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**Gardner**

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**Date: August, 2022**

# Disclaimer

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# Chapter 1

## Abstract

Agriculture in Palestine was and still is one of the most important sources of income and growth in the Palestinian community. From people growing up as farmers to them teaching their children how to carry on their farming job saying that Agriculture is just a small field in Palestine would be considered a huge understatement.

Our project capitalizes on that field in order for it to flourish. Gardner is a robot that traverses all the crops in a green house and taking pictures of each of them and using image processing and object detection to find out whether the crops is ripe or not. It will also collect data about the water and temperature that surrounds the crop and give a log of data about all the information it got. with the feature to also water the crop using a small hose that is connected to a tank on top of the robot.

# **Chapter 2**

## **Introduction**

### **2.1 Background**

With communities getting more and more advanced and more people tending to work in companies or office jobs the agriculture field in Palestine took a huge blow. And with every day that passing by the problem will increase and grow more concerning. The reason for that is because people tend to see farming as an old profession that is only for old people that grew up with it and the future is in other fields.

### **2.2 Problem**

The main problem that faces automation in the Agriculture field is that people tend to not trust machines that much believing that no one can care or make the crop grow as efficient as a human can which on first glance can be true. but with technologies becoming more and more advanced then we can at least use machines to maintain crops instead of picking them and at the same time have the farmer be the one responsible for picking them and making sure which crops is good and which is bad that way we can have an integration between the farmer`s work and the machine`s work.

### **2.3 Objective**

No matter the way you see it automation in the field of farming is inevitable. Our project works on taking care of the crops on behalf of the farmer. and at the same still giving him the feeling that his job isn't taken by a machine

# **Chapter 3**

## **Constraints and Earlier Coursework**

### **3.1.1 Accurate Object Detection**

A huge part of our project is having the ability to detect a certain fruit and being able to detect its type and whether its ripe or not. the speed isn't much important in our project as much as we care about the accuracy so some delay wont have any harm on the overall goal of the project.

### **3.1.2 Data set for the Fruit**

In order for the object detection to work properly we needed a huge set of data for each fruit that we want to detect which is harder than it looks. Each picture in the data set has to be high resolution for the training to be as efficient as possible. not to mention we need different angles and conditions for the object to help the model detect it no matter the condition or angle its in.

### **3.1.3 Robot Movement**

If we want the project to move from one crop to another we cant have a power cable connected to it all the time so to fix that we should have the robot work on batteries connect to the back of it which will work as a power supply for it with the ability to recharge the battery on demand



## 3.2 Earlier Coursework

- **Electrical Circuits:**

This course helped us develop the skills we needed in our ability to analyze and understand different type of circuits we worked with resistors and lot of important component in this course which we each used in order to bring our idea into life

- **Digital Image Processing:**

This course was greatly useful for us in terms of understanding how what is an image and how we can do different types of operations on it. All of this played a huge role in our object detection in our project

- **Digital Circuit Design:**

A vast amount of techniques that we learned in this course was used in our project whether its debouncing that we used in our push buttons or the ASM(algorithmic state machine) which we used in our project more than one time.

- **Wireless Communication:**

With our project having the need to send data from Bluetooth to Arduino and vice versa the wireless course helped us understand the protocols and the processes that we should do in order to establish a well and functional wireless connection between different types of hardware parts in our project.

- **Critical Thinking:**

This course helped learn the skills and the applications that we need in order to prepare and create the paper that you are reading at the moment and gave us a good understanding on how a professional and scientific paper should look like

# Chapter 4

## Literature Review

Our project goal is to make the process of monitoring the plants and overall farming much easier for the trained or new farmers.that's why our project provides multiple features that help with that:

- 1-the ability to traverse a green house and check on the plants that are planted there.
- 2-Send data to the farmer with the readings and the information that it gathered
- 3-Water the plants that are found dehydrated.
- 4-Refill the water tank that is connected to it by having a separate movable water station.
- 5-The ability to remember the last location it was in before it went to refill the water in order to continue the process from the place it left

It might take time for our project to be able to enter the market and for people to accept the fact the robots can be a great help for them in their lives but with time our project can be a huge leap in the fields of farming and agriculture .

