DESIGN AND IMPLEMENTATION OF A CROP HEALTH MONITORING SYSTEM

By

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A Final Year Design Project (FYDP) submitted to the Department of Electrical and Electronics Engineering in partial fulfillment of the requirements for the degree of Bachelor of Science

[Electrical and Electronics Engineering]
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[Electrical and Electronics Engineering]
Brac University
[Spring] [2023]

Declaration

It is hereby declared that.

1. The Final Year Design Project (FYDP) submitted is my/our own original work while completing degree at Brac University.
2. The Final Year Design Project (FYDP) does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The Final Year Design Project (FYDP) does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
4. We have acknowledged all main sources of help.

Student's Full Name & Signature:

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Approval

The Final Year Design Project (FYDP) titled "Design and Implementation of a Crop Health Monitoring System" submitted by:

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of Spring, 2023 has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Bachelor of Science on [Date-of-Defense].

Examining Committee:

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Ethics Statement

We declare and confirm that the project "Design and Implementation of a Crop Health Monitoring System" has fulfilled all the requirements of the Final Year Design Project. The project is completed by the group members. To fulfill this project, we have taken help from numerous research papers, journals, articles which have been summarized in the literature review and cited accordingly. Finally, we are confirming that we have detected 12% similarity from the whole project report.

Abstract/ Executive Summary

This scholarly work aims to present an innovative Quadcopter Drone Crop Monitoring System that addresses the challenges faced by farmers in monitoring and managing their crops. The system integrates quadcopter drones, remote sensing devices, and data analytics software to provide detailed data on crop health, enabling farmers to make informed decisions on the various crop (leaf) diseases. The Quadcopter Drone Crop Monitoring System utilizes a state-of-the-art quadcopter drone equipped with a high-resolution camera. Essentially such a device would capture detailed images of crops from numerous angles, which are then transmitted to a ground station. The data is then processed using advanced algorithms (CNN) that generate detailed reports on crop diseases. The Quadcopter Drone Crop Monitoring System offers several advantages over traditional crop monitoring methods, including faster and more accurate data collection, reduced labor costs, and improved crop management practices. The data on crop (leaf) diseases enable farmers to make timely and informed decisions, leading to improved yields, reduced costs, and increased sustainability. The Quadcopter Drone Crop Monitoring System is an innovative solution to modernize agriculture and optimize crop production in a sustainable manner. This technology-driven solution has the potential to transform the agricultural sector by providing farmers with an efficient and effective tool for monitoring and managing their crops. It is envisioned that this technology will lead to a more sustainable and profitable future for the agricultural industry.

Keywords: Quadcopter drones, remote sensing devices, data analytics software, crop monitoring, agriculture.

Dedication (Optional)

Acknowledgement

Our warmest gratitude to be extended to honorable Chairperson of ATC panel 3, Professor Dr. AKM Abdul Malek Azad, for his unimaginable gracious assistance throughout the entire FYDP EEE400P, EEE400D as well as the final EEE400C. In addition, we would also would like to most earnestly extend our warmest gratitude for his vigilante and thorough assessment on our area of improvement and helping us recognize where and how can. Additionally, we are honored to have Professor Dr. Touhidur Rahman and Mr. Mohammad Tushar Imran, a lecturer at BRAC University, for there kind advice pertaining to the numerous conventions and formatting issues, along with advice for a means to resolve them. They are to us one of the most generous ATC panel 3 co-advisors. We also honored to have Ms. Afrida Malik as Lecturer to be a former ATC panel 3 co-advisor. Finally, but surely, we want to offer our most tremendous thanks to the Chairperson of the FYDP sub-committee, (who is also the Chairperson of the EEE Department) Dr. Md. Mosaddequr Rahman, as well as, the former member of the FYDP sub-committee i.e., Mr Mohaimenul Islam and Mr Rakibul, being kind enough to assistant on various critical stages of our project as well as the project report form.

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1.1 Introduction

Bangladesh is an agricultural country. Agriculture has the most contribution on Bangladeshi economy. Agriculture has created a huge dependency on it of various sectors of the country such as a huge number of people's livelihood depends on agriculture for instance people chose farming as their profession which is providing employment to them. Also people are providing their land in rent to cultivate or hiring people for cultivation. Moreover, agriculture is also contributing to GDP. Bangladesh is also exporting the cultivated products. For these reasons, cultivating healthy crops has become a concern. Producing healthy crops in a huge quantity is not an easy task. To make it easier, modern technologies and devices are being added in this field.

1.1.1 Problem Statement

The aim of our project is to monitor a cultivated land and provide response about the health of the cultivated crops; calculated with the help of previous data and information. The importance of cultivating healthy crops can't be described in words. A small issue in one corner of the land can ruin all the months long efforts of the farmers as well as cause a huge loss in the economy. Growing healthy crops requires a constant monitor of the land. Monitoring the whole land physically is a tough task for a farmer. It is a time killing process. Also, if some sort of irregularity is detected by the farmer in the crops, it is hard to identify the exact disease the crop is carrying; that is, the farmer might not have any knowledge regarding that disease. In this case, due to wrong assumption; wrong treatment might be given which will cause a huge financial loss. So, having a close observation of a large land for a farmer almost every day is a challenging task.

To sum up, drawbacks of the age-old crop monitoring system are:

✓ Waste of time
✓ Providing Wrong Treatment
✓ Difficulties in Monitoring the Land
✓ Financial Loss

1.1.2 Background Study

The population is growing rapidly. An estimation says that the world population will reach 9 billion in 2050[1]. Currently the population of Bangladesh is 167,887,706 according to the United Nations data [2]. The population will reach 179 million in 2030[2]. A report provides an estimation of food expectation which will increase 60% by 2050 worldwide [1]. So, the demand for food is increasing gradually with the abnormal increase of population. To feed this huge population, food productivity needs to be increased. As a result, there will be a huge pressure on agriculture. Farmers can't risk crops due to the lack of monitoring the diseases of the crops. Also wasting time in monitoring the crops physically won't be a good option for them as they must produce more crops in future compared to recent days. So, monitoring the crop's health with the help of technology is important in recent times.

