

**IoT Data Analytics for Operational Status Tracking in The Agriculture  
Field**

BY  
YONG YU HONG

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**Address:**

\_\_No 6, Jalan Tasik Indah 7\_\_

\_\_Taman Tasik Indah\_\_

\_\_51200 Kuala Lumpur\_\_

\_\_Ts Dr Ooi Boon Yaik\_\_

Supervisor's name

**Date:** \_\_24/4/2023\_\_

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## **ABSTRACT**

The research and development of a sustainable, effective, and productive plant growth monitoring system is a key factor that is concerned by the whole agriculture industry. The demand for getting more enhanced systems is a continuous activity in the whole development process and is different based on the different types of planting methods. As in hydroponics, it has several parameters that would decide whether the planting process would provide a better harvest compared to others such as water level, light, water nutrient, etc. And with a successful arrangement of these parameters, there are also several ways to measure the growth rate of a plant like weight, height, and leaf colour. So, the problem is how to build a system that can capture and record any abnormal situation that happened in order to get a great monitoring system. Many monitoring systems already occur in the market or proposed in a paper, but nothing is perfect, there are also contain some issues in these existing systems like the cost, the accuracy, or even the universality and the biggest issue is the market is still lack of datasets for the research and statistic used in this field. To solve these problems and limitations, this present system would propose a plant growth monitoring system that applies the Raspberry Pi camera to provide a plant growth dataset that is uncommon and difficult to find in the market. After fulfilling and completing the development of the whole system, it can be expected to provide a monitoring system that can monitor the daily operation of the system and also import the growth rate data to create a demanded dataset.

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## LIST OF ABBREVIATIONS

<i>IoT</i>	Internet of Things
<i>IR</i>	Infrared technology
<i>RTC</i>	Real time clock

# CHAPTER 1

## Introduction

### 1.1 Background information

Agriculture is an activity that involved and cannot be overlook in the whole human's history, and the way of operating this work is getting more advanced, easier, and convenient due to the technology is develop and evolve rapidly nowadays. Go through the whole planting process, crop growing management is a significant part that require a lot of effort to research, discuss and enhance it.

Similar with the concept of “industry 4.0” evolution, there is also a term “agriculture 4.0” which refers to the upcoming major changes that will affect the field, such as a greater emphasis on precision agriculture, the internet of things (IoT), and the use of big data to boost operational efficiency in the face of population growth and climate change. The procedure of evolution in agricultural field is follow by 1.0 – labors operate manually with some simple tools, 2.0 – labors operate by machinery, 3.0 – the start of implement and deploy the robot for the operation, and the last and current 4.0 – the start of implement the smart system to transform the farm to smart farm by the technology emphasis above.

Growth rate is a significant data that would be interested to be collect and analysis under agriculture 4.0, and to evaluate and verify the plant growth rate, the different proposed systems would apply different parameters such as weight, height, leaf size, leaf colour, etc. These parameters can be used to identify the growth rate because within the plant growing process, parameters would change respectively by a different stage of the growing process as stated in [1] which are seed, sprout, vegetative, buddling, flowering and ripening these 6 stages. And these parameters can be collected by many types of IoT devices for humans to research and identify a better solution for the plant monitoring system.

### **1.2 Problem Statement and Motivation**

Nowadays, the technology that can apply to the agriculture field and process was mature enough and fully developed in the market. But currently, there are lack of software or method that can collect the data during the whole crop growing process by hydroponic method in Malaysia. Those data are significant for the researcher, company and organization who are willing and intend to invest, in research, and analysis the better way to manage the crop growing process.

The aim of the project is to propose and develop an application and a method to collect the crop growing data and monitor the growing process by apply such technic like image processing and database storage to provide a hydroponic plant growth dataset which is rare and hard to found in the market.

### **1.3 Project Objectives**

This project would focus on the develop a solution to collect the crop growing data with image processing and internet of thing (IoT) technologies. After that, analyze the collected data to gain valuable insights into the crop growing process.

And the final objective of this project is to create an advanced hydroponic system that includes a robot arm with a Raspberry Pi camera attached. A distinct QR code label will be attached to each crop in the system, serving as a point of reference for measuring crop height and width.

The current present methodology for this system would mounting the camera in a fixed position to capture images and developing a program that utilizes the QR code as a reference point to extract the necessary data from the captured images.

### **1.4 Project Scope**

In the planning, I would like to propose and develop a program that are able to collect the hydroponics crop growing data by using a well working hydroponic system and used it to monitor the growing process using techniques such as image processing, internet of thing (IoT) to provide a plant growth dataset that is uncommon and difficult to find in the market.

### **1.5 Impact, significance, and contribution**

Agriculture development is a significant and sustainable activity all over the world, especially in Malaysia. It is astonishing that in Malaysia, the development and evolution of the agriculture field are still in progress 1.5 according to the speech of Mr Wong Seng Yee, an expert in the smart agricultural area. So, this project would help to give some insight to the farm owner to be aware of the important of smart agriculture about how it would benefit their business to become more profitable and reliable, and also provide a developed solution to them.



## CHAPTER 2

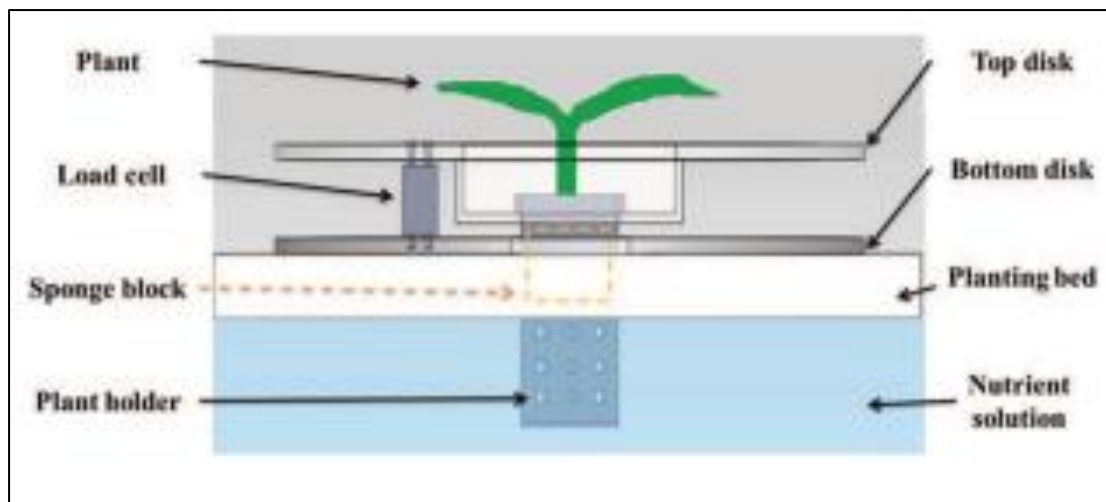
### Literature Reviews

#### 2.1 Previous works on collect and measure the plant growth rate.

##### 2.1.1 An Automated and Continuous Plant Weight Measurement System

[2] proposed a research paper that implements an automated and continuous weight measurement system in order to overcome the problem of the traditional weight measurement method which is required labour to take the growing plants out and measure them manually by an electronic balance. The problem is through this method, it cost the suffer to hire labour to do the simple and tedious work, and also the process is destructive for the plants.

There are many automated plant weight measurement systems have been developed before [2]. However, they are still having some problems exit and require solving for letting the system can perform well generally and without any restrictions. For example, the instrument built by [3] has the limitations that it is only suitable and can only be applied in the laboratory because it took two electronic balances to measure the weight of one plant. And [4] proposed the system that is only suitable for measuring a group of a plant's weight and not a single plant, [5] has a restriction on a certain type of plant. So, to overcome these issues, [2] provides a solution that show in figure 2.1 which implements the single plant weight measurement system which contains an LDB-2 kg load cell, top and bottom disk, and a plant holder. The strength of this proposed system is it can apply to the real farm environment because of its simple, useful design and also it is suitable for almost all types of plants. One of the advantages of this system is it is made for a single plant measurement system which would help the customer can have better plant growth management.

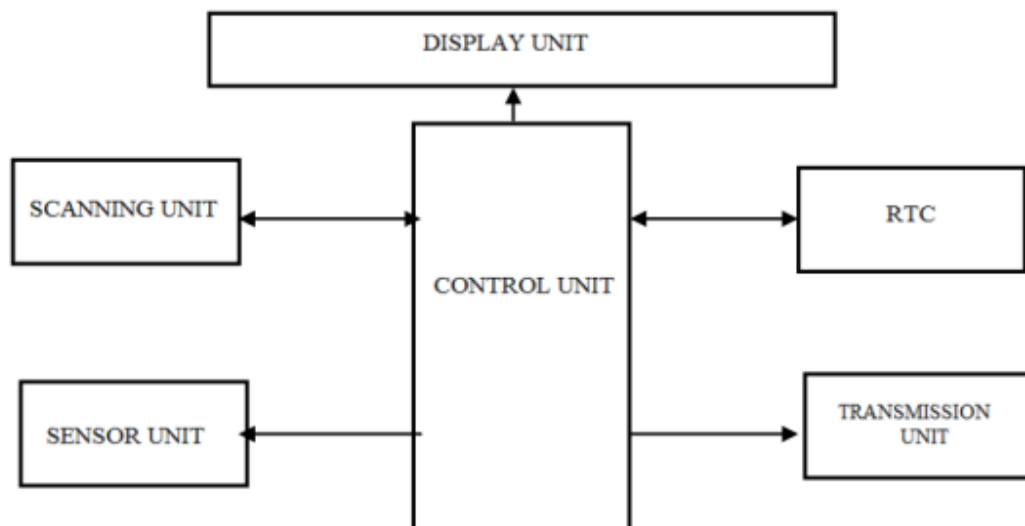


**Figure 2.1: The design of weight measurement instrument**

### 2.1.2 Infrared technology: using IR sensor to measure plant height

[6] proposed a system that use the infrared technic to design and implement a height measurement system. As the demand of a non-contact plant growth monitoring system is getting higher because of to have a non-destructive monitoring process during the whole measurement process. And the problem occurs when trying to apply the visual monitoring method which is by identify any changes happen by a picture or simply human vision and is subject to the human judgement. Human might unable or overlook some tiny changes about the issues of plant or the issues was detected but is too late to solve it.

So, in order to solve this problem, [6] use an infrared sensor to measure the plant height. The overall device will show in figure 2.2 which contain the control unit, scanning unit, real time clock (RTC), display unit, and transmission unit. The main idea and the basic operation are use the scanning sensor to scan the target which is plant by the coordinate mapping. Through this technique, the system can used to collect the plant's height and width data. The strength of this proposed idea is this monitoring system is accurate, cost-effective, and user-friendly.



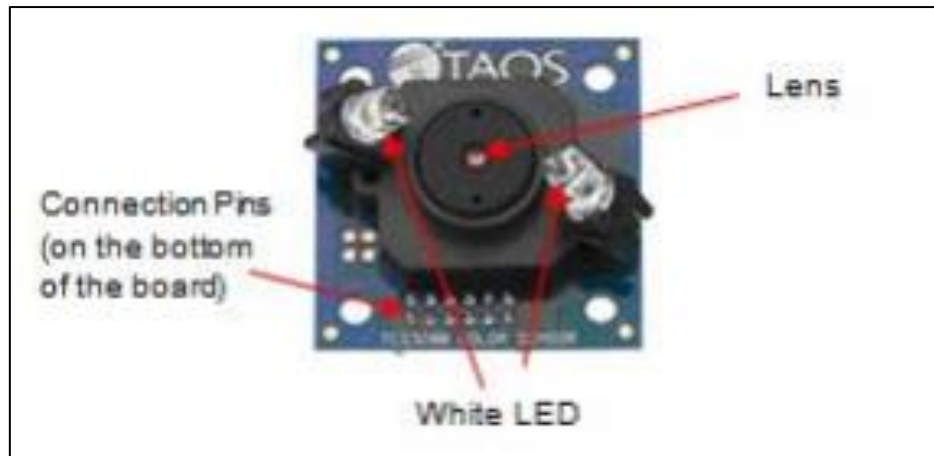
**Figure 2.2: The design of height measurement instrument by IR technology**

### 2.1.3 Parallax TCS3200: Low cost colour sensor

[7] proposed an automated system that measures the plant growth rate by its leaf colour. As in the last few past decades, followed by the enhancement of the performance and the popularity of integrating those robots into industry used for replacing the repetitive tasks done by humans, it is also common and needed to implement robotic techniques into the agriculture field. These robots can be used to help monitor and maintain the growing process of the plants.

