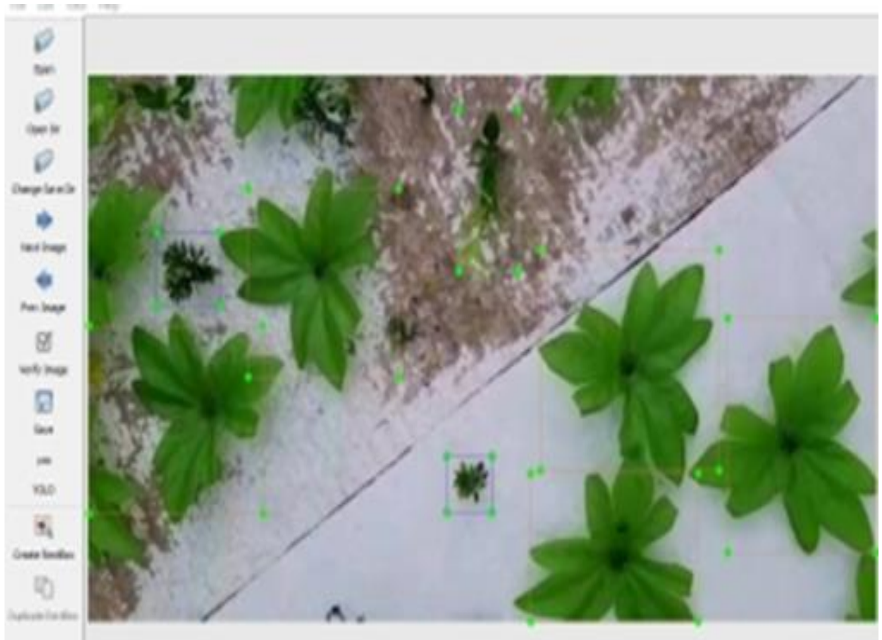

Figure 2.16 Labeling images using Labeling Master

2.4.2.3 Creating Dataset

Roboflow is the Tool used for the creation of data set. Roboflow normally simpler the computer workflow from the data organization, creating data set, preprocessing and annotation verification to export the format of your required model. It is more much helpful for the creation of the dataset for the object detection.

2.4.2.4 Training Dataset

Google Colab Jupyter Notebook is a tool used for the training of the dataset. A Jupyter Notebook is a component of Jupyter Lab. Jupyter Lab is a development environment and is web-based for codes, data and Jupyter Notebooks. We can write and execute the codes in Jupyter Notebook just like Google Colab Notebook. Jupyter Notebook is web application and is commonly open source and customizable that enables a user to create documents, which contain narrative text, visualizations, live code and equations. Jupyter Notebook is used for machine learning, numerical simulation, statistical modeling, data cleaning and transformation, data visualization and much more. After successfully implementing all the above steps, the next step is to train the object detector using the configuration, data file and the convolutional layer weights, this is a long process it can take 4-8 hours for completion. After every 1000 iterations, the weight file will be saved in the backup folder in the Google Drive. After training, we can observe a chart of how your model did throughout the training process. It shows a chart of our average loss vs. iterations. It is an excellent tool for performing deep learning tasks.

2.4.2.5 Google Colab Notebook

As, training the data set require High-end GPU, therefore the most economical way of training the data set using GPU is to utilize the Googles Free GPU on Colab Notebook. Colab Notebook gives access to a variety of GPUs with different memories. Training on Colab makes the process faster as compared to the system with no access to GPU.

2.4.2.6 Setting up GPU

The colab notebook initially is not set for the GPU usage, following steps are taken to enable GPU on Colab Notebook.