Till now several techniques have been implemented to monitor crop's health and some methods are still on progress. Some of the very efficient technology that are being used or can be used in monitoring crop's health are satellite-based crop monitoring, drone-based monitoring, crop monitoring using rover or using IoT and so on.

The use of Unmanned Aerial Vehicles or Drones have been increased tremendously in recent times. At the very beginning of inventing drones, it was just aimed at military usage. But now in almost every sector, drones are being used for getting a sustainable output. For instance, traffic observation, cartography, landscape photography, fireguard. Among them, one of the most popular examples in agriculture [3].

Nowadays agriculture is considered as one of the most important economic resources of many countries including Bangladesh. For some country, economy without agriculture can't be imagined. Among them, most of the countries export their crops to other countries and earn foreign currency. To cope up with the recent situation, agriculture needs to be improved. Many countries have already thought and implemented various technologies in producing crops. Some countries have successfully implemented drone and mobile applications together to get a better result from agriculture. The motive behind proposing this technology is to improve the quality of crops as well as minimize the struggles of farmers. Here drone has been used as an autonomous vehicle containing some additional features to build a smart agriculture. Some of those features are sensors, multispectral cameras, GPS. Autonomous drone does not need any human control. It will fly according to the previously set commands and follow the selected paths capturing images. Then the drone sends the pictures autonomously for processing. Generally, gimbal is used in drones for holding camera. Without gimbal, capturing stable pictures is not possible. Moreover, with the help of autonomous flight software, the route gets fixed in which the drone will travel. Drone captures images of the selected area and using image processing, the captured images are processed, and a report will be provided about the health of the land. Multispectral camera with NDVI sensors is used to capture those tiny things which human eyes cannot detect easily. A report about plant health can be provided instantly with the help of this camera. Multispectral band is required to monitor the health of the plants. Bands is basically a group of wavelengths; Blue, Green, Red, NIR are some of the well-known bands. The main task of these bands is to differentiate Chlorophyll which is a green colored biological pigment and responsible for the photosynthesis of plants. It absorbs as well as reflects (green light) strongly with a wavelength ranging 450-520 nm (blue) and 630-690 nm (red) and for healthy plants, the range of NIR is 700-1000 nm [4]. Using the wavelengths, it calculates NDVI (Normalized Index Vegetation Index) and provides a decision about plant health. NDVI=(NIR-Red)/(NIR+Red) Here NIR is reflection of the near-infrared spectrum and red is the reflection in the red range of the spectrum. High NDVI value indicates healthy plants. On the other hand, low NDVI means plant growth is poor or the plant is containing any disease. Server is used to connect devices and for image processing. Besides, mobile application is for serving the users. User will get access to the data Through mobile application. The drone's activity can also be monitored by mobile applications. A lot of experiments have been done using land rovers on agriculture fields. Till now many countries have successfully spread seeds on fields. As spreading seed was a successful attempt, observing crop's leaves can be done using land rover. Research is still on progress in this issue. But here one problem that can be raised is the lack of control option. The method of minimizing this difficulty is using IoT as a medium of communication [5]. Satellite could have been used as an alternate solution to the problem of crops disease. Satellite is being mainly used in soil mapping of a very large area. It is helping in a useful decisionmaking process. It provides decision about the crop that can be cultivated in that specific area, depending on the particles of the soil. There are several biophysical parameters by which crop condition can be measure using satellite. They are, Normalized Differences Vegetation Index (NDVI) and Leaf Area Index (LAI). Lai is basically the ratio of the area of one side of a green leaf and unit ground area covered by the plant. But LAI is the most important index in yield estimation. Yield is basically the ratio of production to area. Through the result of crop yield estimation, planning of cultivation are done wisely. A lot of research has been done using earth observation mission like Sentinel 2 and Landset 8 on how accurately the yield of crop can be estimated [6]. In providing prediction of yields different algorithms of machine learning is used. But all these vegetation indexes are used in crop mapping and yield estimation. It will declare which land is suitable for which crop. They do not provide any decision on the contamination of the leaves of the crops. However, sunlight is essential for satellite remote sensing system. Reflection of the sunlight will be received by the satellite sensors. Moreover, the type of the crop can be identified using satellite remote sensing. Every type of crop has its individual pattern and phasing through which it can be distinguished. Here it is also proved that crop monitoring in done by satellite in terms of identifying the crop type, portion of soil and water on the land. But research on crops leaf monitoring has not been done yet using satellite. In recent times, some projects have successfully proved that agro rover is a good choice for making the agriculture smart. Along with detecting crops health, some researchers have also implemented some additional features such as soil moisture sensor and pesticide sprayer. With the help of sensor, the condition of soil can be observed and proper action will be taken. With the help of a camera, the rover will detect insects on the leaves and will spray pesticides accordingly [7].

In any automatic crop monitoring system, one of the most important things is image processing. It is mainly used to measure the affected area. Various images are basically being grouped into different parts through image segmentation. There are several ways of image segmentation. Among them, genetic algorithm is popular [8]. It is because many images can be processed through this algorithm also it provides optimum solution [9]. Neural network has added a new dimension to the process [10]. Color co-occurrence matrix and feature extraction is done using neural network.

1.1.3 Literature Gap

From the background research on this field we can measure the importance of further advancement in this sector. Despite doing lots of research in this field, providing solution to some obstacles is still not possible. Likewise, the vibration noise is creating issue in the control system of the drone. With this vibration, the whole system oscillates for which capturing stable picture has become a challenge. To solve the oscillation problem, the noise must be deducted that can be either electrically or mechanically but till now there is no progress in this issue.