There are many ways to build a non-destructive measurement method a different type of parameters such as weight, height, width, root, and leaf is also significant parameter that can be used on it. [7] said that a subtle leaf colour change can be used as a measure of plant health, which also means that leaf colour has potential that can be used to measure the plant growth rate as in different stages of the plant growing process, the leaf colour would change respectively too. This method can provide a different side of the view in the measurement process.

The reason why [7] want to propose this system is that they want to build a new way to measure the plant growth rate which also is non-destructive, automated, and low cost. And the solution they provided in this project is a system that includes the colour sensor (Figure 2.3) and a robotic arm (Figure 2.4) to control the movement of the sensor.



**Figure 2.3: Parallax TCS3200 colour sensor**



**Figure 2.4: The robotic Arm**

#### **2.1.4 Limitation of Previous Studies**

The limitation of the overall previous studies would be show in the table 2.1 below.

For method 2.1.1 which is use weight as the measure parameter method, the reason why it is costly is that to measure every single plant, each plant needs to be assigned an electronic balance which is very expensive to implement in a real-world situation. And this is the reason why its universality is the lowest in these reviews system, but if overlook the cost, the weight would perform well in the measurement process.

For method 2.1.2 which is an infrared height sensor, [6] has stated that it is also quite expensive to implement it although it is cheaper than method 2.1.1. The performance of this method is on average, there is no very outstanding area of this method except for the cost.

For method 2.1.3 which is the colour sensor, the weakness of this method is it is required to implement very close to the plant, the effective detection distance is the smallest compares to other methods. Follow by the incremental distance between the detection target, the measurement error would also become higher. And because this is

a colour sensor, the light also is one of the issues which will affect the accuracy when the sensor is placed in a very bright or very dark environment.

Table 2.1: The limitation of previous studies.

Parameter \ Method	Cost of initial installation	Distance within the target	Universality	Accuracy of the result	Non-destructive
Weight electronic balance	High	Very close (Stick together)	Low	High	Yes
IR height sensor	High	Moderate	Moderate	Moderate	Yes
Colour sensor	Low	Close	High	Low when the distance too far away from the target	Yes

## 2.2 Previous works on the leaf segmentation

### 2.2.1 RGB Colour Channel Variation Based Segmentation of Crop Leaf Lesion

[8] proposed a leaf segmentation solution in order to find a lesion part on a leaf. One of the natural disasters that pose a hazard to crops throughout their growth is the disease. By solving this issue, the most popular method across the world is by applying a large number of pesticides which would harm and pollute the natural environment with its chemical composition. In order to stop the pollution, a precise spraying system is introduced and applied, it can spray the pesticide to only the lesion crops, and to achieve this accuracy of leaf lesion detection, image segmentation would act as a significant component in this system.

[8] is an image segmentation technique that separates lesions using variations in the RGB colour channel between leaves and the area of the lesion. Through the observation of tobacco leaves with brown spot disease, they first examine the intensity aspects of the R, G, and B channels in a colour image and examine their changing patterns in the lesion area. The relationships between these three colour channels are then discovered by the study of change rules, and they draw conclusions about how to segment lesions

using the disparity between the RGB colour channels. Lastly, try using tobacco leaves that have the illness brown spot which is shown in figure 2.5 below.

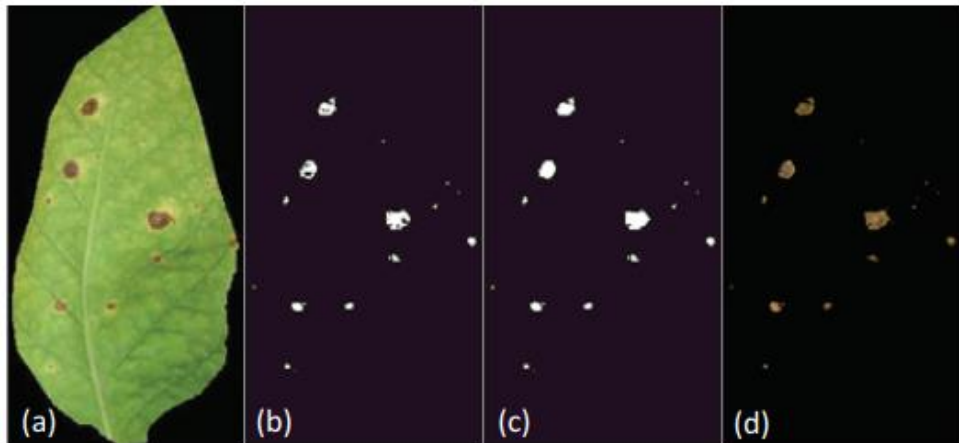


Figure 2.5 Process and result of segmentation: (a) the original image, (b) segmented by union operation, (c) morphological closing and hole filling, (d) final segmentation result

[8] later compare the performance of the proposed solution with other methods such as the threshold value method and k-means clustering algorithm which can also be used to perform segmentation tasks. And the result of comparing these 3 methods shows that [8] gives the solution that has a distinct advantage in the run time compared with k-means clustering, and a better segmentation result compared to the others two methods.

## CHAPTER 3

### System Methodology/Approach

The final goal of this project would be a hydroponic system that have robot arm which a raspberry pi camera attached, and each crop would have its unique QR code label attached in order to be the benchmark of measuring the height and width of the crops.

The current approach of this system is attached the camera statically to capture the image and develop the program that can retrieve the required data from the image captured.