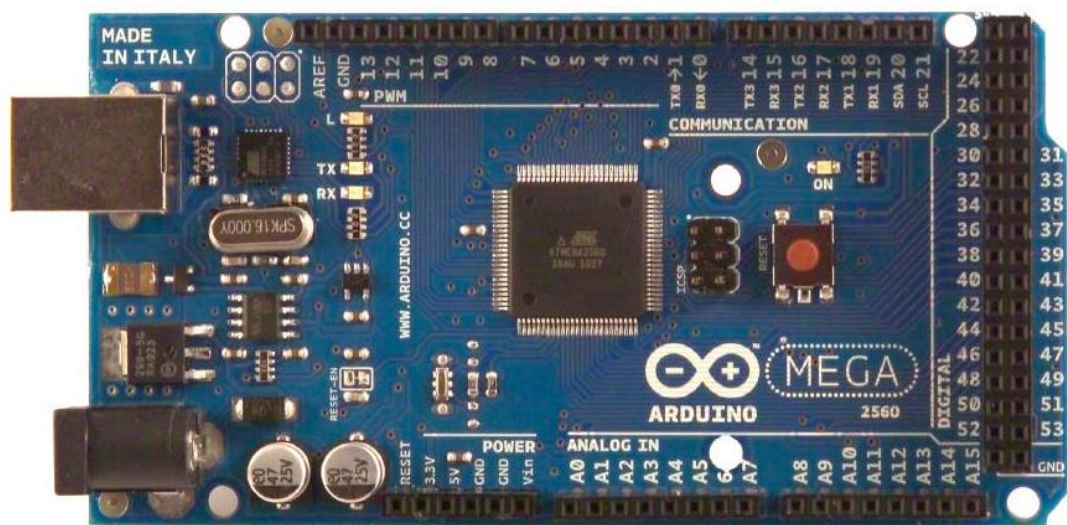
# Chapter 5

## Methodology

### 5.1 Equipment and Components

#### 5.1.1 Arduino Mega

One of the most important components of our project the Arduino is a micro-controller board based on the ATmega2560. It has 54 digital input/output pins, 16 analog inputs, 4 UARTs, It contains everything needed to support the micro-controller



It was used in our project to connect the drivers and motors together and give the robot the logic it needed to move around different crops. We also connected it to the Raspberry Pi 3 so that whenever the robot detects an RFID card the Arduino sends a command to the Raspberry Pi which initiates the object detection process.



### 5.1.3 RFID Sensor

The RFID reader is a network-connected device that can be portable or permanently attached. It uses radio waves to transmit signals that activate the tag. Once activated, the tag sends a wave back to the antenna, where it is translated into data. We put the RFID tags inside the plant pot so that whenever the sensor reaches it the robot will stop and take a picture of the plant making it easier for us to know when the robot came across a plant



### 5.1.4 OAK Camera

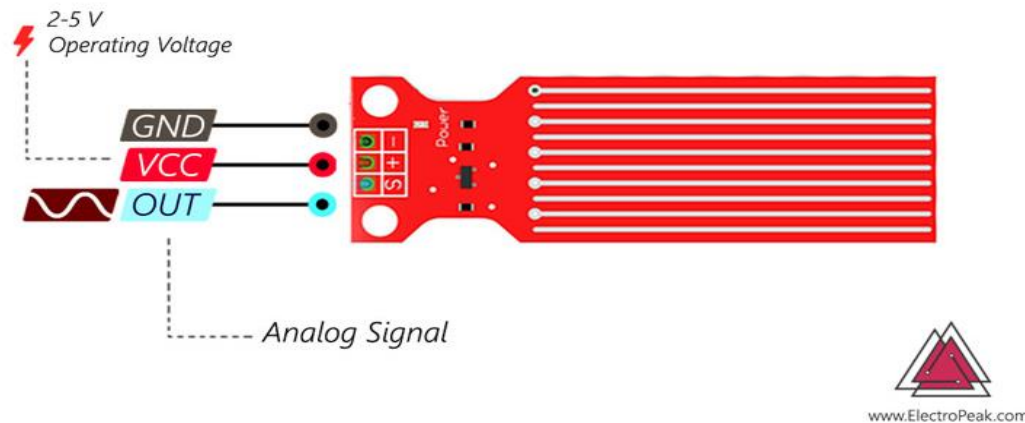
OAK Camera is a spatial AI powerhouse, capable of simultaneously running advanced neural networks which can be a huge help in the process of object detection unfortunately we had to use it as a plain camera since we left the job of image processing to the raspberry pi