1.1.4 Relevance to current and future Industry

Now a days it is seen that in many developed countries, landowners are using satellite to observe the crop growth, coloration and density. But for an underdeveloped country like Bangladesh, having access to satellite image is expensive. Moreover, there a question rises of accuracy of the images the satellite will be providing. Because satellite monitors the land from a very distant place where cloud, light and weather can cause an issue. Satellite is highly depended on weather conditions. Unfavorable revisit time of satellite can also play a role of barrier in monitoring the crops constantly [11]. So, satellite crop monitoring is not a good option for Bangladeshi agriculture. So, farmers require a reliable system that will provide them accurate information about their crop's health which we will be able to provide. This drone-based crop monitoring system will be cost effective for the farmers as well as easy to catch because the service providing agencies will make the service of crop monitoring available for the farmers having huge land. Till now research on this field is continuing with the crop images but in near future it might be done with real time data, that is with videos of the crops, diseases can be detected which will be proved much easier to provide the result than the current process. Additionally, the importance of this type of technology is increasing day by day. It already in a demand of the current industry as it has been proved earlier that the population is increasing in a fast pace which ultimately helping to increase the demand of food, for which technology like this is needed for fast production. Bangladesh is also exporting a huge quantity of agricultural products like vegetables, nuts, fruits and what not. Focusing on the economic development, this exportation will increase day by day. As a result, demand of this technology will also increase simultaneously.

1.2 Objectives, Requirements, Specification and constraint

1.2.1. Objectives

The objective of the project is to provide a solution to the crop's health issue in a sustainable and effective manner. To achieve the goal, we intend to involve the followings in our project:

- Capturing images of crops leaf
- Implementing image processing on the image data to identify the disease of the crop
- Providing a report on plant health
- Using soil moisture sensor to provide a report on the condition of the soil

1.2.2 Functional and Nonfunctional Requirements

Functional Requirements:

- **Land Requirements:** we need a minimum amount of land (50-60 yards) to monitor the crops of the land.
- **Capture image using drone:** To monitor the crop health we need to capture clear and high-resolution images of the crops.
- **Collecting Sensor data:** Monitoring the crop health properly we also need the humidity level and soil moisture level of that particular area.
- **Performing Image Processing:** We need to prepare a trained model using the data with the help of image processing to predict the disease of the crop.
- **Sending Data to the cloud:** For the automatic process for getting the prediction of the crops we need to send the data to the cloud; it will compare the data from the pretrained model and give us the report.

Nonfunctional Requirements:

- **Battery Backup:** As all the tasks are done by the battery, we need to carry extra battery for the emergency or tackle nonresponsive situation of the battery.
- **Permission from the authority:** As we are working with the drones, we need to maintain a certain type of rules provided by the civil aviation authority of Bangladesh.
- **Ensuring Public Safety:** While flying the drone we must ensure that it makes no harm to the human, animals and the properties also we need to take consent from the people of the area where we are going to fly the drone.
- **Operated by Appropriate Person:** We have to ensure that the drone is operated by an experienced person because it is necessary to get specific data from the drone and for getting that we need a good operator otherwise it may hamper the whole thing.

1.2.3 Specifications

- **Soil moisture measurement**

Monitoring soil parameters is the most important aspect of agriculture because it directly affects the crop. A wide range of soil properties as well as their biological activities, such as Bactria and other things, which aid in the crop's quick growth, are represented by the concepts of soil function and quality. After a particular amount of time, soil moisture may start to decrease. The amount of perception, the rate of water intake, and air temperature are only a few of the variables that affect soil moisture. When farmers plant crops on their land, they simply look at it and if they think it looks good, they plant the crops. However, in order to plant their crops effectively, farmers must consider a number of factors, including the soil, the local humidity, and certain factors based on a country's geographic location.

An electrical device known as a soil moisture sensor can be used to measure the soil moisture that has accumulated in the soil of a specific area. [12]. Unlike other sensors on the market, the capacitive soil moisture sensor we are going to employ in our project uses capacitive sensing rather than resistive sensing. It is built of a substance that resists corrosion and has a long lifespan.

- **Humidity and Temperature Measurement**

Since Bangladesh is mostly an agricultural nation, temperature and humidity have a significant impact on our crops. But for certain crops, the soil in our nation is particularly productive. To gain the most from the soil, we must establish a relationship with the temperature and humidity. As part of our experiment, we'll keep track of an area's temperature and humidity to determine which crops can thrive there.

We will use the DHT11 humidity and temperature sensor to collect the temperature and humidity from that area in order to measure the humidity and temperature. Up to 125 degrees Celsius, plus or minus 0.5 degrees Celsius, can be measured. There are several more components with some IC at the back along with the main component of that sensor, which senses humidity, and another component, a thermistor, which senses temperature [13].

- **Image Processing**

Deep learning and AI are being used more frequently these days, and engineers are incorporating these sorts of systems into their projects on a daily basis to give them autonomy and the ability to perform predictive algorithms. In this assignment, we will identify which plant has which specific disease using photographs of plant leaves. Additionally, in order to put this into practice, we need to compile a sizable collection of photos including different types of healthy and sick plant leaves in order to train the model. When our model is complete,we will be able to forecast both the presence of diseases and the health of the plants.

1.2.3.1 System Level Specification:

In order make the drone we will need certain type of things which will be serving our purpose the way we want.