#### 3.1 System Design Diagram

##### 3.1.1 System Architecture Diagram

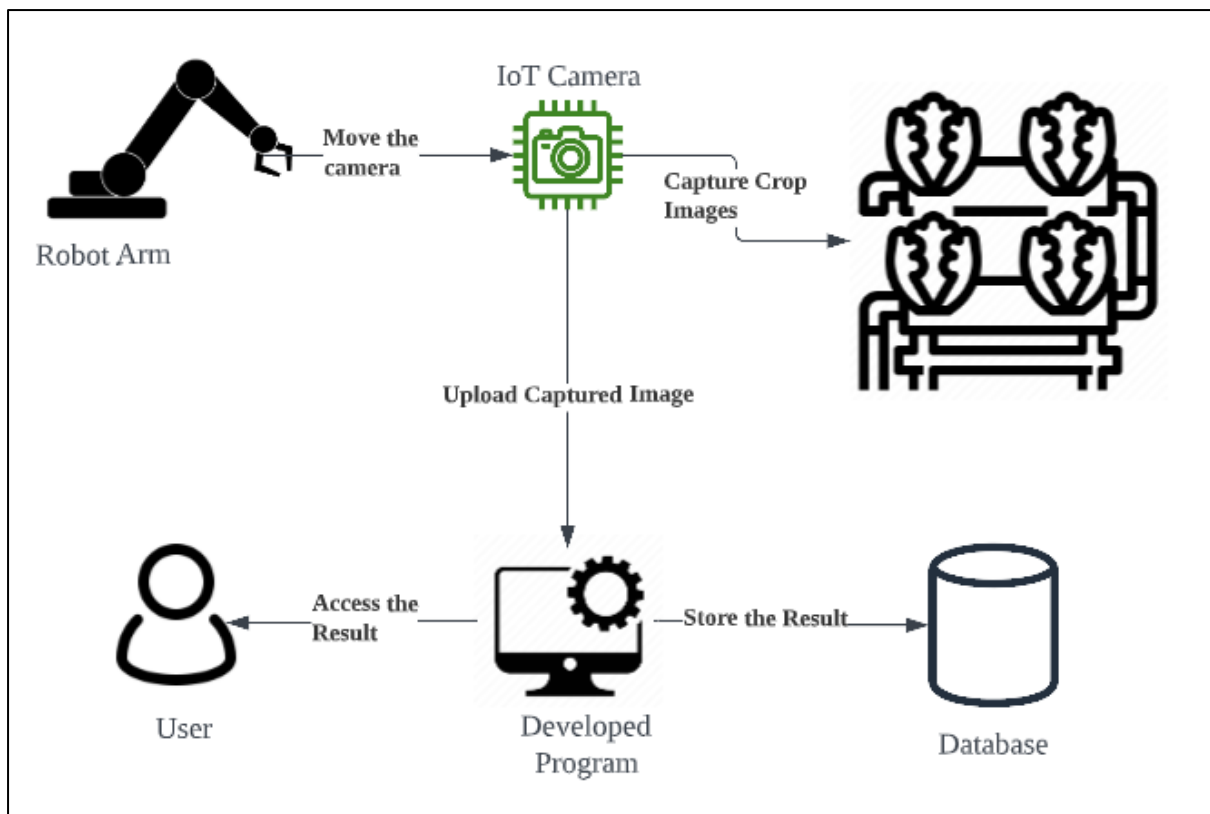


Figure 3.1 Final View of System Architecture Diagram

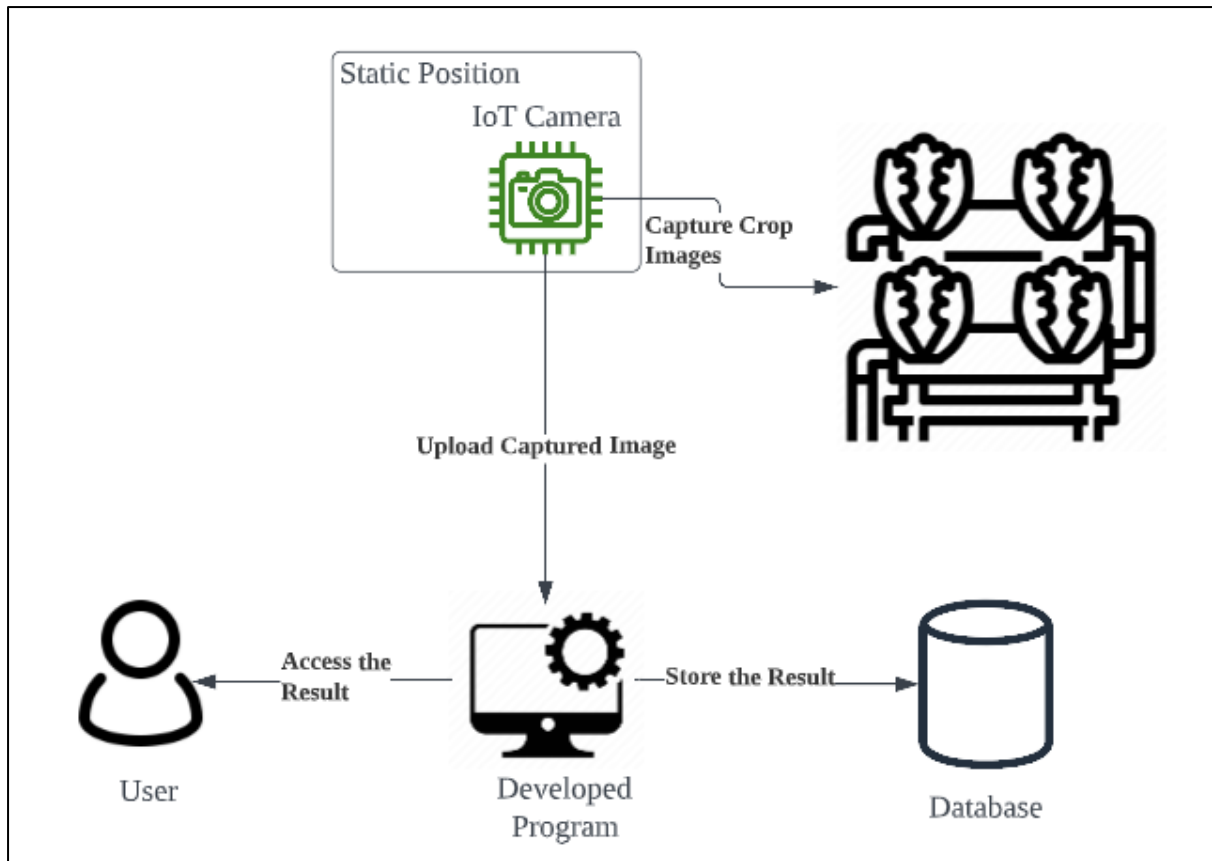


Figure 3.2 Current View of System Architecture Diagram



## 3.1.2 Use Case Diagram and Description

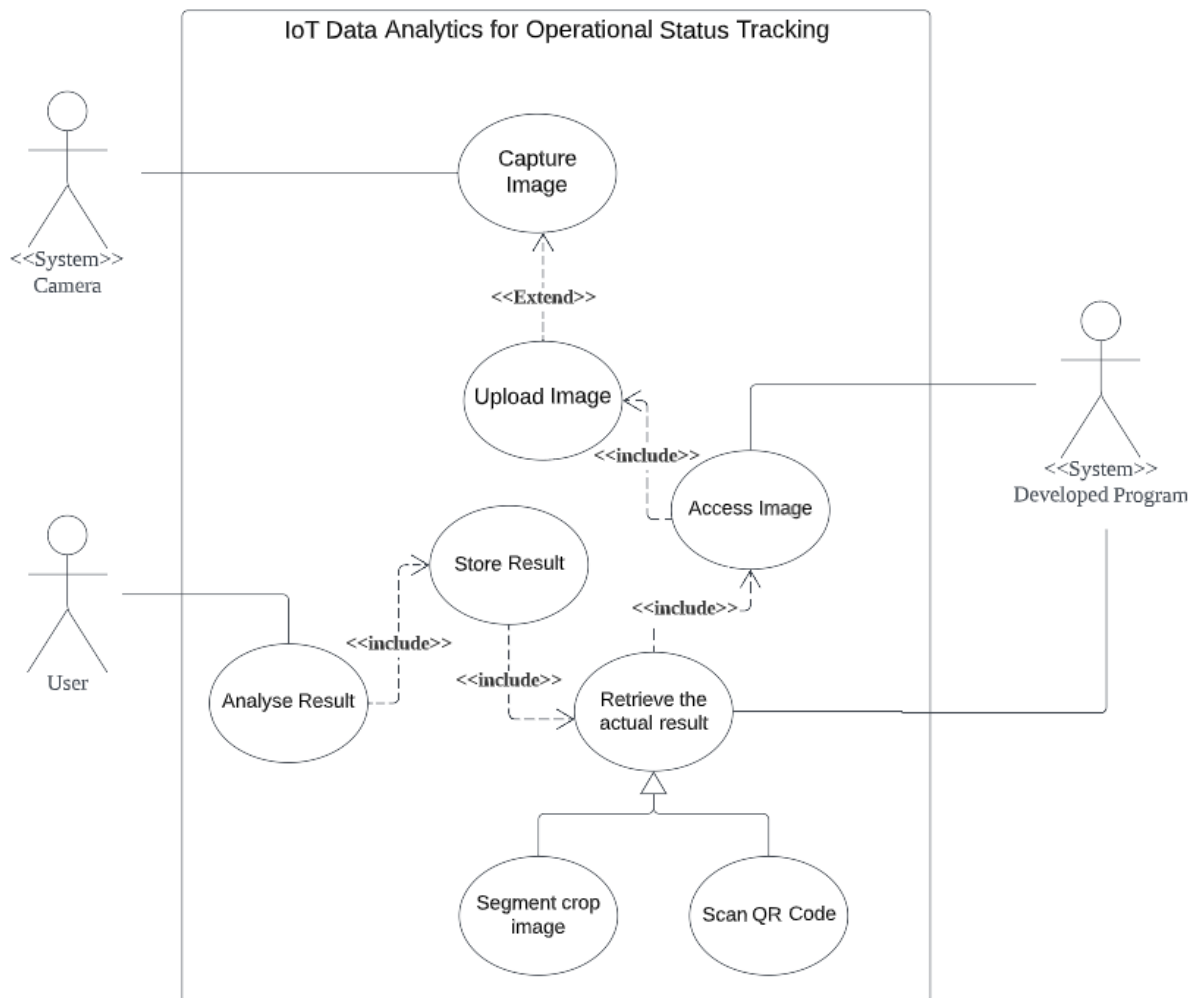


Figure 3.3 Use Case Diagram

Description:

This system will consist of three actors to operate it which are camera, developed program, and user. Camera handles the image capture and upload use case, developed program handle the image processing, data retrieval, and data upload use case, and user handle the data analysis use case.

3.1.3 Activity Diagram

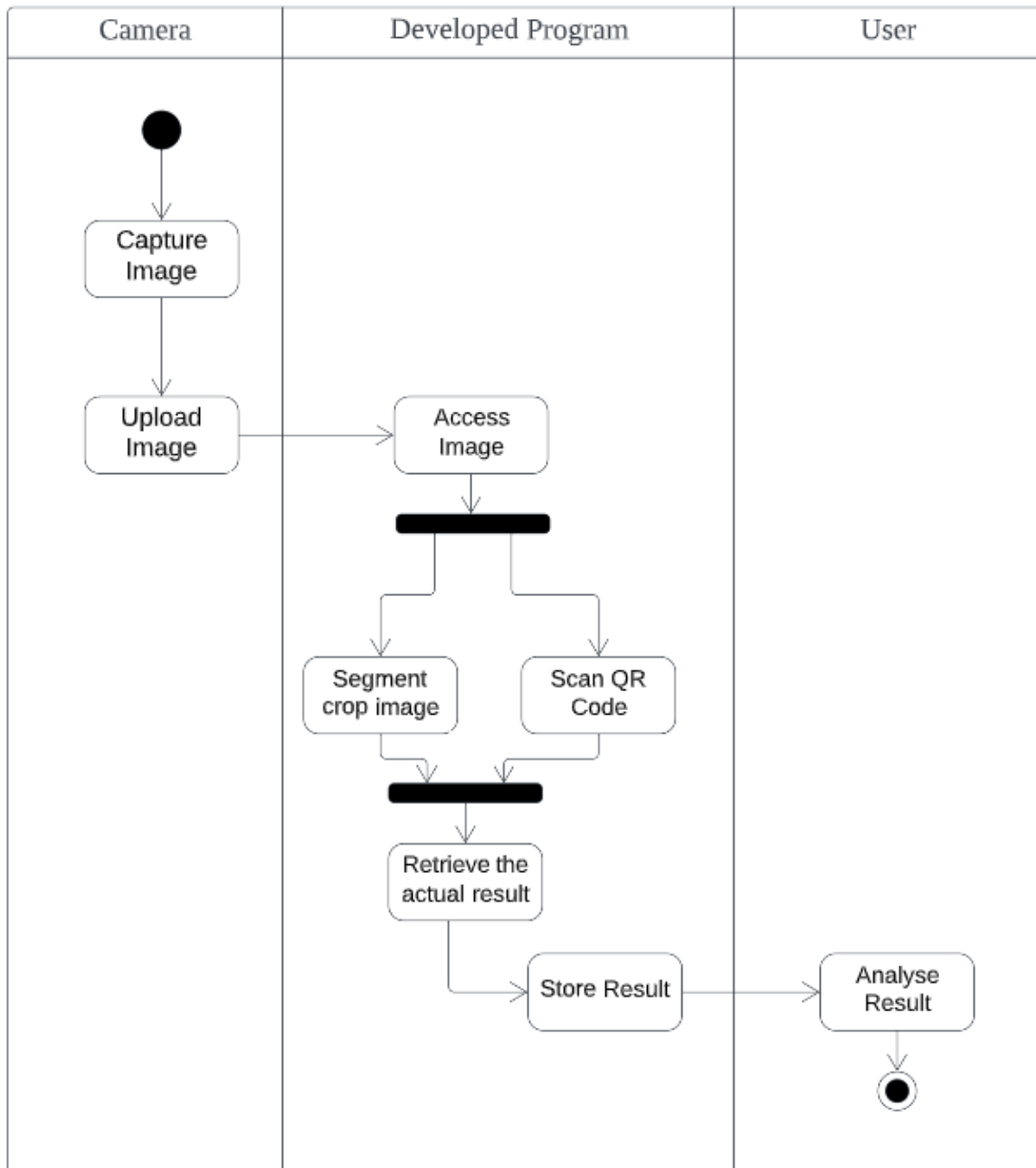


Figure 3.4 Activity Diagram

## CHAPTER 4

### System Design

#### 4.1 System Block Diagram

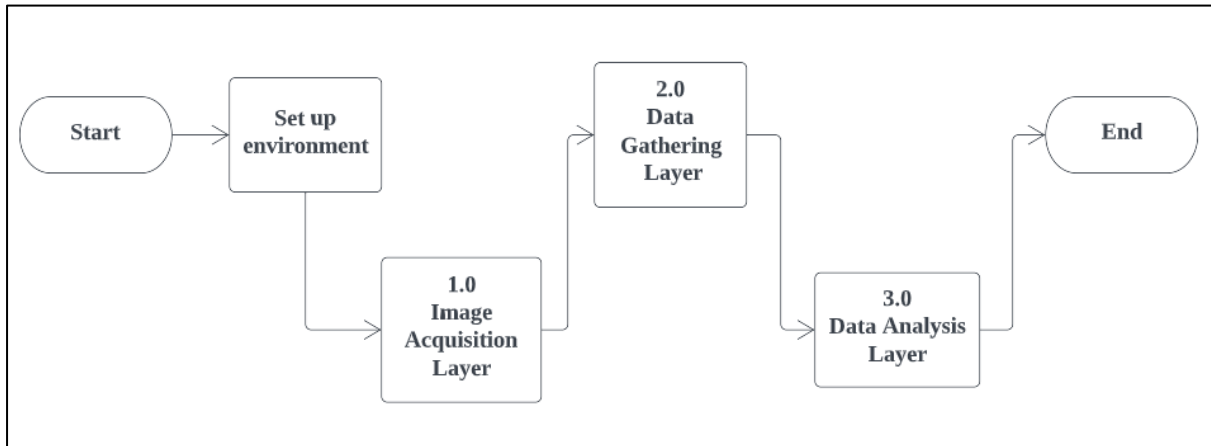


Figure 4.1 System Block Diagram

Figure 3.6 show the lower-level representation of this proposed system. It contains 3 main layer which is image acquisition layer, data gathering layer, and data analysis layer. Details operation flow of each layer would be show below.