1. Click Edit at top-left of notebook

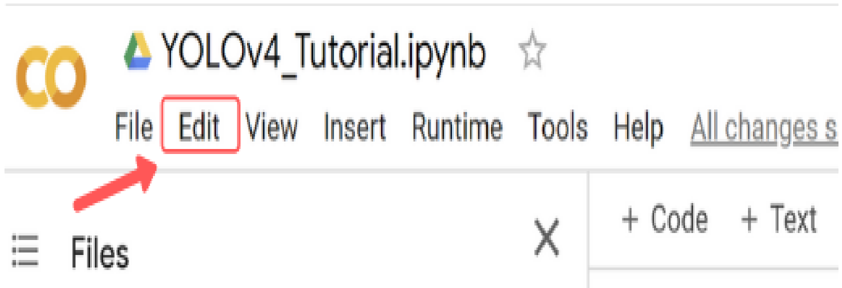

Figure 2.17 YOLO Tutorial 1

2. Click Notebook Settings within Dropdown.

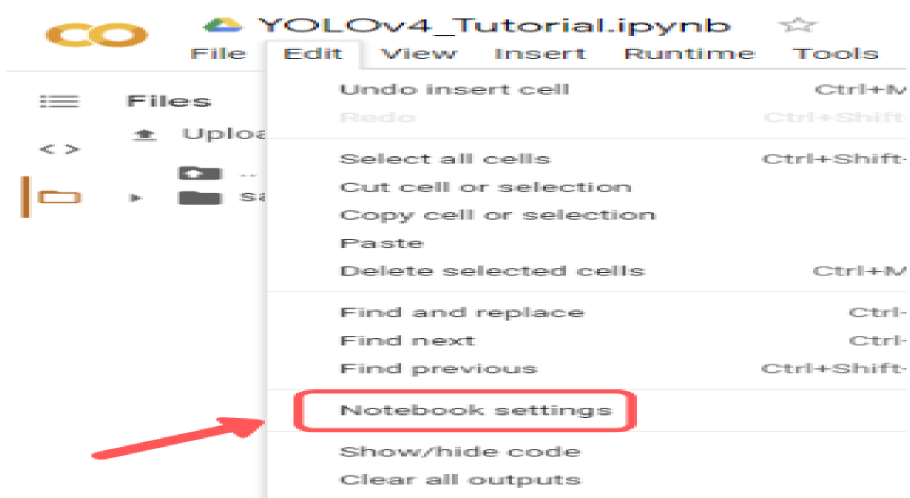

Figure 2.18 YOLO Tutorial 2

3. Under Hardware Accelerator select GPU and then hit Save.

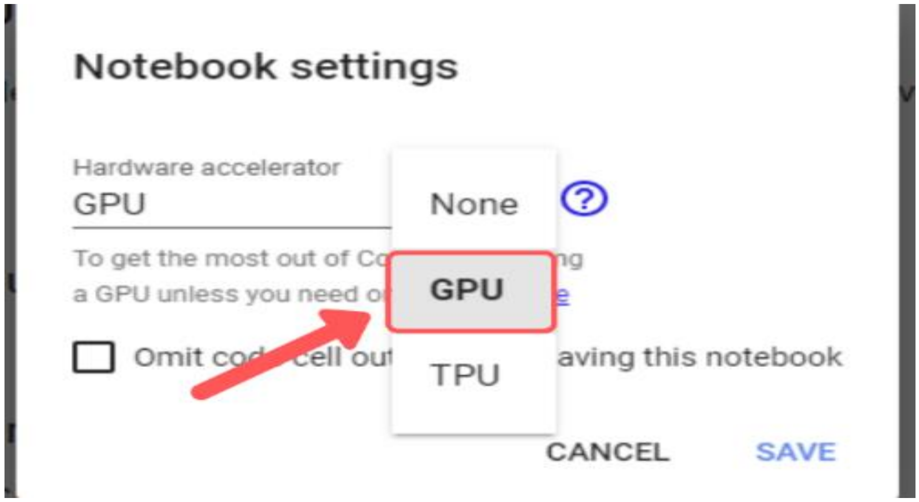

Figure 2.19 YOLO Tutorial 3

2.4.2.7 Linking Google Drive

For linking the google drive containing the annotated data and the configuration files for the training with the colab notebook we follow the following step. Google Drive is the fastest way to process the data in the Google Colab Notebook. Figure 2.20 shows the commands for mounting google drive in google colab.