Table 1: System Level Specifications

Name	Description
Flight Controller	Flight Controller will control the whole flightweit's in the air it also contains gyroscope, barometer and sometimes built in GPS. Specs: Power supply: LP2985-3.3 Max voltage: 16V Onboard 4 Megabytes Data flash chip for automatic data logging
BLDC Motor	Brushless DC motor will make the thrust touplift the drone Specs: Operating voltage: 7.2V to 12VMaximum current:13Amp for 60Sec Maximum Watts:150 Watt Weight of motor:50-60 grams
ESC (Electronic Speed Controller)	This will control the speed of the motor. Specs: Constant Current: 30A (Max 40A < 10sec).Suitable battery: 2-3cell LiPo
Quadcopter Frame	This will carry the whole components for thedrone. Specs: Motor centers: 480mmHeight: 170mm Weight: 405g (frame only) Motor Mount Bolt Holes: 16~19~25mm
Propeller	This will spin aerodynamically and producethrust. Specs: Length: 10″.Pitch: 4.5″. Weight: 25 gm. Shaft Diameter: 9.5 mm. Total Length: 10 inch / 250 mm. Material: ABS (Acrylonitrile butadienestyrene)
Power Module	This will make a bridge between the flight controller and the ESC and deliver sufficientpower. Specs: Operating Voltage:6~28 VDCMax Input Voltage:28 V DC Max Current Sensing: 90 A

Remote Controller	This will give command to the drone to go back and forth lower and higher. Specs: Modulation mode: QPSK Spread spectrum: DSSS OperatingVoltage: 8.6~15V Channel bandwidth: 5.0MHz Operating Current: <105mA Adjacent channel rejection: >38dbm Control distance: more than 600 meters groundChannel: 12
LiPo battery	This will give power to the motor and remote.Specs: Weight: 182 gm Voltage: 11.1V Capacity: Minimum 2200mAh
Battery Charger	This module will charge the battery. Specs:Input: 110v or 240v A/C (50/60Hz) Cell Count: 2~3s Output Current: 3 x 800mA
Vibration absorber	Vibration absorber will absorber will absorb the vibration and keep the orientation of the controller same. Specs: made of rubber.
Telemetry Kit	This will give the drone command followed byGPS wirelessly. Specs: Band: 433MHz Sensitivity: - 117dBm sensitivity Interface: Standard TTL UART TX Weight: 5g(15g with antenna) Output power: 100mW (20dBm)
GPS module	This will give the co-ordinates to the drone.Specs: Voltage: +3.5V to +5.5VDC Max attitude height:18000 Tracking sensitivity: -161dBmCapture sensitivity: -148dBm Temperature:40℃ to 80℃

Microcontroller	This will take the reading from the sensor. Specs: Operating Voltage: 5V 14 Digital input / output ports: TX, RX,1 pair of TTL level serial transceiver ports RX / TX Measurement accuracy (25°C): temperature: +0.5;humidity: + 2%RH (10; 90%RH) Resolution: temperature: 0.1 °C, humidity:0.1%RH
Camera	This module will take the camera of the plant leaves. Specs(minimum): 8-Megapixel native resolutionhigh-quality. Cameras are capableof 3280 x 2464-pixel of static images Capture video at 1080p30, 720p60 and 640x480p90 resolutions .4µm X 1.4 µm pixel with OmniBSI.

1.2.3.2 Components Level Specification:

These are the components we are going to use to make our drone:

Table 2: Component Level Specifications

Components	Model	Specification
Pixhawk Flight Controller	PX4 2.4.8	**Processor:** 32bit STM32F427 Cortex M4 core with FPU. 32-bit STM32F103 failsafe co-processor. Frequency: 168 MHz RAM size: 128 kB. Flash Memory size: 2 MB **Sensors:** Gyroscope: ST Micro L3GD20H 16 bit Accelerometer/Magnetometer: ST Micro X4HBA 303H 14 bit Accelerometer/Gyroscope: Invensense MPU 6000 3-axis Barometer: MEAS MS5607 **Interfaces:** 5x UART (serial ports),1 high-power capable, 2x with HW flow control. 2 CANs: 1st CAN with an internal 3.3V transceiver. 2nd CAN one on expansion connector. Spektrum DSM / DSM2 / DSM-X® Satellite compatible input. Futaba S.BUS® compatible input and output. PPM sum Signal Input. RSSI (PWM or voltage) input. I2C. SPI. 3.3 and 6.6V ADC inputs. Internal micro-USB port and external micro-USB port extension

UBLOX NEO-8M GPS module with Compass	Ublox NEO-M8N	Ublox Neo-M8N or M9N module Industry leading –167 dBm navigation sensitivity Cold starts: 26s LNA MAX2659ELT+ 25 x 25 x 4 mm ceramic patch antenna Rechargeable Farah capacitance Low Noise 3.3V regulator Current consumption: less than 150mA @ 5V Fix indicator LEDs Protective case 26cm cable included Diameter: 50mm total size, 32 grams with case. M8N: Concurrent reception of up to 3 GNSS (GPS, Galileo, GLONASS, BeiDou) M9N: Concurrent reception of up to 4 GNSS (GPS, Galileo, GLONASS, BeiDou)
GPS Folding Antenna Mount Holder	Model F08456	Color: Black Material: Aluminum Color Black Diameter of GPS Plate: 40 mm. Diameter of Base Plate: 35 mm Weight (in gm): 20g Height: 14 cm. Mounting Hole Spacing: 16-35 mm Diameter of Mounting Rod: Â 4mm
BLDC motor	DJI 2312 800KV	Operating voltage: 7.1V to 12.5V (2 to 3 Li-poly or 6to10 NiCad) No load current: 0.5Amp Maximum current:14 Amps for 60 seconds Maximum Watts: 250 watts Weight of motor:55-60 grams Maximum operating temperature: + 80°C
Fiber Quadcopter Frame	S500 Glass Fiber	Motor centers: 480mmHeight: 170mm Weight: 405g (frame only) Motor Mount Bolt Holes: 16~19~25mm
Brushless ESC	HSKRC BLHeli_S BLS30A	Peak Current: 40A Supports high KV values Function: DSHOT150/300/600/ONESHOT Firmware: BLHeli-S firmware Voltage: Supports 2 to 4 cells Battery Power BEC output: none PCB Dimensions: 13mm × 25mm × 5.4mm Weight (in grams): 5.4g per piece PCB power cord length: 12 cm PCB signal line length: 19 cm