#### 4.2 System Components Interaction Operations

##### 4.2.1 Image Acquisition Layer

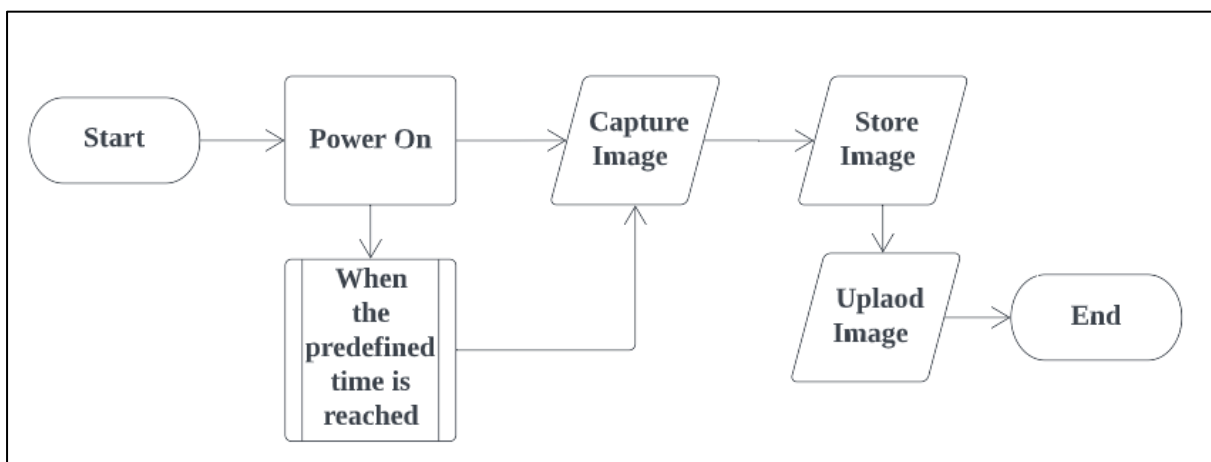


Figure 4.2 Flow Chart of Image Acquisition Layer

Inside the image acquisition layer, when the raspberry pi module is configured and installed, it would start to capture image when power is on or meet the predefined time. The captured image would store locally and upload a backup online.

### 4.2.2 Data Gathering Layer

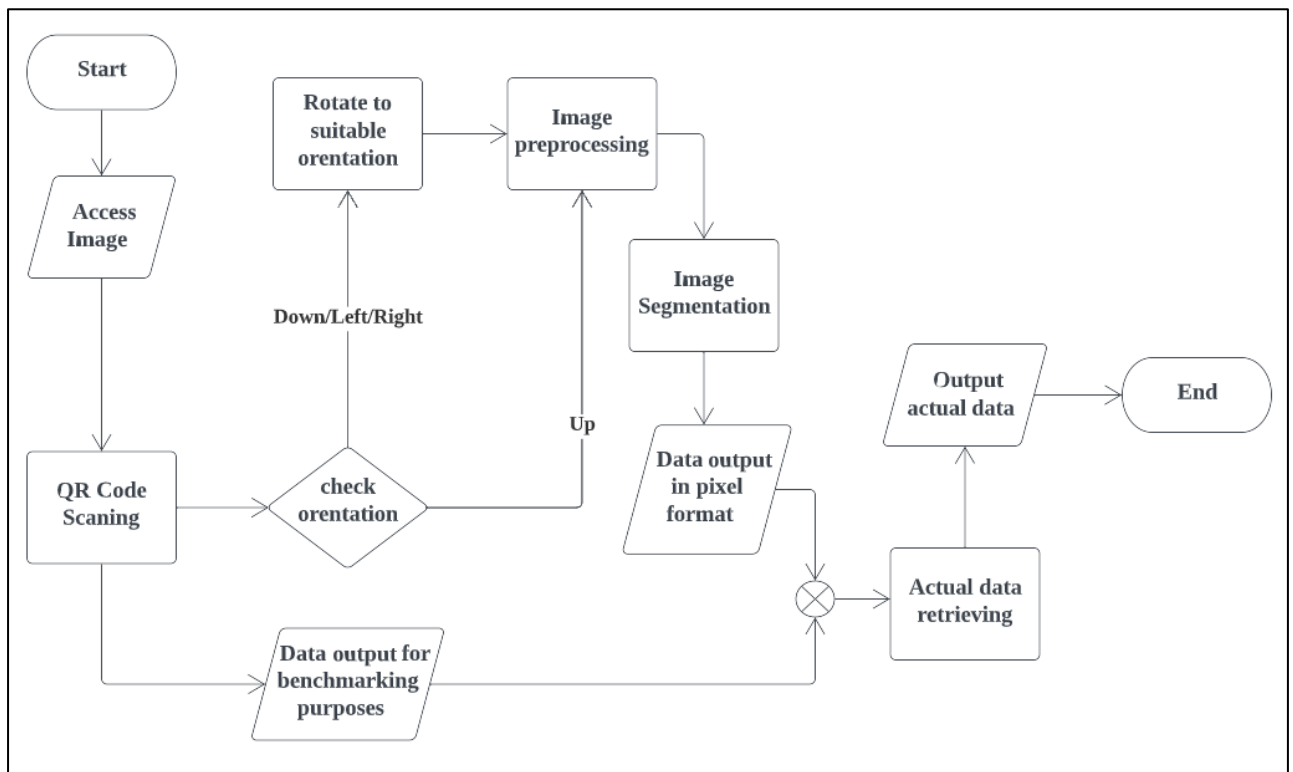


Figure 4.3 Flow Chart of Data Gathering Layer

Inside the data gathering layer, developed program would start using the captured image to do two task which is scan the QR code inside the image as the benchmark, and check the orientation of QR code to determine the need of change the image orientation. Another task is to segment out the plant image of the captured image. At the end, retrieving the actual measurable unit data such as centimeter or millimeter by comparing the pixel format data with benchmark data.

### 4.2.3 Data Analysis Layer

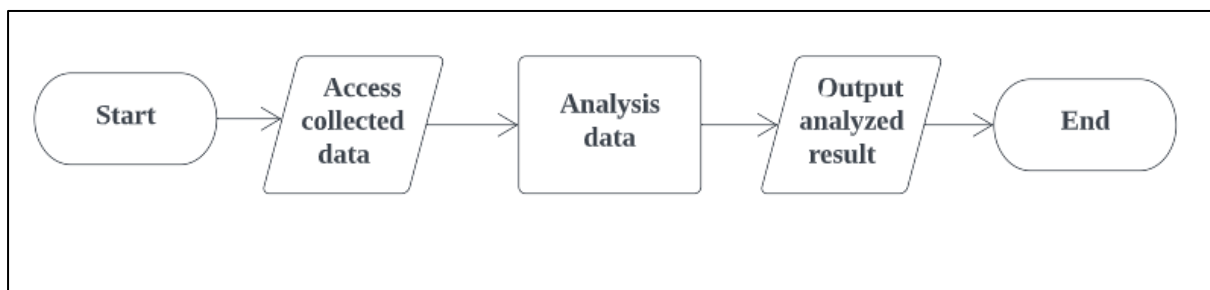


Figure 4.4 Flow Chart of Data Analysis Layer

Inside the data analysis layer, user or researcher can use the collected data to analysis and retrieve the information needed. For instance, growth rate of the plant in different environment.

### 4.3 System Components Specifications

#### 4.3.1 Hardware Involved

##### 1. City Vertical Farm L

The table 4.1 describe the specification of City Vertical Farm L which is an indoor nutrient film technique system that design and build by CITYFARM company, and it is used as the basic planting operation in this project. It contains 3 level of platform and each level have  $2 * 8 = 16$  slots for a plant. And figure 3.1 show the appearance of City Vertical Farm L.

Table 4.1: Specifications of City Vertical Farm L

Description	Specifications
Model	City Vertical Farm L
Dimension	130cm (L) * 65cm (W) * 175cm (H)
Maximum capacity	48 plants
Maximum water capacity	100 Litters
Level	3 level
Light	Individual light for each level



Figure 4.5: City Vertical Farm L

## 2. Raspberry Pi Cameras

Beside of that, in order to achieve the goal, which is collect the plant growth rate data, the raspberry pi camera is a portable light weight camera that is used for capture pictures, and also programmable to perform scaling function. To fulfil the need of monitoring three layers of the planting area, this system would need three camera which shown in figure 4.6, and the figure 4.7 control board to supply power and operate these three cameras.



Figure 4.6: Raspberry pi camera.



Figure 4.7: Control board of raspberry pi camera.

### 3. Raspberry Pi Board Integrate with Multi Camera Board

Since there are 3 level of slot in City Vertical Farm L infrastructure, a normal raspberry pi board will not have enough camera slot can provide to support multiple pi cameras operate at each level at this project, to solve this issue figure 4.8 multi camera board is used to integrate with raspberry pi board and provide support of operate multi camera function which up to maximum 4 camera operate at same board which shown in figure 4.9.

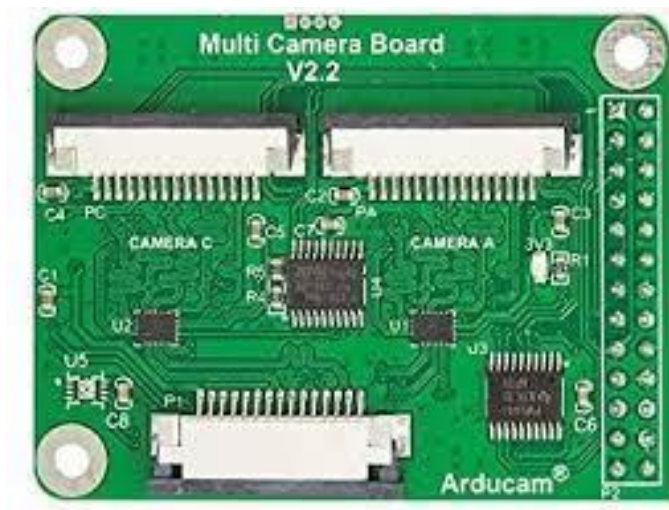


Figure 4.8: Multi camera board V2.2



Figure 4.9: Integrated pi control board

## 4. QR code

Each crop depicted in Figure 4.10 will be equipped with a QR code label. The QR code serves two purposes: firstly, it serves as the benchmark for retrieving the actual width and height of the crops; secondly, it functions as an indicator of orientation. The QR code must be attached correctly and aligned with three position nodes, as demonstrated in Figure 4.11.



Figure 4.10: QR Code Attached

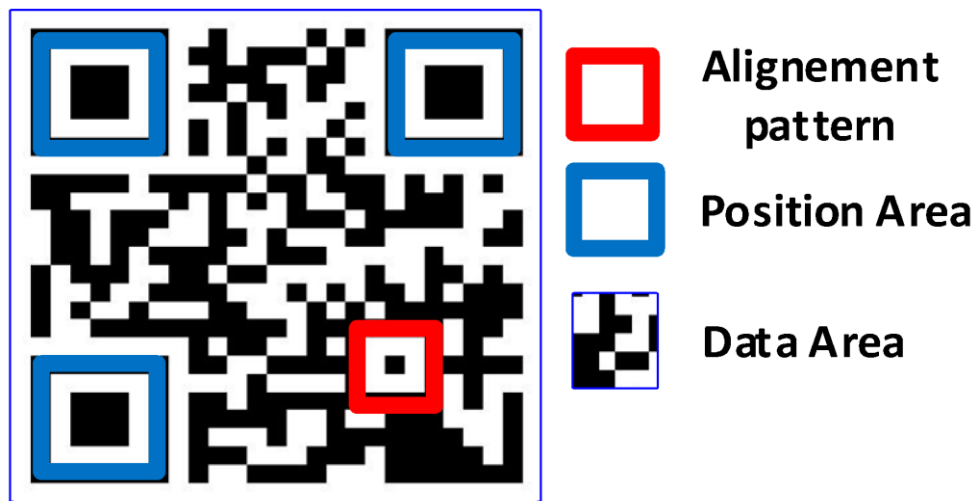


Figure 4.11: Structure of a QR Code



### 4.3.2 Software Involved

Before start to develop the proposed system, there are several software needed to be installed and downloaded in the laptop in order to headless configure the raspberry pi board:

1. VNC viewer



Figure 4.12: VNC Viewer

VNC (Virtual Network Computing) viewer enables users to connect to and remotely manage the desktop environment of another machine across a network. Without requiring physical access or travel, a computer or server can be conveniently managed remotely using a VNC viewer.