### 5.1.5 Water Sensor

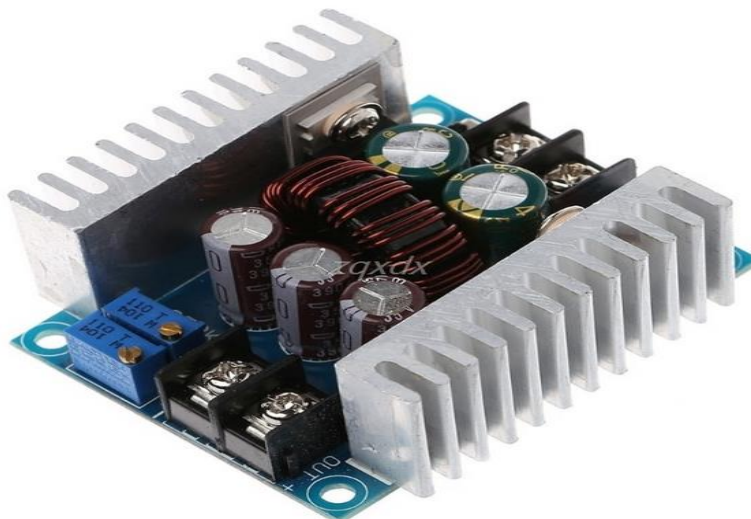
We used the water sensor to detect the percentage of water that surrounds the plant in order to give more data that the farmer can use. It simply detects water then. When Wi-Fi is enabled, the sensor can send out a notification to the farmer through a smartphone app.



We connected the sensor to the Arduino in order for it to get power from it and send the analog signal to it.

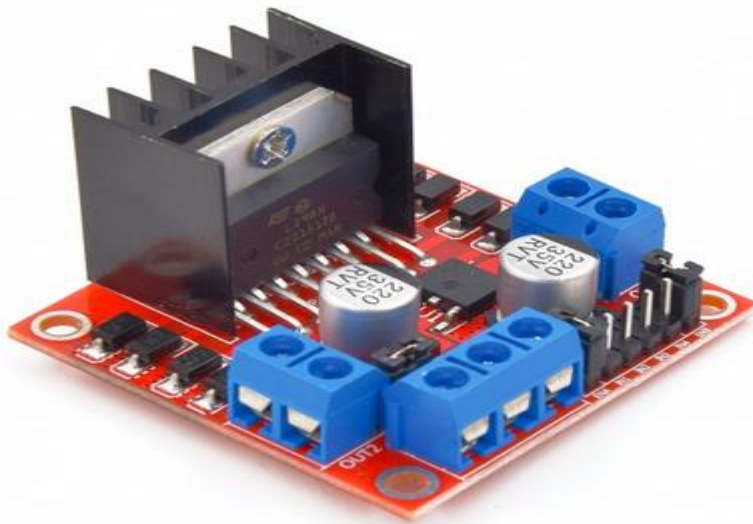
### 5.1.6 Adjustable 1.2-36V DC/DC - 300W Buck Converter

In our project we said that we want to add a power supply that will remove the need to use a cable to power our project but we want a stable 5V for the components that we have to work. To do that we added the buck which will convert the 11V that we get from the batteries into 5V which will allow our project to function properly.