Propeller	1045 Self-locking Propeller CW/CCW	Self-Locking Silvery Propeller Cap: L' means counter-clockwise Black Propeller Cap: R' means clockwise Length: 10″. Pitch: 4.5″. Weight: 22 gm. Shaft Diameter: 9.5 mm. Total Length: 10 inch / 250 mm. Material: Carbon Nylon
Pixhawk PowerModule	APM 2.6 V1.0	Operating Voltage:6~28 VDCMax Input Voltage:28 V DC Maximum Current Sensing: 90A Connecting Type: XT-60
Radiolink Transmitter and Receiver	AT9S Pro	Size: 183mm*100mm*193mm, R12DS- 41*23*14mm Weight (in grams): 880g Frequency: 2.4GHz ISM band (2400MHz to 2483.5MHz) Modulation mode: QPSK Channel bandwidth: 5.0 MHz Spread spectrum: DSSS&FHSS/CRSF Adjacent channel rejection: >38dbm Transmitter power: <100mW (20dbm) CRSF 10mW/25mW/100mW/500mW/1W/2W (Optional) Operating current: DSSS&FHSS <90mA@12V CRSF Depends on transmission power selected Operating voltage: 7.4~18.0V Control range: Maximum range in air DSSS&FHSS - 4000 meter. The actual control distance depends on the flying environment. Control range: CRSF Depends on the RX and TX from BLACKSHEEP Channel qty: 10 -12 channels Signal output: PWM/SBUS/PPM/CRSF Compatible model: include all 120 degree and 90 degree swash-plate helicopter, all fix wings, glider and multi-rotor Simulator model: under the simulator model the transmitter action turn off, change to power saving model Screen: 2.8 inches 16 colorful screen, 240*320 pixels
LiPo Battery	2200mAh 11.1v 3s	Weight: 182 gm Voltage: 11.1V Capacity: 2200mAh Cell Type: Li-polymerConfigurations: 3S Continuous Discharge Rate: 25CMax Burst Rate: 90C Discharge (Output) Lead: T Plug ConnectorCharging (Balancing) Lead: JST-XHR Wire Length: 100mm Operating Temperature Range: -20°Cto 60°CPVC color: Silver and Black

Radio Telemetry Kit	Pixhawk 433Mhz, 100mW	Band: 433MHz Antenna connectors: RP-SMA connectorOutput power: 100mW (20dBm) Sensitivity: -117dBm sensitivity Interface: Standard TTL UART Connection status: LED indicators TX Weight: 5g (15g with antenna)
Lipo Charger	B3 Pro	Input: 110v or 240v A/C (50/60Hz)Cell Count: 2~3s Battery Type: LiPoly Output Current: 3 x 800mA
APM SHOCK ABSORBER ANTI-VIBRATION	APM	Material: Glass Fiber Frame 1 Dimensions (L×W×H): 90mm×60mm×2mm Frame 2 Dimensions (L×W×H): 100mm×70mm×2mm Shock absorber Height: 12mm Weight (in grams): 24.00g Shipment Dimensions: 10 cm × 5 cm × 4 cm
Caddx CMOS FPV Camera	Turbo EOS2 1200TVL	Image Sensor: 1/3″ CMOS sensor Horizontal Resolution: 1200 TVL Television System: NTSC / PAL option My MAGE: 16:9 Synchronize: Internal Electronic shutter PAL: 1 / 50~100,000; NTSC: 1 / 60~100,000 Signal to noise ratio > 52dB (AGC OFF) Video output: CVBS Lens: 2.1 mm Hey.Illumination: 001Lux@F1.2 Automatic gain control: Present BLC: Present WDR: Global WDR DNR: 2 DNR Dimensions: 14mm × 14mm × 16mm Wide power input DC: 3.3-6V Operating temperature: -20°C~+ 60°C Working humidity: 20%~80% Weight (in grams): 3.5g
Skydroid Mini OTG Receiver 5.8G 150CH Mini FPV Receiver	SKYDROID 5.8G FPV OTG	Color: White Product name: 5.8G FPV receiver Output signal: AV analog signal Only suit for android support UVC Size: 61x33x10mm Weight (in grams): 30g FPV Receiver: 150CH, 5.8G

1.2.4 Technical and Non-technical consideration and constraint in design process

The concept and implementation of drone crop monitoring system will bring change and organized data of agricultural sector in Bangladesh. But there are multiple factors to consider as well. Many of these factors are predetermined and can be categorized into the following sections. The two aspects essential of which there are of different types are:

1. Considerations
2. Constraints

Design considerations are factors that need to be taken into account during the design process of a system or product. These considerations include various aspects such as functionality, usability, aesthetics, performance, safety, and cost. Design considerations help ensure that the final design meets the desired objectives, addresses user needs, and is feasible to implement within the given constraints. They involve making informed decisions about the selection of components, materials, and technologies, as well as considering the impact of the design on the user experience and overall system performance.

Additionally, design process considerations can also be referred to the factors and elements that are taken into account during the various stages of the design process. These considerations include aspects such as user needs, problem definition, research and analysis, ideation and concept generation, feasibility assessment, iterative design, sustainability, safety and regulations, aesthetics, and collaboration. They guide the design process, ensuring that the resulting solution is user-centered, feasible, visually appealing, compliant with regulations, and addresses the identified challenges or opportunities. These considerations shape the decision-making and actions throughout the design process to create effective and well-rounded designs.