2. Advanced IP scanner



Figure 4.13: Advanced IP Scanner

Advanced IP Scanner is a network scanning tool that is free, fast and user-friendly. Its goal is to help users in discovering all of the hardware plugged into their local networks. In this project, Advanced IP Scanner is used to identify the Raspberry Pi board's IP address, which is required to connect remotely to the Raspberry Pi desktop environment using VNC Viewer.

After that, there is also a need to boot a SD card for containing the OS of raspberry pi board, the required software list below:

1. Raspberry Pi Imager v1.7.2

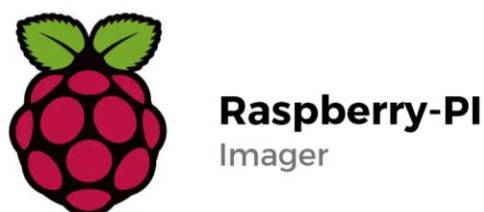


Figure 4.14: Raspberry Pi Imager

Raspberry Pi Imager is a free, open-source utility tool developed by the Raspberry Pi Foundation. It is intended to make it easier to install operating systems (OS) on Raspberry Pi boards. With its user-friendly graphical interface, Raspberry Pi Imager offers users the ability to choose from a variety of preconfigured operating systems such as Raspberry Pi OS, Ubuntu, Kali Linux, and more.

### 2. Raspbian OS Full (32-bit edition)



Figure 4.15: Raspbian OS

Raspbian OS is an open-source Debian-based operating system designed specifically for the Raspberry Pi series of single-board computers. The Raspberry Pi Foundation created and maintained it as the official operating system for the Raspberry Pi.

And the software or library needed for processing image include:

#### 1. PlantCV v: latest



Figure 4.16: PlantCV

PlantCV (Plant phenotyping using computer vision) is an open-source image analysis software package developed for plant biology research. Researchers can extract quantitative data from photographs of plant tissues and organs with the help of a variety of tools and functions for automated image processing and analysis of plant images. The website <https://plantcv.readthedocs.io/en/latest/> provides comprehensive

information about the library, including its features, usage instructions, and documentation.

### 2. pyzbar v:0.1.9

Pyzbar is a Python library used for decoding and reading QR codes and barcodes from images and video streams. Pyzbar offers a straightforward and user-friendly interface to decode several kinds of barcodes, including EAN, UPC, Code 128, and QR codes. Pyzbar was an important element of this project because it responsible to read the height and width of the QR code, and the orientation of the QR code either.

### 3. Anaconda



Figure 4.17: Anaconda

Anaconda is a free and open-source distribution of the Python and R programming languages for scientific computing, data science, machine learning, and artificial intelligence. It contains a variety of libraries and tools needed for data analysis, such as Spyder IDE, Jupyter Notebook, and others. Conda, a built-in package manager in Anaconda, makes it easier to install and manage packages and dependencies.

### 4. Jupyterlab



Figure 4.18: Jupyterlab

## CHAPTER 4

Jupyterlab offers a contemporary user experience for interacting with Jupyter notebooks, code, and data. Jupyterlab may be started via the Anaconda Navigator or the Anaconda prompt and is pre-installed with Anaconda which have stated above.

## CHAPTER 5

### System Implementation

#### 5.1 Hardware Setup

##### 5.1.1 Operating System set up

In this part, the Raspberry Pi OS need to be shown and configure headless in the laptop. To achieve this target, Raspberry Pi Imager provide a useful feature that can preconfigure some of the OS settings that can simplify this operation which can preconfigure the username, password, and enable the Secure Shell Protocol (SSH) during booting progress.

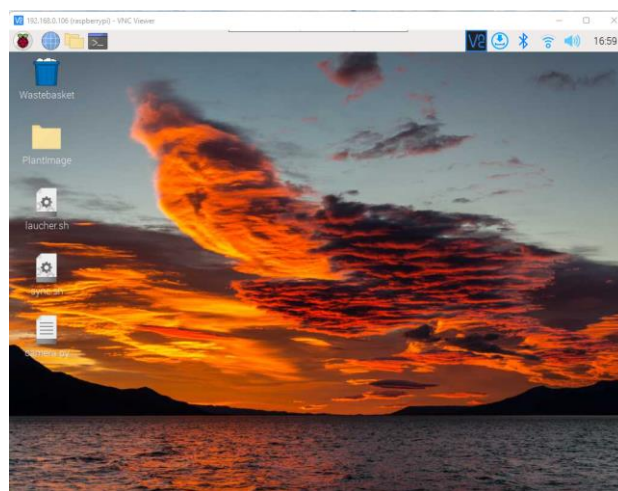


Figure 5.1 Raspberry Pi OS in VNC viewer

##### 5.1.2 Camera Set up

In order to collect the image from City Vertical Farm L, multiple raspberry pi cameras are configured to achieve this target by integrating the multi-camera board with the raspberry pi board. And to automate this capture process, the “crontab” command is used here to provide a regular schedule to run the code for capturing the image, in this project, it is set to capture an image every 1 hour. This command is better than applying the sleep function in the code because it is an automated schedule every time the pi board boot.

After that, in order to easier access the captured image, OneDrive is configured and use here for sync the image container file as shown in figure 4.2 below and the sync process is also using the “crontab” command to schedule sync it every 1 hour.

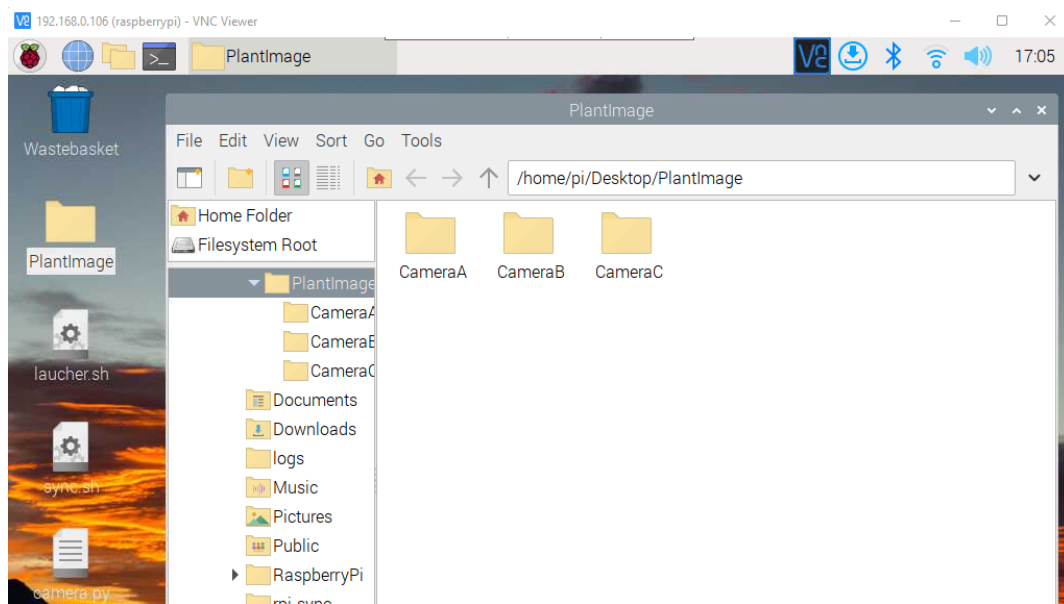


Figure 5.2 Image file in Pi board

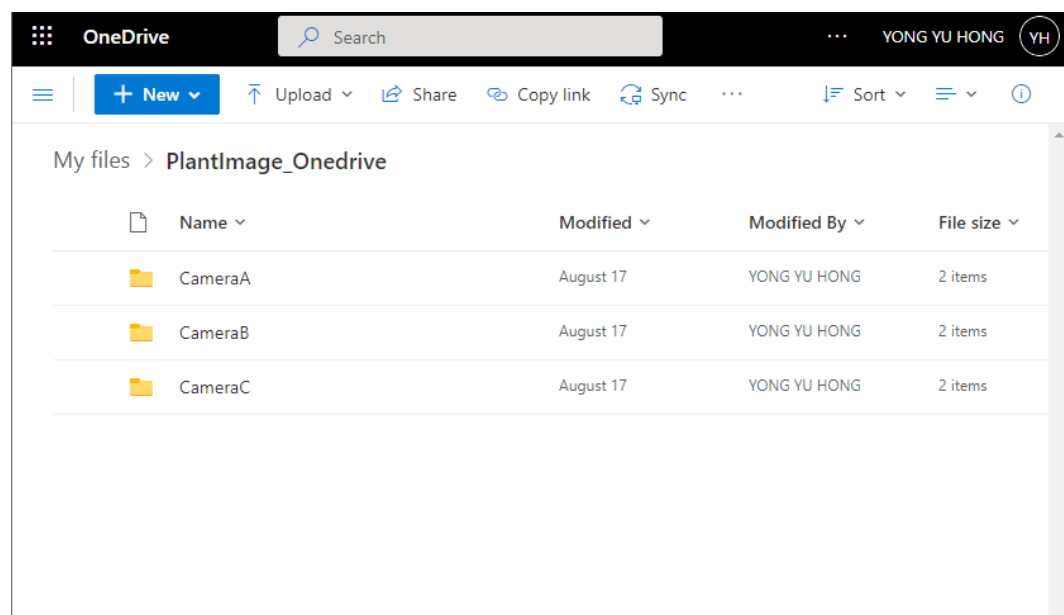


Figure 5.3 Image file that is sync with OneDrive

## 5.2 Software Set up

In order to perform the system operation required for this project, two specific libraries need to be installed: PlantCV and pyzbar. These libraries provide essential functions that allow for the analysis and manipulation of plant images, and the detection and decoding of QR codes within those images. Figure 5.4 below show the installation code of these library.

```
pip install plantcv
pip install pyzbar
```

Figure 5.4: Installation Code Required

### 5.3 System Operation

#### 5.3.1 QR Code Scanning

Using pyzbar to scan and decode the QR code made the system to recognize the QR code's orientation which allowed the captured image to be rotated to the proper orientation for processing. In order to ensure precise measurements and data retrieval from the QR codes, this functionality was necessary.