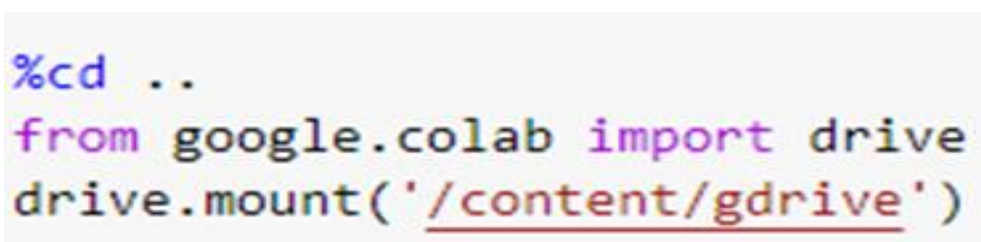

Figure 2.20 YOLO Tutorial 4

2.4.2.8 Re-configuring the cfg file

We can edit the .cfg to fit our needs based on our object detector. In the .cfg file set the batch = 64, subdivisions = 16. Keeping in mind the number of classes we used in the labelling process we need to make few more changes to the .cfg file.

2.5 Power Supply

The main source for the running of any electric device is power supply that operates the entire module. In our case, we used lipo batteries having 12 volts and 2800mah.

2.5.1 Rechargeable Lipo Battery

The lipo 12-volts, 2.8 ampere-hour rechargeable battery is used for giving power to the robot. Figure 2.21 shows a Lipo battery used in the project. Its discharge time is very longer that makes it able to operate the robot for long time while it has short charging time. This battery act as an internal power supply for all circuit.

Figure 2.21 Lipo Battery

3 Results and Discussions

3.1 Results of different YOLO variants

In first approach, Yolov3 technique is used and trained weights of 282 MB are used. The computational power was Dell latitude E6520 with 8 GB of RAM. The system produces 14 FPS with a mean average precision of 82.29 percent. In second approach, Yolov4 technique is used and trained weights of 282 MB is used. The computational power was Dell latitude E6520 with 8 GB of RAM. The system produces 16 FPS with a mean average precision of 92.30 percent. In third approach, Yolov3 technique is used and trained weights of 282 MB are used. The computational power was Intel Xeon CPU with 32 GB of RAM. The system produces 22 FPS with a mean average precision of 82.29 percent. In fourth approach, Yolov4 technique is used and trained weights of 282 MB are used. The computational power was Intel Xeon CPU with 32 GB of RAM. The system produces 25 FPS with a mean average precision of 92.30 percent. In fifth approach, Yolov3 tiny technique is used and trained weights of 48 MB are used. The computational power was Dell latitude E6520 with 8 GB of RAM. The system produces 20 FPS with a mean average precision of 92.38 percent. In sixth approach, Yolov4 tiny technique is used and trained weights of 48 MB are used. The computational power was Dell latitude E6520 with 8 GB of RAM. The system produces 22 FPS with a mean average precision of 95.20 percent. In seventh approach, Yolov3 tiny technique is used and trained weights of 48 MB are used. The computational power was Raspberry Pi 4 model B+ with 2 GB of RAM. The system produces 1.2 FPS with a mean average precision of 92.38 percent. In eights approach, Yolov4 tiny technique is used and trained weights of 48 MB are used. The computational power was Raspberry Pi 4 model B+ with 2 GB of RAM.

The system produces 1.8 FPS with a mean average precision of 95.20 percent. Table 3.1 shows the data in tabular form.

Table 3.1 FPS Table

Framework	**Weights File Size (Mb)**	**System**	**mAP**	**FPS**
Yolov3	282	Dell latitude E6520 (8gb)	82.29	14
Yolov4	282	Dell latitude E6520 (8gb)	92.30	16
Yolov3	282	Intel Xeon CPU (32gb)	82.29	22
Yolov4	282	Intel Xeon CPU (32gb)	92.30	25
Yolov3 tiny	48	Dell latitude E6520 (8gb)	92.38	20
Yolov4 tiny	48	Dell latitude E6520 (8gb)	95.20	22
Yolov3 tiny	48	Raspberry Pi 4 (2gb)	92.38	1.2
Yolov4 tiny	48	Raspberry Pi 4 (2gb)	95.20	1.8

4 Conclusion & Future Work

4.1 Conclusion

A system is designed and constructed based on internet of things, computer vision and deep learning that performs the elementary functions in farm automation of smart agriculture system. Selective spray technique using yolov4 is implemented for weeds and crops. When the system will detect weed using the camera attached to raspberry pi it will automatically turn the pump on, and pesticides would be sprayed via nozzle on the weeds only. The data from different sensors attached to the raspberry pi will be transmitting constantly to the android app using IoT technology, which gives time-to-time report of the farm to the owner and farmers.