### 5.1.7 L298N

The L298N is a dual H-Bridge motor driver which allows speed and direction control of two DC motors at the same time



We used two of the L298N in order to control all four of our DC motors which will be used to drive the robot around

### 5.1.8 JGA25-370 DC Motor

The driving power of our project when connected with the L298N driver we can control the movement of the robot. each one of the four motors was connected to a wheel that allows the robot to move smoothly



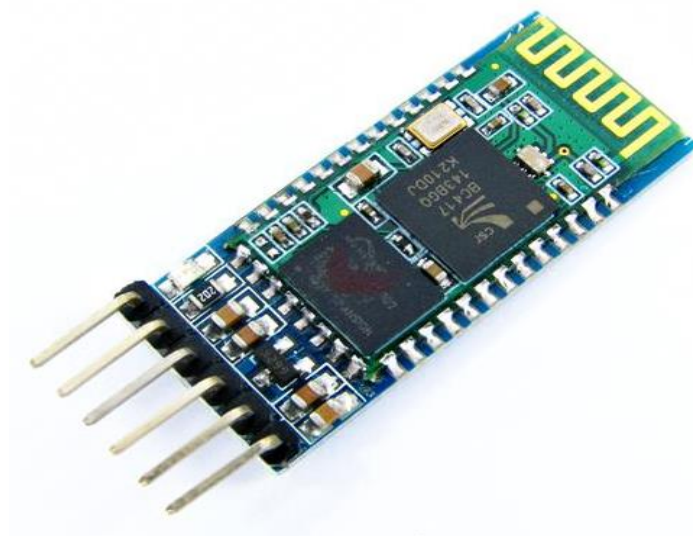
### 5.1.9 Line Sensor fc-123

ideal for detecting white/black lines which we will be using in our project this component uses IR to detect whenever a black line is present in front of the robot



### 5.1.10 Bluetooth Module HC-05

HC-05 is a Bluetooth module which is designed for wireless communication. This module can be used in a master or slave configuration. It has a range up to <100m and uses serial communication to communicate with devices' serial port.





### 5.1.11 Small water pump

Connected to our tank with a hose so that the robot can water the plants on demand.



### 5.1.12 Rotoliner Actuator

A metal rod connected that extends forward on command.



We used this as a extendable hand where we added the water sensor in front of it so it can get closer to the plant and get accurate readings.

### 5.1.13 Single Cell Lithium-ion Batteries

Arguably our main source of power in our project. We used six of these (3 on the back and 3 on the front) in order to power our drivers, motors and most of the component that we mentioned before.



We connected 3 batteries inside a battery case the we glued on top of the body of the robot.



#### **5.1.14 Micro Switch**

Used in our watering station this switch is used to notify the station that the robot just arrived at it which then starts the process of opening the valve and filling the tank again



#### **5.1.15 Micro Solenoid Valve**

Connected to our switch in the watering station this valve is used to allow the water to move from the tank in the station to the tank inside of the robot