The type of considerations are as follows:

1. Technical Consideration
2. Non-technical Consideration
3. Health and Safety Consideration

The following tables illustrates these different types of Considerations, i.e., the Technical Consideration, Non-technical Consideration and Health and Safety Consideration. Each of the 3 tables provides information pertaining to the different kinds of the respective specific type of consideration they are drawn for.

Table 3: Technical Considerations for Optimal Design Solution

Technical Considerations	Description	Degree of Importance
Technical Feasibility	Assessing whether the project is technically feasible given current technologies, expertise, and resources	Very High
Design and Development	Developing a comprehensive design that meets project requirements, including hardware and software specifications	High
Material Selection	Identifying suitable materials for the project based on their properties, availability, and cost	Medium
Manufacturing Process	Determining the best manufacturing process for the project, including considerations such as time, cost, and scalability	High
Testing and Quality Assurance	Developing a comprehensive testing plan to ensure the project meets quality standards, identifying potential failure modes and implementing measures to mitigate risks	Very High
Safety and Risk Management	Identifying potential safety hazards and implementing measures to reduce risk, including the use of protective equipment and safety procedures	Very High
Environmental Impact	Assessing the environmental impact of the project and identifying ways to reduce negative impacts and enhance sustainability	Medium
Regulatory Compliance	Ensuring compliance with relevant technical regulations and standards, such as those related to safety, emissions, and waste management	High
Maintenance and Support	Developing a maintenance and support plan for the project, including spare parts, training, and documentation	High

Table 4: Non-Technical Considerations for Optimal Design Solution

Non-Technical Considerations	**Description**	**Degree of Importance**
Project Budget	The financial resources available for the project, including funding for materials, labor, and equipment	Very High
Schedule	The timeline for the project, including milestones and deadlines	High
Stakeholder Engagement	The involvement and communication with stakeholders, including project sponsors, team members, customers, and other relevant parties	High
Human Resources	The availability and suitability of human resources, including skilled personnel, management, and support staff	Medium
Market and Competitive Analysis	Assessing the market and competitive landscape, including potential demand, market trends, and competing products or services	Medium
Legal and Intellectual Property Considerations	Identifying and addressing legal and intellectual property considerations, such as patent or copyright infringement and contractual obligations	High
Political and Societal Considerations	Identifying and addressing political and societal considerations, such as public opinion, community impact, and regulatory compliance	Medium
Reputation and Branding	Maintaining and enhancing the reputation and branding of the organization or project, including communication and marketing strategies	Low
Ethical and Social Responsibility	Identifying and addressing ethical and social responsibility considerations, such as sustainability, social justice, and corporate responsibility	High

Table 5: Health and Safety Considerations for Optimal Design Solution

Health and Safety Considerations	Description	Degree of Importance
Hazard Identification	Identifying potential health and safety hazards associated with the project, including exposure to chemicals, radiation, or physical hazards	Very High
Risk Assessment and Mitigation	Conducting a risk assessment to identify potential hazards and implementing measures to reduce risks, including the use of protective equipment, safety procedures, and emergency response plans	Very High
Training and Education	Providing appropriate training and education for personnel involved in the project, including safety procedures, emergency response, and the use of protective equipment	High
Compliance with Regulations and Standards	Ensuring compliance with relevant health and safety regulations and standards, including those related to personal protective equipment, hazardous materials, and emergency response	High
Ergonomics and Human Factors	Ensuring the project design takes into account ergonomic and human factors considerations to reduce the risk of injury or illness	Medium
Health and Wellness Programs	Implementing health and wellness programs to promote employee well-being and reduce the risk of illness or injury	Low
Incident Reporting and Investigation	Establishing procedures for incident reporting and investigation to identify the root cause of incidents and prevent their recurrence	High
Emergency Preparedness and Response	Developing emergency preparedness and response plans to address potential health and safety incidents, including natural disasters, fires, and hazardous material spills	Very High

Design process constraints refer to the limitations and restrictions that impact the design decisions and outcomes. These constraints can be related to various factors, such as technical, functional, economic, regulatory, and resource limitations. Designers need to work within these constraints to create viable and effective solutions. Examples of design process constraints include budgetary limitations, time constraints, available materials or technologies, manufacturing capabilities, safety regulations, and specific project requirements. Considering and managing these constraints is essential for ensuring that the design solution is practical, feasible, and meets the desired objectives within the given limitations.

The Types of Constraints: are

1. Technical Constraints
2. Non-technical Constraints

Table 6: Technical constraints for Optimal Design Solution

Technical Constraints	**Description**	**Degree of Impact**
Technical Compatibility	Ensuring that all components and technologies used in the project are compatible with each other	Very High
Technical Complexity	Managing the complexity of the project to ensure it can be effectively designed, developed, tested, and maintained	High
Technical Standards	Adhering to technical standards and protocols, such as those related to software and hardware interfaces, data formats, and communication protocols	High
Technical Resources	Ensuring that adequate technical resources, such as hardware, software, and infrastructure, are available and can be effectively utilized	Medium
Technical Expertise	Ensuring that the project team has the necessary technical expertise and skills to design, develop, and maintain the project	High
Technical Scalability	Designing the project to be scalable and able to handle increased demand or functionality in the future	Medium
Technical Constraints of Legacy Systems	Managing the constraints posed by legacy systems and ensuring they can be integrated with the new project	Medium
Technical Risks	Identifying and mitigating technical risks that could impact the success of the project, such as hardware or software failures	Very High
Technical Performance	Ensuring the project meets required technical performance standards, such as processing speed, accuracy, or reliability	High