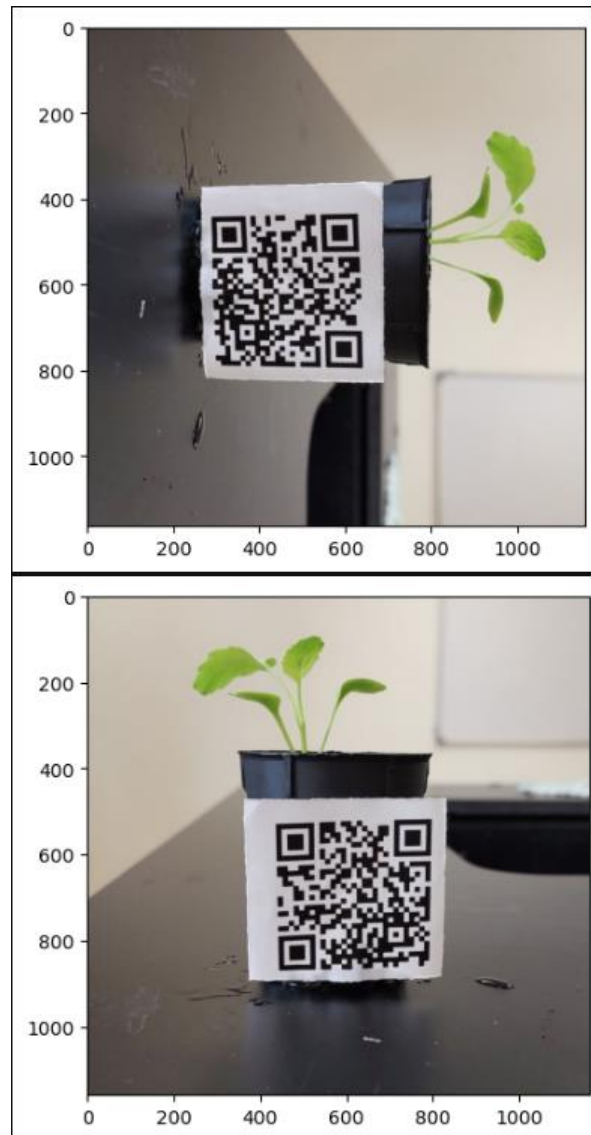


Figure 5.5 Rotate Crop Image

After that, it is imperative to obtain the length of the QR code in pixel format, which will be utilized for the subsequent retrieval of the actual height and width of the plants.

```

# Detect the QR code
qr_codes = decode(gray)

# Check if QR code was detected
if qr_codes:
    # Get the first QR code found (assuming only one QR code in the image)
    qr_code = qr_codes[0]

    # Get the size of the QR code in pixels
    qr_code_x = qr_code.rect[0]
    qr_code_y = qr_code.rect[1]
    qr_code_width = qr_code.rect[2]
    qr_code_heigh = qr_code.rect[3]

    # since qr code is a square, the longer means the more accurate of teh length data
    if qr_code_heigh > qr_code_width:
        qr_code_length = qr_code_heigh
    else:
        qr_code_length = qr_code_width

    # Print the size of the QR code
    print("QR code length: {} pixels".format(qr_code_length))
else:
    print("QR code not detected")

QR code length: 361 pixels

```

Figure 5.6 Get the QR Code Length

### 5.3.2 Image segmentation

Image segmentation is required in order to return the accurate crop data. And the whole process can be separate to several process which is:

1. Convert the RGB image to grayscale using different color subchannel, in this project, channel 'a' which is green-magenta channel is selected.

```

# channel = color subchannel ('L' = Lightness, 'a' = green-magenta, 'b' = blue-yellow)
a = pcv.rgb2gray_lab(rgb_img-crop_img, channel='a')

```



Figure 5.7: Grayscale Image Conversion



2. Set a binary threshold on the image



Figure 5.8: Binary Thresholding

3. Find the object

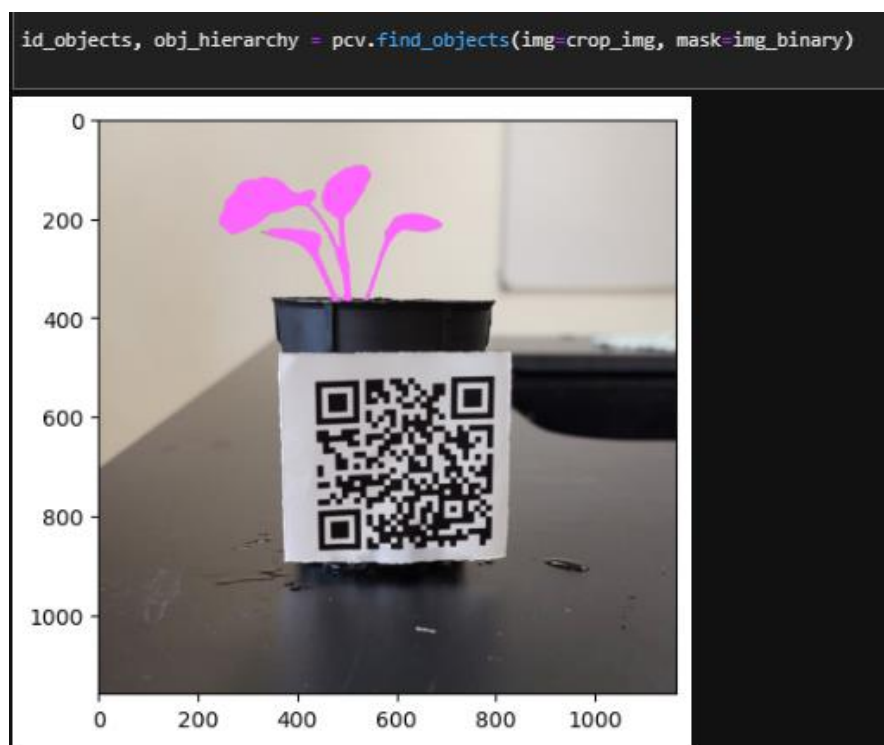


Figure 5.9: Object Finding

4. Combine object



Figure 5.10: Object Combination

5. Apply the mask

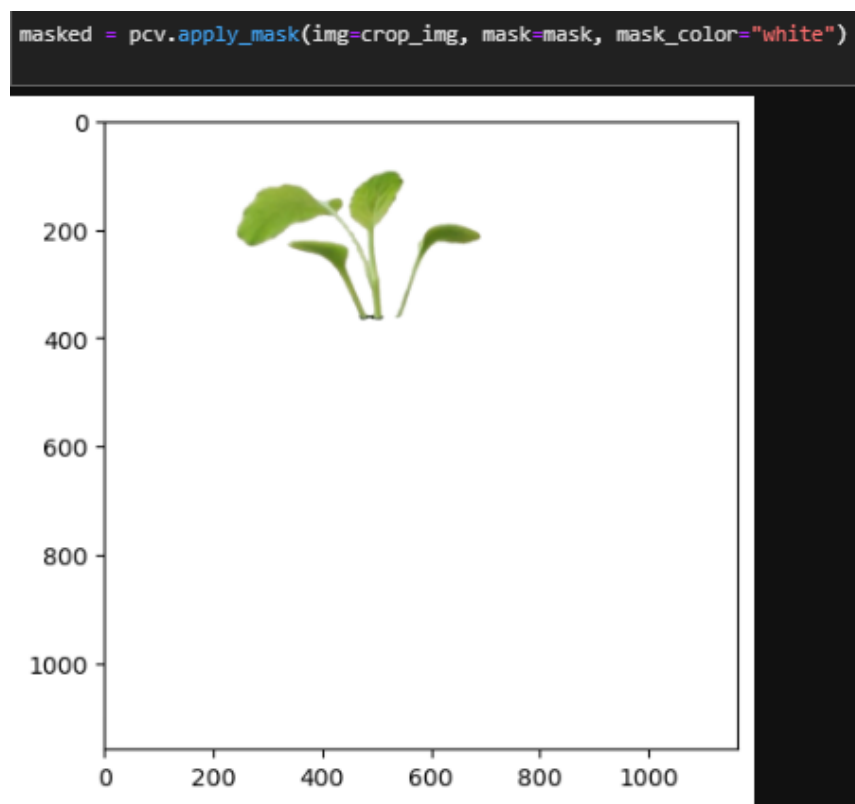


Figure 5.11: Image Mask Applied

### 5.3.3 Retrieve the Data out from the Segmented Image

The PlantCV library offers a range of useful functions for analyzing plant images. One particularly valuable function is `pcv.analyze_object()`, which returns various data related to the input image. In this project, the height, width, and pixel size of the crops were specifically extracted using this function for further analysis.

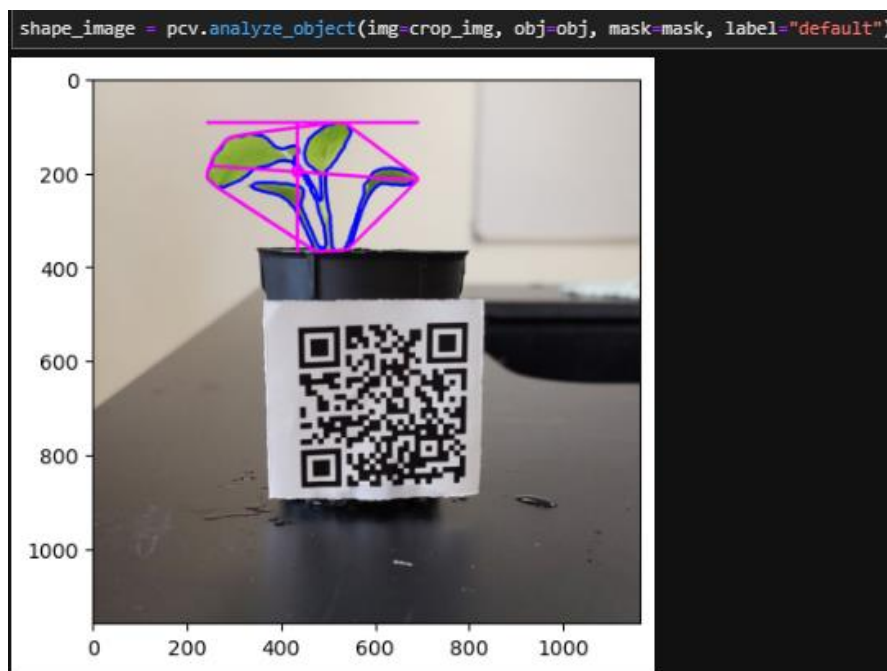


Figure 5.12: Result of `analyze_object()` Function

```

plant_height_PlantCV = pcv.outputs.observations['default']['height']['value']
plant_height_PlantCV

275

plant_width_PlantCV = pcv.outputs.observations['default']['width']['value']
plant_width_PlantCV

447

plant_green_pixel = pcv.outputs.observations['default']['area']['value']
plant_green_pixel

31349.0

```

Figure 5.13: Returned Data

### 5.3.4 Retrieve the Data needed

Since all the pixel format data already retrieved, by given the actual QR code length, the actual plant height and width can be retrieved by using a proportion concept in mathematics shown below:

$$\begin{aligned} \therefore Actual_{PlantHeight} : Actual_{QRcodeLength} &= Program_{PlantHeight} : Program_{QRcodeLength} \\ \therefore Actual_{PlantHeight} &= Actual_{QRcodeLength} \left( \frac{Program_{PlantHeight}}{Program_{QRcodeLength}} \right) \end{aligned}$$

```
actual_qrcode_length = 3.7 #(cm)

actual_plant_height_PlantCV = round(actual_qrcode_length * plant_height_PlantCV / qr_code_length,2)
actual_plant_height_PlantCV

2.82

actual_plant_width_PlantCV = round(actual_qrcode_length * plant_width_PlantCV / qr_code_length,2)
actual_plant_width_PlantCV

4.58
```

Figure 5.14 Actual data Retrieval

### 5.3.5 Store the Result

Once all the necessary processing has been completed, the resulting data will be stored in a CSV file for future analysis purposes.

```
# Define the output file name
output_file = "data.csv"

# Open the output file for appending
with open(output_file, "a", newline="") as csvfile:
    # Create a CSV writer object
    writer = csv.writer(csvfile)

    # Write the header row if the file is empty
    if csvfile.tell() == 0:
        writer.writerow(["Height", "Width", "Green_Pixel_Size"])

    # Write the data rows
    writer.writerow([actual_plant_height_PlantCV, actual_plant_width_PlantCV, plant_green_pixel])
```

Figure 5.15: Data Storing

### 5.3.6 Data Analysis

Once data has been collected and stored in a CSV file, it can be used to analyze growth patterns and evaluate the health of the crops. By looking at each attribute stored, such as length, width, and pixel size, it is possible to get a sense of how the crop is growing over time.

For instance, the length and width data can be used to create a graph showing how the crop is growing over time. By plotting these data points over several days or weeks, it is possible to identify any periods of stagnation or decline in the crop's growth. Similarly, the pixel size data can be used to analyze the quality of the crop and detect any signs of disease or other issues that may be affecting its growth.