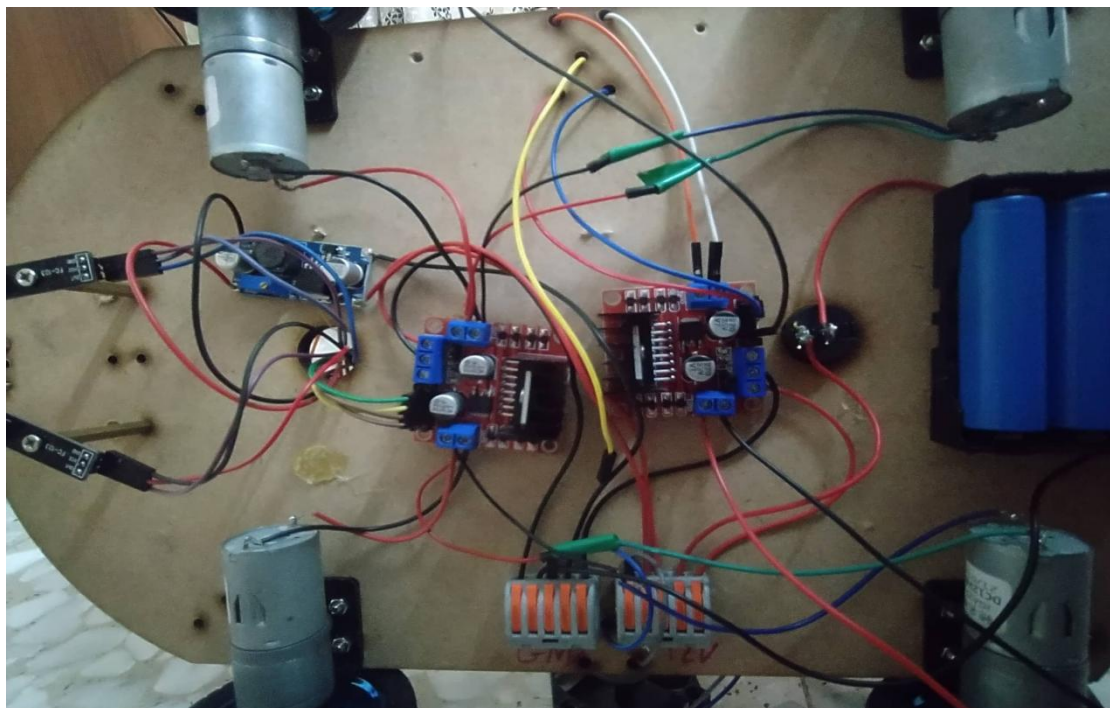
## 5.2 Components Implementation

Having the components is just a fraction of the work needed now we had to test each component independently and make sure that they all work as intended which needed a lot of experience and trail and error for it to eventually work then we were able to start implementing them in our project.

### 5.2.1 Motors , Drivers and Line Sensors

As stated above each driver has to control two motors.the drivers take an input logic of 5V and outputs a logic of 12V that it send to the motors that are connected to it.There is a lot a speed pin which is used to control the analog speed of the drivers however we didn't use this pin because we figured that the speed was good enough for now.Each motor has a gear that enables it to move on dirt in case the crop was planted on rough terrain.we also need to mention that each one of the motors is connected to a tier which can also handle moving on rough terrain.

After connecting both of the drivers to the motors we also connect the drivers to the Arduino in order to receive the logic that we need to move the robot.The logic of movement will mostly come from the Line Sensors where they will give signal when the color black is detected and no signal if any other color is present.



from the previous picture we can see all connection between different types of component. the drivers connected to the motor and the Arduino that is present on the back of the robot, the line sensor also connected to the Arduino to give it the logic it needs in order to move and finally the power supply that is used to power all of these components

### **5.2.2 The Power Supply**

At the beginning of this report we said that the robot can have a cable to power it since that would be impractical so to avoid this conundrum we decided to create our own power supply which can solve this problem.

We used 6 Single Cell Lithium-ion Batteries where each one gave us an output voltage of 3.7V knowing that the battery case can fit 3 of each we can calculate that about 11V coming out of each one of these battery cases.

But most of our components work on 5V and giving them above the required threshold would damage if not burn the circuits inside them. This is when the Buck Converter comes into work with two rotatable screws on the side that we can use in order to change the value of output that the buck gives.

### **5.2.3 Other Components**

Most of the other components consist of other sensors and the Bluetooth Module which we simply connected to the Arduino in order to send and receive that data.

### **5.3 Raspberry Pi Connection and Implementation**

The Raspberry Pi was directly connected to both the Arduino and the OAK camera on boot a script inside the Raspberry Pi will execute which will wait for the command that activates the image processing which will come from the Arduino the moment the RFID sensor reaches and RFID card which will be located inside of the pot that the plant is in.

After passing by a plant a script will run forcing the camera to take an image of the plant then the object detection process will commence which will take the image and start the process on it.

After the process is finished the output of the object detection will be send to the Arduino which will after that send it to the user/farmer using the Bluetooth module that is connected to it.

### **5.4 Watering And Water Refilling**

Not only does our system check for crops status but it also makes sure to keep it as good as possible that's why inside the robot we added a water bottle that works as a water tank .with a hoes attached to it whenever the robot stops at an RFID tag it extends its arm towards the plant and checks the water level if the water level is found to be enough the bump wont run and the plant wont be watered but if the water level was low the robot will water the plant using the mentioned hoes earlier.

If at anytime the water tank is emptied due to multiple watering actions a sensor inside the tank will notify the robot and start a course where it will ignore all the plants in front of it and go straight to the watering station where it will refill its water when it hits a switch that sends a signal to a valve attached to the station which is attached to tank full of water .