4.1.1 Comparison

In Pakistan, the widely used method of farming is conventional method, which is being used for decades, in the next session we will be discussing the advantages and disadvantages of using AGRIBOT as compared to conventional farming methods.

4.1.1.1 Conventional Method

Pakistan is an agricultural country and the method used for farming is conventional methods. The conventional method is labor dependent and labor is greatly involved in conventional farming. If we take example of spraying, the consumption of spray in conventional method is 1200 milliliter per acre approximately for any crop in Pakistan. Water is essential part of making spray solution, with every 1200 milliliters of spray about 100 liters of water is used. Electric sprayers are nowadays very common in Pakistan's agriculture system. Variety of Electric sprayers are available in the market, these sprayers are battery operated and are used for direct application of spray on the fields. Conventional spraying is not much accurate it produces only 70 percent accuracy, which result in low yields of crops. In conventional farming, minimum 1.5 hour is required for a single and well-trained man to spray an acre of crop. The direct application of pesticides on crops can get the plants under stress condition. The stress condition stop the growth of the plant for limited time depending upon how toxic is the pesticide. Conventional method is not an economical method as labor is required for the task to accomplish. Nowadays people charge 500 PKR for spraying a single acre.

4.1.1.2 Using AGRIBOT

AGRIBOT usage can reduce the amount of pesticides consumption by 90 percent. In testing phase, only 200 milliliters of pesticides were used per acre as compared to 1200 milliliters per acre in conventional method. Similar, is the case with the consumption of water 10 liters per acre is required as compared to 100 liters per acre required in conventional farming. Using AGRIBOT we can achiever 90 percent accuracy in pesticide spraying due to its state of the art ability of detection of weeds and precision spraying. It surely require more time than conventional farming technique but is more accurate and reliable and there is no need of labor for this job. As, the pesticides are only sprayed on the weeds not on the plants so, there is no concept of crop stress condition. The crop will continue its state of growth or fruiting so, there will be no hindrance in the growth of the plant while AGRIBOT is spraying the pesticides. It is very economical way of spraying pesticides as the amount of the pesticide consumed is low and there is no labor involved so, automatically the spraying cost of single acre is lower as compared to the cost of spraying in conventional farming. More yields are expected using AGRIBOT as compared to conventional farming. Table 4.1 shows the data in tabular form.

Table 4.1 Conventional method vs AGRIBOT

Benchmarks	Conventional Method	Using AGRIBOT
Spray Consumption	1200 ml / acre	200 ml / acre
Water Consumption	100 L / acre	10 L / acre
Accuracy	70 %	90 %
Time	1.5 hour / acre	3 hours / acre
Manpower Required	Yes	No
Crop Stress	Yes	No
Economical Method	No	Yes
Yield	Regular Yield	20 % more yield

4.2 Future Work

In future, using these very techniques we would be able to process all crops. We can also use different pesticides for different kind of weeds found in the crop. This system can be modified and can be converted to an autonomous farming robot, which includes watering, seeding, ploughing, fruit picking and self-spraying model. We can say that, in future tunnel farming will be fully automated if these very modules are added to the system by making changes in the hardware systems and the chassis of the robot. Moreover by replacing the driving motors with high torque motors and replacing simple wheels with larger heavy Agribot will be able to operate in the fields on any type of terrain.

4.2.1 Autonomous Robot

AGRIBOT is primarily a RC vehicle, which is being controlled using Bluetooth module and Arduino Uno. In future, we will be going to upgrade the RC vehicle to autonomous vehicle, for this approach, we will be using another set of camera and raspberry pi for detection of the lines in the fields and for making own decisions using deep learning algorithm's for moving left or right [16].

4.2.2 Weed based spraying system

In current state, only a single spray tank is used and single spray is being used for all types of weeds. In future, for every type of weed dedicated spray is sprayed using different tanks and spray pumps for dedicated weed type. In this method, every weed would be sprayed only with specific pesticide [17].

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