Table 7: Non-technical constraints for Optimal Design Solution

Non-Technical Constraints	Description	Degree of Impact
Budget	The amount of financial resources available for the project	Very High
Schedule	The timeline for the project, including deadlines and milestones	Very High
Stakeholder Needs and Expectations	Ensuring the project meets the needs and expectations of stakeholders, such as customers, sponsors, and team members	High
Legal and Regulatory Requirements	Ensuring compliance with legal and regulatory requirements, such as building codes, environmental regulations, and labor laws	High
Political and Social Factors	Considering political and social factors that could impact the project, such as public opinion, government regulations, and cultural norms	Medium
Market Demand and Competition	Understanding market demand and competition for the project and ensuring it meets customer needs and expectations	Medium
Resource Availability	Ensuring adequate availability of resources, such as personnel, equipment, and materials, to support the project	High
Organizational Culture	Ensuring the project aligns with the organizational culture and values, and promoting stakeholder buy-in and engagement	Low
Reputation and Branding	Maintaining and enhancing the reputation and branding of the organization or project	Low

1.2.5 Applicable compliance, standards, and codes

While conducting the project, we are bound to follow some international standards. Some of the standards we are going to keep in concerns are listed below.

P2700/D1.00, Dec 2013 - IEEE Standard for Sensor Performance Parameter Definitions
This standard denotes a framework of the performance of sensors, its limitations, conditions etc. Here reliability, performance of temperature, humidity and other types of sensors are

discussed. In our project, we are going to check the soil moisture and humidity for which we need some sensors [14].

IEEE 2413-2019 - IEEE Standard describes the architectural framework of Internet of Things (IOT), followed by the international standards ISO/IEC/IEEE 42010:2011. Here some descriptions of many IOT domains, definitions of IOT domain abstractions and commonalities between different IOT domains are discussed [15]. The use of IOT in different projects is discussed in this standard.

ISO/IEC 21990:2002 talks about the service of GSM 3.40 in terms of communication system with the help of Short Message Service (SMS) [16]. In our project we are using a GSM module for which we need to maintain this standard.

IEEE 1936.1-2021 talks about the drone applications. It states drone application classes, application scenarios and application execution environments are specified. It also specifies drone safety management, the requirements of flight control system, flight platform etc. In our project we are going to capture images of crops by using drone. So, here we will have to follow this standard [17].

Civil Aviation Authority of Bangladesh (CAAB) has provided a number of internet-accessible details on flying for fun or for work [18].

1. Do not fly your drone higher than 60 meters (200 feet)
2. Do not fly within 9km (5 miles) of built-up areas
3. You must fly during daylight hours and only fly in good weather conditions
4. Stay 300 meters (1000 feet) away from buildings, people, and vehicles
5. The pilot must have a fire extinguisher on hand at all times
6. Any person conducting such operations shall be of minimum age of 18 year.
7. Respect others privacy when flying your drone.
8. Any person conducting such operations shall be responsible for conducting a safe operation and shall not pose a risk to aviation safety.
9. Do not fly your drone in sensitive areas including government or military facilities. Use of drones or camera drones in these areas are prohibited.
10. Do not fly your drone farther than visual line of sight – FPV equipment is not allowed unless specifically permitted.

1.3 Systematic Overview/summary of the proposed project

Monitoring a huge cultivated land physically and examining every plant for the farmers is close to impossible. Not only the have to just monitor the plants but also, they must detect the disease that the plant is carrying according to the disease which is a time killing process. For solving this problem, we have proposed a system in which we are going to capture images of leaves and provide the prediction of the disease. We have applied image processing to train dataset for prediction. We have provided two alternative designs along with our main design. Major differences are observed by electrical and mechanical simulation. Through further analysis we have proved that the optimal solution for our project is monitoring crops using a flying drone. Moreover, we have studied on the ethical issues for conducting our project and provided a contingency plan for risk management.

1.4 Conclusion

The project “Design and Implementation of a Crop Health Monitoring System” is mainly an agriculture-based project. Focusing on the current scenario of the agriculture and through the assumption of the future scarcity, we have fixed the objectives of our project. For conducting this project, we have taken some important things on account which are the constraints we are going to face throughout the project implementation and the ways to overcome them. Also, the standards and code that we are going to follow. Moreover, we went through different literature to know about the previous process of research on this field.

Chapter 2: Project Design Approach [CO5, CO6]

2.1 Introduction

Project design approach is an organized and methodical strategy for planning and implementing projects that accomplish intended goals. It comprises identifying project objectives, defining project scope, and designing a plan of action to attain those objectives. The method contains several procedures and instruments that may be modified to meet the particular requirements of a project.

Designing a crop monitoring system requires a thorough and systematic approach to ensure that the system meets the needs and requirements and objectives. The various steps taken for the project design approach for the case of this crop monitoring system are as follows:

- Define the problem and user requirements: Identify the problem that the crop monitoring system aims to solve, and gather information on the needs and requirements of the users. This may involve conducting surveys or interviews with farmers, agronomists, and other stakeholders.
- Determine the scope and objectives: Define the scope of the project and the specific objectives that the crop monitoring system needs to achieve. This may include identifying the crops to be monitored, the types of data to be collected, and the frequency of monitoring.
- Select the appropriate technology: Evaluate different technologies and tools that can be used for crop monitoring, such as drones, satellites, sensors, and mobile applications. Consider the cost, accuracy, and reliability of each technology, as well as the ease of use and maintenance.
- Develop the data collection plan: Develop a plan for collecting the necessary data, including the sampling strategy, data collection methods, and data management procedures. This may involve designing surveys, setting up sensors or cameras, or deploying drones or satellites.
- Develop and Optimize Multiple Design Approaches: There are three Design Approaches that Are Developed each one is self theoretically (along with conceptually), developed and optimized. Not only that but also, upon using necessary simulation environments, that are appropriate to analyze these design approaches, the development and optimization of each design approaches is done so. Through the gathering of relevant simulation Data Results.
- Analyze the data: Use appropriate statistical and analytical methods to analyze the data collected from the crop monitoring system. This may involve developing algorithms to detect crop growth patterns, identifying disease or pest outbreaks, or predicting yields.
- Communicate the results: Communicate the findings of the crop monitoring system to the users and other stakeholders. This may involve generating reports, visualizations, or interactive dashboards that provide insights into crop health and productivity.
- Evaluate and iterate: Evaluate the performance of the crop monitoring system and identify areas for improvement. This may involve conducting user feedback surveys,

analyzing each of the three system performance metrics, and making necessary changes to the system design or data collection plan.