After the process of filling the water the robot can go back to the point it left from so if it examined three plants before it will simply ignore these three plants and go back to the point it ran out of water and continue its job from there.

## 5.5 Object Detection

We mainly used YoloV5 for our object detection which stands for You only look once. This is an object detection algorithm which is famous for its speed and accuracy. It uses a set of pretrained weights which are saved in a specific path which it uses to make a prediction on the desired image.

The prediction is made using conventional neural network (CNN) that detects objects in real-time with great accuracy. This approach uses a single neural network to process the entire picture, then separates it into parts and predicts bounding boxes and probabilities for each component. These bounding boxes are weighted by the expected probability hence the name “you only look once”.

### Why YoloV5?

There are multiple versions for Yolo spanning from 1-5 but we choose YoloV5 for multiple reasons these being

- It is about 88% smaller than YOLOv4
- It is about 180% faster than YOLOv4
- It is roughly as accurate as YOLOv4 on the same task

### Training process:

Since we decided to use YoloV5 we now need to train our own model of data and then extract the weights in order to use them to predict the type of object that we want in our project.

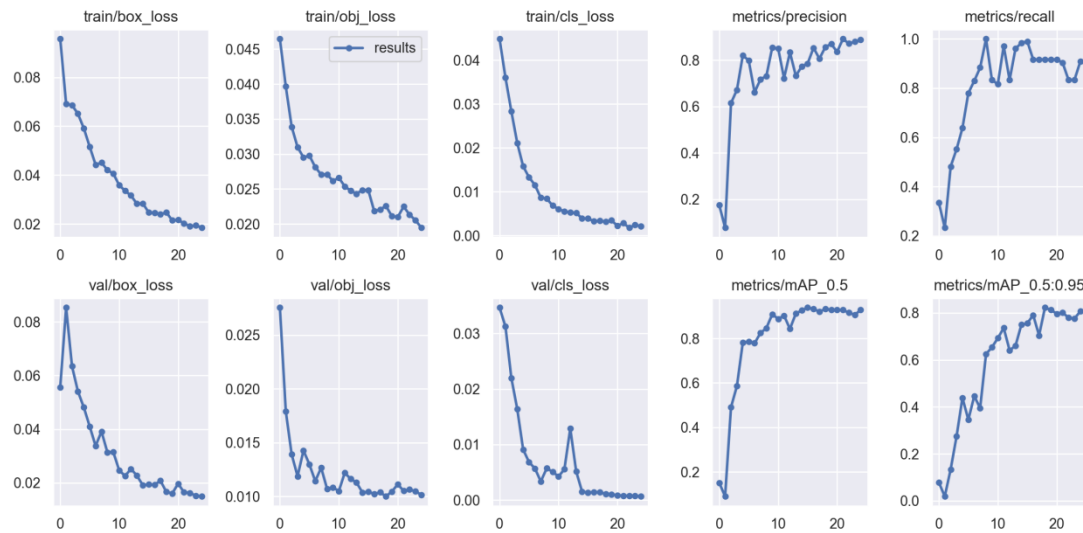
The most important element that we need is a good data set which is easier said than done. Each image needs to be clear, high res and we should have multiple angles on each object that we want our model to learn.

After having our set of images we need to label our images so that the train class can understand what object the image has and the position the object in the image is.