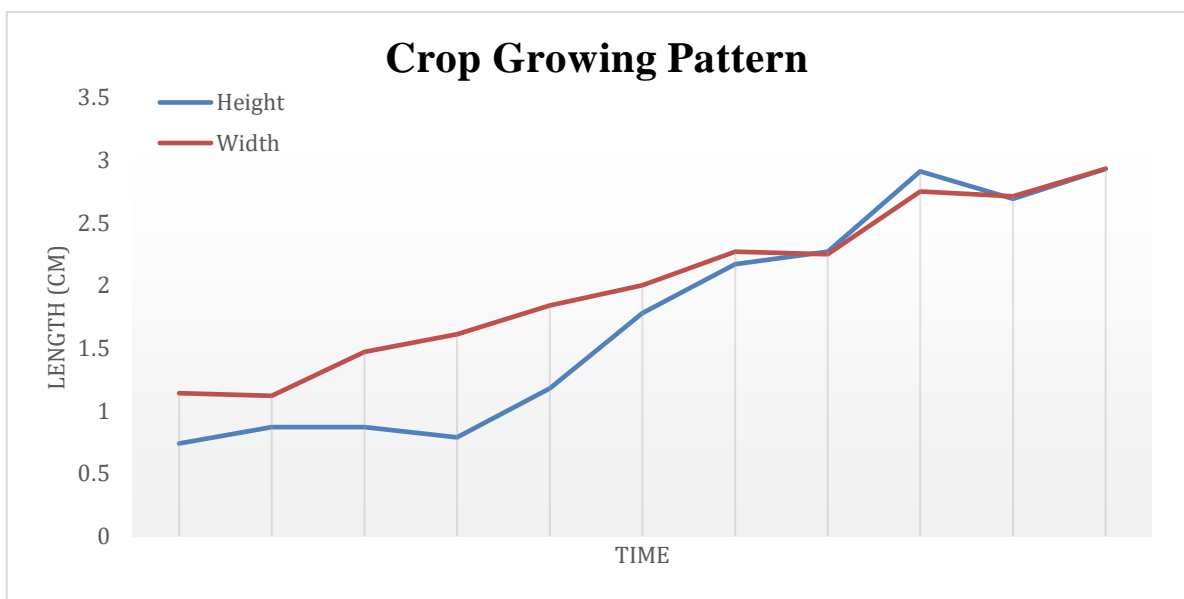


Figure 5.16: Crop Growing Pattern by Height and Width

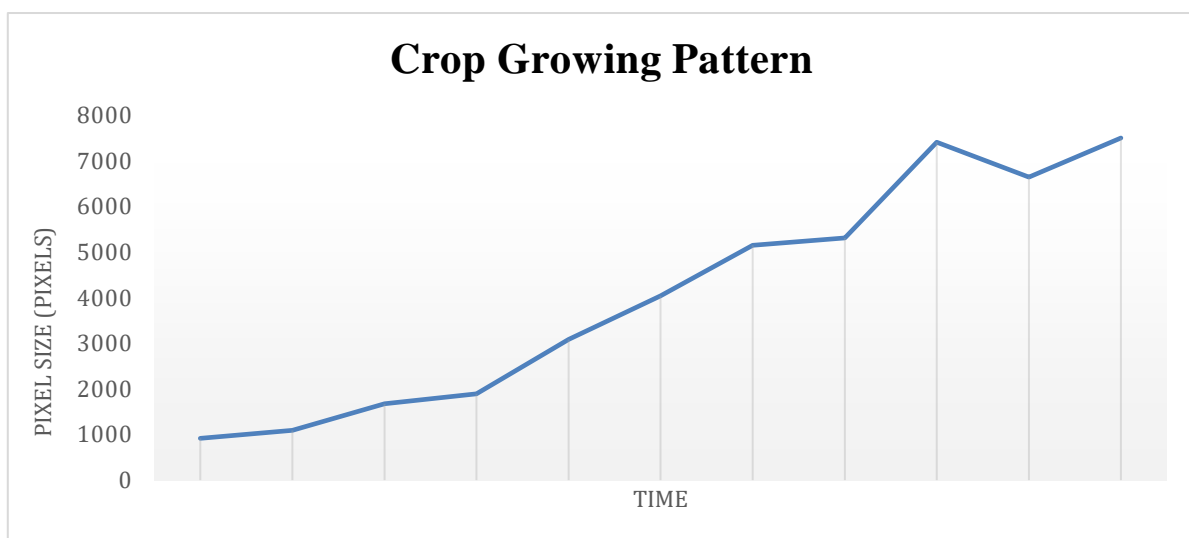


Figure 5.17: Crop Growing Pattern by Pixel Size

## CHAPTER 6

### System Evaluation and Discussion

#### 6.1 System Testing

The system test here needs to verify that the software application or system being tested is functioning as per the defined requirements. Two component is required to test here which is:

- Raspberry Pi Board Working Status Testing

Steps:

1. Power on the board.
2. Verify that the board's power indicator light turns on.
3. Wait for camera to capture image.
4. Checking the folder whether the camera is functioning properly and can capture images.

Expected result if success:

- ✓ Board's power indicator light should turn on.
- ✓ The folder should have captured new image store inside.

Expected result if fail:

- ✗ Board's power indicator light will not turn on.
- ✗ The folder does not have new captured image store inside.

- Program Working Status Testing

Steps:

1. Run the program.
2. Verify that the QR code can be scanned.
3. Verify that the crop image is correctly segmented out.
4. Checking the csv file whether the data is successfully recorded.

Expected result if success:

- ✓ QR code information can be retrieved.
- ✓ Crop image is segmented clearly.
- ✓ The csv file should have record mew data inside.

Expected result if fail:

- ✗ QR code cannot be scanned.
- ✗ Fail to export data into csv file.

## 6.2 Testing Setup and Performance Metrics

### 6.2.1 Verification Plan

Table 6.1 Verification Plan

Test Case	Test case description	Input	Expected Results
Image Capture	<ul style="list-style-type: none"> <li>Raspberry pi camera can capture image.</li> <li>Image can be stored and uploaded.</li> </ul>	-	<ul style="list-style-type: none"> <li>A clear crop image captured by pi camera.</li> <li>Image uploaded in OneDrive folder.</li> </ul>
QR Code Detection	<ul style="list-style-type: none"> <li>QR code can be scanned.</li> <li>Information can be retrieved.</li> </ul>	Captured image	<ul style="list-style-type: none"> <li>No error message after scanning QR code.</li> <li>QR code's length and orientation is retrieved.</li> </ul>
Image Segmentation	<ul style="list-style-type: none"> <li>Image can be loaded.</li> <li>Crop body part can be segment out.</li> </ul>	Captured image	<ul style="list-style-type: none"> <li>A clear segmented crop image.</li> </ul>
Data Retrieval	<ul style="list-style-type: none"> <li>Image data can be retrieved.</li> <li>Actual data transformation is correct.</li> </ul>	Segmented Image	<ul style="list-style-type: none"> <li>Crop's data retrieved.</li> <li>Transform the data from pixel format to centimeter format.</li> </ul>
Data Storing and Analysis	<ul style="list-style-type: none"> <li>Required data is stored inside csv file.</li> <li>Csv file can be created and read.</li> </ul>	Data retrieved	<ul style="list-style-type: none"> <li>Data successfully load inside the target csv file.</li> <li>Csv file can be access and not corrupt.</li> </ul>

### 6.2.2 Performance Matrix

A performance matrix will be implemented to statistically calculate the performance of the developed system based on the image segmentation results.

Table 6.2 Performance Matrix of the Segmentation Result

	Leaf Segmented Positive	Leaf Segmented Negative
Stalk Segmented Positive	9	0
Stalk Segmented Negative	15	0

Table 6.1 shows that out of the 24 images tested, only 9 images were successfully segmented to include both the leaf and stalk regions, while the remaining 15 images failed to correctly segment the stalk region. There were no false negatives for leaf segmentation. And the accuracy value can be calculated based on the equation below:

$$Accuracy = \frac{\textit{Part that is segmented positive}}{\textit{Total case}}$$

Therefore, it can be concluded that the segmentation algorithm has a higher accuracy in identifying leaf regions than stalk regions since by the result of equation, accuracy of segment out the leaf part is 1, and accuracy of segment out the stalk part is 0.375.

### 6.3 Project Challenges

One of the key challenges faced by the current project is the low accuracy of stalk segmentation. This is related to the distance between the camera and the crops. Specifically, when the camera is positioned further away from the crops, the stalks can become unobtrusive and blended in with the background, making it more difficult for the image segmentation algorithm to accurately identify them. This is due to the fact that longer camera distances tend to result in higher levels of noise and reduced photo quality when it zoom to focus on the target crop.

As a result, the accuracy of the image cropping process can be significantly impacted by the distance between the camera and the crops. This can create issues in terms of data accuracy and reliability, as well as making it more difficult to analyze the resulting images effectively.



## 6.4 Objectives Evaluation

The evaluation of each objective:

- Make use of the hydroponic system to grow some crop for data collecting.

Figure 6.1 illustrates that the hydroponic system constructed in the lab is functioning effectively. Most of the crop can growth successfully and healthy.

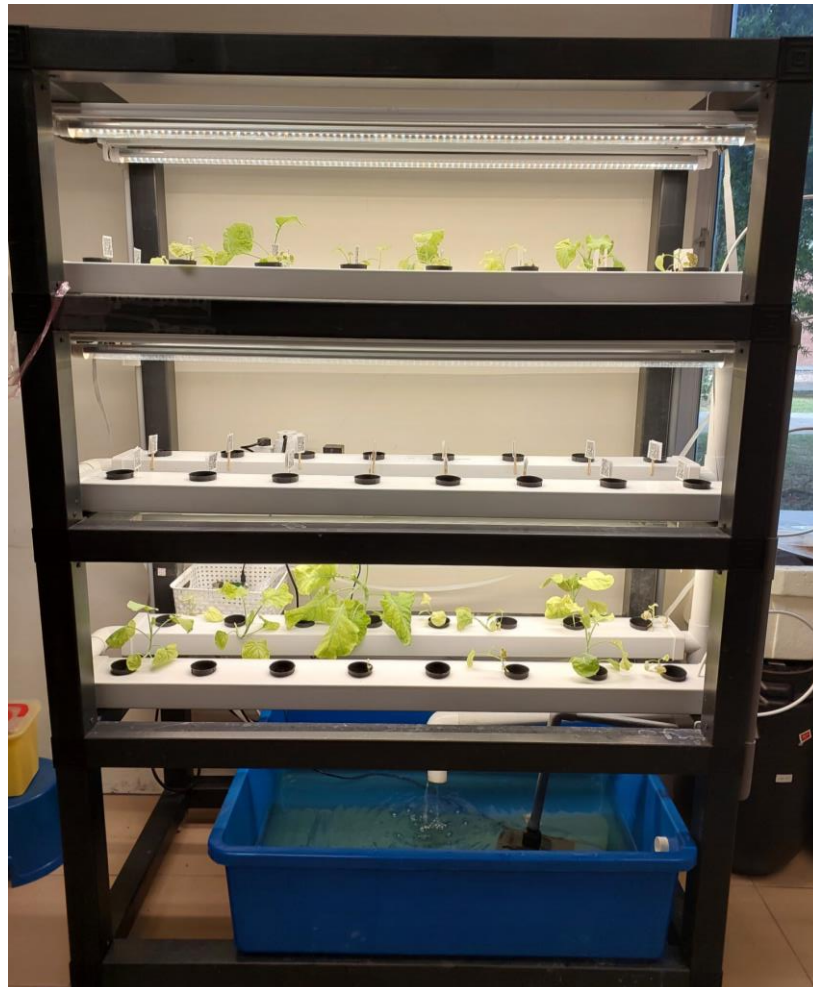


Figure 6.1 Hydroponic System in Lab

- Develop a comprehensive program for collecting crop growing data.

As figure 6.2 shown, the program can successfully collect the data from the image, and width and green pixel size are collected more accurately because the height data accuracy was affected by the distance of the camera between crops.