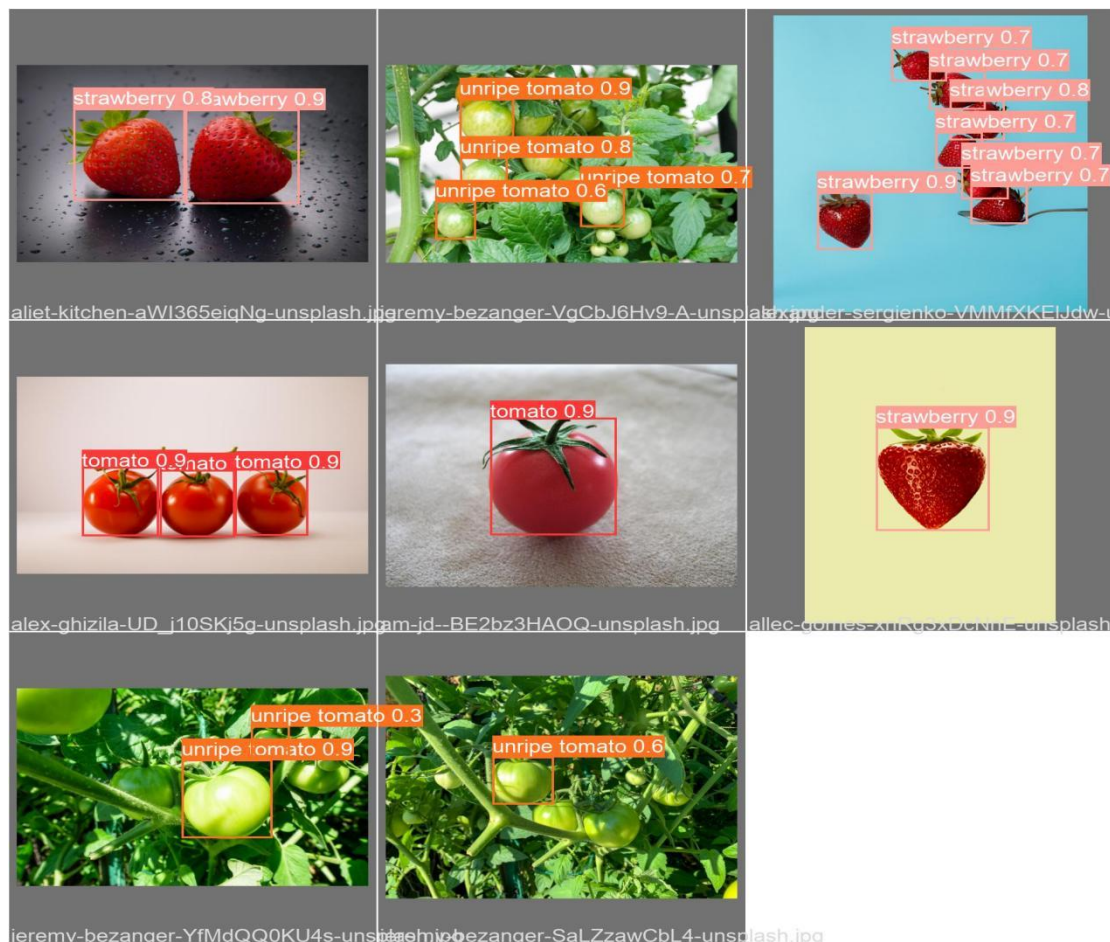
After doing that we will have an XML file containing the data that the YoloV5 needs to train our model



Following our training process we can see our model accuracy and loos using the graphs that are provided inside our YoloV5 folder.



We can also have a prediction on some sample data that we provide for our class.





# Chapter 6

## Results & Discussion

In the end we can say that we made a project that provides multiple features that can help farmers every where with their job.these features being:

- The ability to traverse to different types of plant without the need for a cable or an external power source.
- The ability to identify different types of fruit and whether they are ripe or unripe
- Give readings about the surroundings of the plant and the condition its in
- Water the plant on demand and make sure that the environment is well hydrated
- Send all these data serially to the farmer so that he can use it later

# Chapter 7

## Conclusion & Future Work

### **7.1 Conclusion:**

### **7.2 Future Work:**

Our project even though is working on a small scale right now it can easily work on a more wide and bigger scale. we can have multiple units working on a farm each going on its own lane. Not to forget that the object detection model can easily learn new types of fruit with only needing to add extra images of that fruit to the dataset that we had .

We can also integrate it with a green house environment where the green house will change its state according to the data that it receives from the robots whether it's a change in the temperature or the humidity the gathered data will have a huge contribution to the overall growth of the plants.

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- <https://www.raspberrypi.com/documentation/computers/raspberry-pi.html> (raspberry pi Documentation)
- <https://docs.arduino.cc/hardware/mega-2560> (Arduino Documentation)
- <https://docs.luxonis.com/projects/hardware/en/latest/pages/BW1098OAK.html>( OAK Camera Documentation)
- <https://github.com/ultralytics/yolov5> (YoloV5 GitHub repository )