Height	Width	Green_Pixel_Size
0.74	1.14	917
0.87	1.12	1089
0.87	1.47	1674
0.79	1.61	1892
1.18	1.84	3090
1.78	2	4041
2.17	2.27	5155
2.27	2.25	5312
2.91	2.75	7411
2.69	2.71	6647
2.93	2.93	7505

Figure 6.2 Part of the Collected Data

- Analysis the data to get some insight of the crop growing process.

As figure 5.16 and figure 5.17 shown in section 5.3.6, the data can be used to analyze and conclude that the crop are growing successfully and healthy.

## **CHAPTER 7**

### **Conclusion and Recommendation**

#### **7.1 Conclusion**

In conclusion, the project has successfully leveraged the capabilities of the Raspberry Pi board and its camera module to capture crop images automatically at predefined intervals. The image processing component plays a critical role in ensuring the reliability and availability of the developed solution. PlantCV, a powerful and user-friendly image processing library, has been instrumental in streamlining the image processing workflow and reducing the overall workload of the project. The use of QR codes as a benchmark for transforming pixel data into measurable centimeter-based data has been a key factor in ensuring the accuracy and consistency of the captured data. Overall, the project has successfully developed a solution that can accurately retrieve measurable data from the captured crop images.

#### **7.2 Recommendation**

However, one of the major challenges faced during the project was due to the fixed camera position, which limited the accuracy of the image segmentation process. This issue can be effectively resolved when it reaches the final goal of this project which incorporating a robot arm or other technologies that allow for camera mobility. Thus, it is recommended that future improvements to the project focus on exploring techniques that enable camera movement for better accuracy and reliable data collection.

## REFERENCES

[1]

W. Woodstream, “Learn The Six Plant Growth Stages,” *www.saferbrand.com*.  
<https://www.saferbrand.com/articles/plant-growth-stages#:~:text=The%20stages%20that%20plants%20go>

[2]

W.-T. Chen, Y.-H. F. Yeh, T.-Y. Liu, and T.-T. Lin, “An Automated and Continuous Plant Weight Measurement System for Plant Factory,” *Frontiers in Plant Science*, vol. 7, Mar. 2016, doi: 10.3389/fpls.2016.00392.

[3]

Takaichi, M., Shimaji, H., and Higashide, T. (1996). Monitoring of the change in fresh weight of plants grown in water culture. *Acta Hortic.* 440, 413–418. doi: 10.17660/ActaHortic.1996.440.72

[4]

Baas, R., and Slootweg, C. (2004). On-line acquisition of plant related and environmental parameters (plant monitoring) in gerbera: determining plant responses. *Acta Hortic.* 654, 139–146. doi: 10.17660/ActaHortic.2004. 654.14

[5]

Helmer, T., Ehret, D. L., and Bittman, S. (2005). CropAssist, an automated system for direct measurement of greenhouse tomato growth and water use. *Comput. Electron. Agric.* 48, 198–215. doi: 10.1016/j.compag.2005. 04.005

[6]

S. Gupta and A. Mudgil, “Plant Growth Monitoring System,” Jun. 2012.

[7]

M. Seelye, S. Gourab, D. Gupta, Bailey, and J. Seelye, “Low Cost Colour Sensors for Monitoring Plant Growth in a Laboratory.”

[8]

Y. Feng, G. Ren, K. He, Y. Liu, and L. Li, “RGB color channel variation based segmentation of crop leaf lesion,” *IEEE Xplore*, Jun. 01, 2015.  
<https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7334180> (accessed Sep. 01, 2022).

[9]

A. Janwale, “Plant Leaves Image Segmentation Techniques: A Review,” *INTERNATIONAL JOURNAL OF COMPUTER SCIENCES AND ENGINEERING*, vol. 5, pp. 147–150, Jun. 2017.

## FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

<b>Trimester, Year: T3Y3</b>	<b>Study week no.: 4</b>
<b>Student Name &amp; ID: Yong Yu Hong, 20ACB04003</b>	
<b>Supervisor: Ts Dr Ooi Boon Yaik</b>	
<b>Project Title: IoT Data Analytics for Operational Status Tracking in The Agriculture Field</b>	

### 1. WORK DONE

Reset up the lab environment by considering the light duration problem.

### 2. WORK TO BE DONE

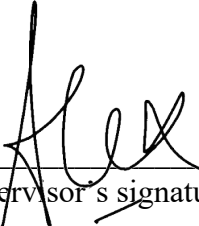
Finding a better way to segment out the plant image, and the rest of the project.


### 3. PROBLEMS ENCOUNTERED

Segmentation output not good enough, need to overcome this in order to proceed to the rest of the project.

### 4. SELF EVALUATION OF THE PROGRESS

Still acceptable, not in a rush time.

  
\_\_\_\_\_  
Supervisor's signature

  
\_\_\_\_\_  
Student's signature

## FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

<b>Trimester, Year: T3Y3</b>	<b>Study week no.: 6</b>
<b>Student Name &amp; ID: Yong Yu Hong, 20ACB04003</b>	
<b>Supervisor: Ts Dr Ooi Boon Yaik</b>	
<b>Project Title: IoT Data Analytics for Operational Status Tracking in The Agriculture Field</b>	

### 1. WORK DONE

Discovered a new library to handle the image segmentation part.

### 2. WORK TO BE DONE

Retrieve the data and also set up the QR code for the reference purpose.


### 3. PROBLEMS ENCOUNTERED

Opencv library cannot handle QR code scanning when don't have a clear background.

### 4. SELF EVALUATION OF THE PROGRESS

Still acceptable, not in a rush time.

  
\_\_\_\_\_  
Supervisor's signature

  
\_\_\_\_\_  
Student's signature

## FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

<b>Trimester, Year: T3Y3</b>	<b>Study week no.: 10</b>
<b>Student Name &amp; ID: Yong Yu Hong, 20ACB04003</b>	
<b>Supervisor: Ts Dr Ooi Boon Yaik</b>	
<b>Project Title: IoT Data Analytics for Operational Status Tracking in The Agriculture Field</b>	

### 1. WORK DONE

New library for QR code scanning discovered data transformation done.

### 2. WORK TO BE DONE

Data storing and analysis.


### 3. PROBLEMS ENCOUNTERED

Camera connector seems malfunction, need to capture the image from the beginning again.

### 4. SELF EVALUATION OF THE PROGRESS

Still acceptable, not in a rush time.

  
\_\_\_\_\_  
Supervisor's signature

  
\_\_\_\_\_  
Student's signature

## FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

<b>Trimester, Year: T3Y3</b>	<b>Study week no.: 12</b>
<b>Student Name &amp; ID: Yong Yu Hong, 20ACB04003</b>	
<b>Supervisor: Ts Dr Ooi Boon Yaik</b>	
<b>Project Title: IoT Data Analytics for Operational Status Tracking in The Agriculture Field</b>	

### 1. WORK DONE

All components of the project are done.

### 2. WORK TO BE DONE


Writing the report and waiting image to e captured.


### 3. PROBLEMS ENCOUNTERED

Still waiting camera to capture enough image for data retrieval.

### 4. SELF EVALUATION OF THE PROGRESS

Still acceptable, not in a rush time.

  
\_\_\_\_\_  
Supervisor's signature

  
\_\_\_\_\_  
Student's signature



POSTER

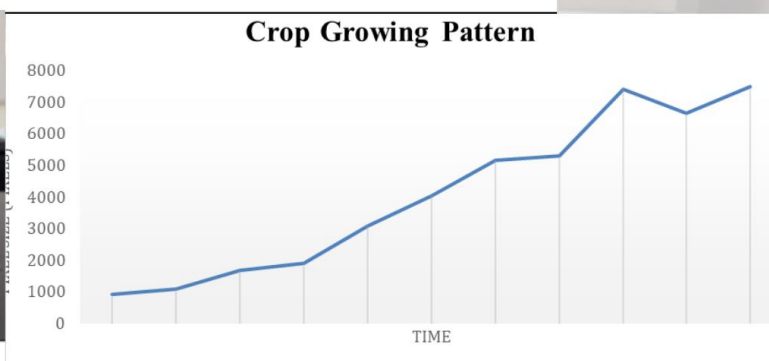
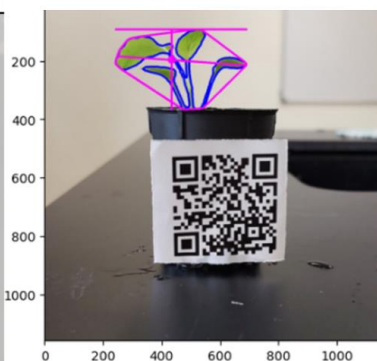
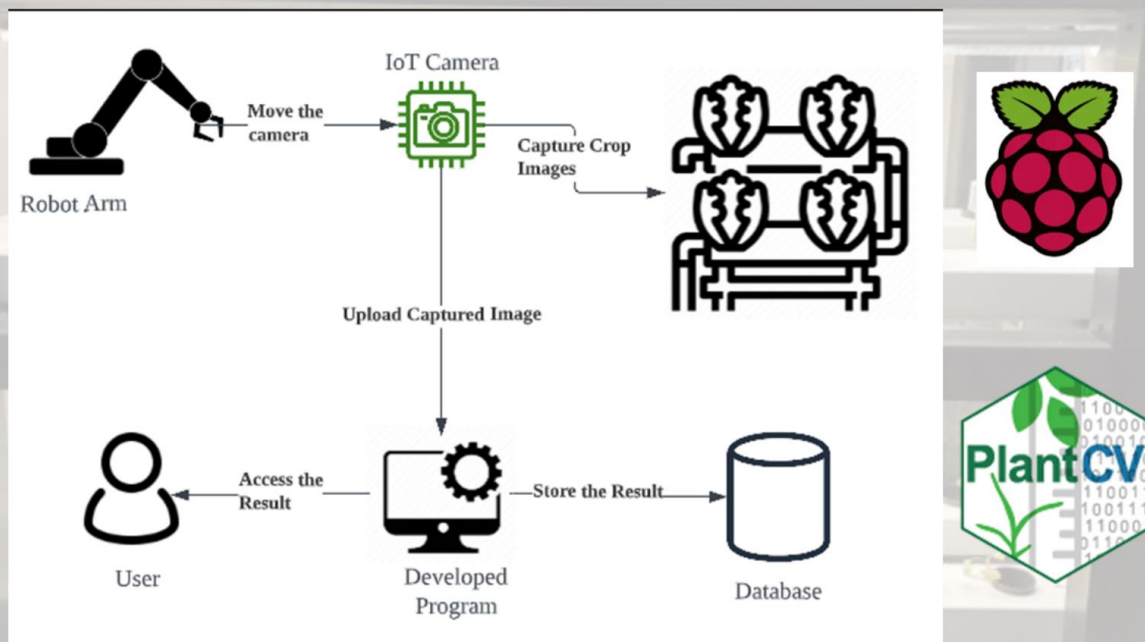


# IoT Data Analytics for Operational Status Tracking in The Agriculture Field

## Description

The proposed solution would create an Internet of Things (IoT) based smart farm environment to gather information on the growth rates of hydroponic plants. For academics, companies, and organisations looking to invest in studies and analyses to discover more effective ways to manage crop growth in the 4.0 agricultural revolution, these data are crucial.

## Final Goal of System design



Student: Yong Yu Hong

Supervisor: Ts Dr Ooi Boon Yaik

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**FACULTY OF INFORMATION AND COMMUNICATION  
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<b>Full Name(s) of Candidate(s)</b>	Yong Yu Hong
<b>ID Number(s)</b>	010813-10-1511
<b>Programme / Course</b>	Bachelor of Computer Science
<b>Title of Final Year Project</b>	IoT Data Analytics for Operational Status Tracking in The Agriculture Field

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Name:   Ts Dr Ooi Boon Yaik  

Date:   24/4/2023  

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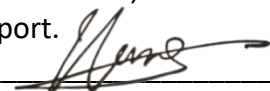
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