- Deduce the Optimum Design Solution through Design Comparison by assessment of various essential technical and non-technical parameter that are relevant.

This ensures that the crop monitoring system is effective, efficient, and meets the objectives.

2.2 Identify multiple design approach

2.2.1 Design Approach 1: Satellite Monitoring Approach

Initially, a survey was conducted from which the major crops grown, as well as where they are grown and which diseases are prevalent, were deduced. The first design approach is known as the satellite monitoring approach. The transmitting antenna on the transmitting end sends the commanding signal to the satellites of the satellite network. The appropriate monitoring satellites of that network of satellites would take real-time spectral images of the necessary plot of land. These spectral images are then sent to the receiving antennae of the control room. Finally, this is processed with the use of machine learning. Then, using historical data and past data (sent from satellites), the model training and finally model evaluation are done. Results are generated, stored, and updated periodically. They are periodically shown to be updated when represented. The vegetative index, stress index, and water index are all calculated. These are used to determine crop growth and disease progression rates as well as deduce the crop health**.**

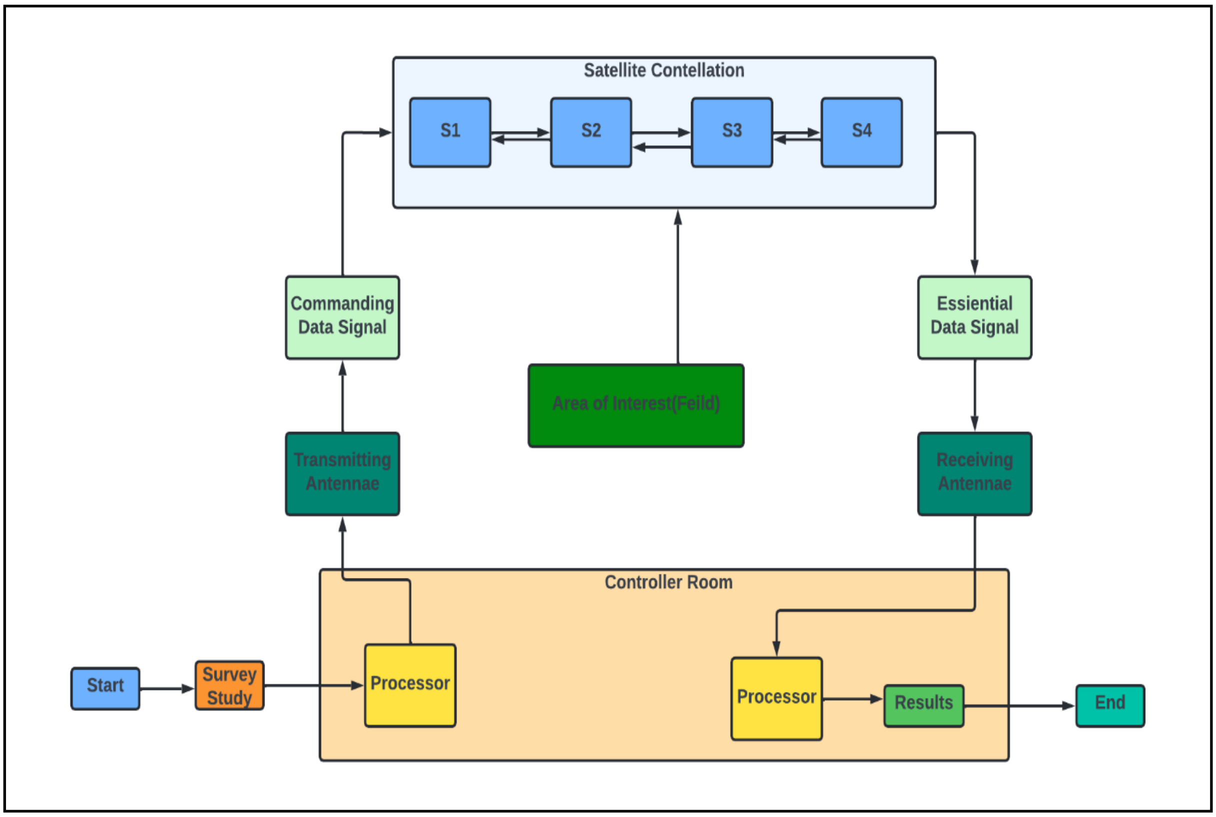


Figure 1: Block Diagram of a Satellite Crop Monitoring Approach.

2.2.2 Design Approach 2: Land-Based Rover Approach

The monitoring of the farmland with the use of numerous sensors as well as cameras. The land-based rover can essentially be used to capture various spectral images, thus collecting necessary spectral data. This is required in order to calculate the necessary crop parameters, subsequent to which the required understanding of the crop health, crop growth rate, and crop disease progression are calculated. Now essentially controlled remotely, the robotic vehicle provides the same quality result as traditional surveying. However, it would be without risk to personal health and safety and with fewer personnel than would typically need to be involved.

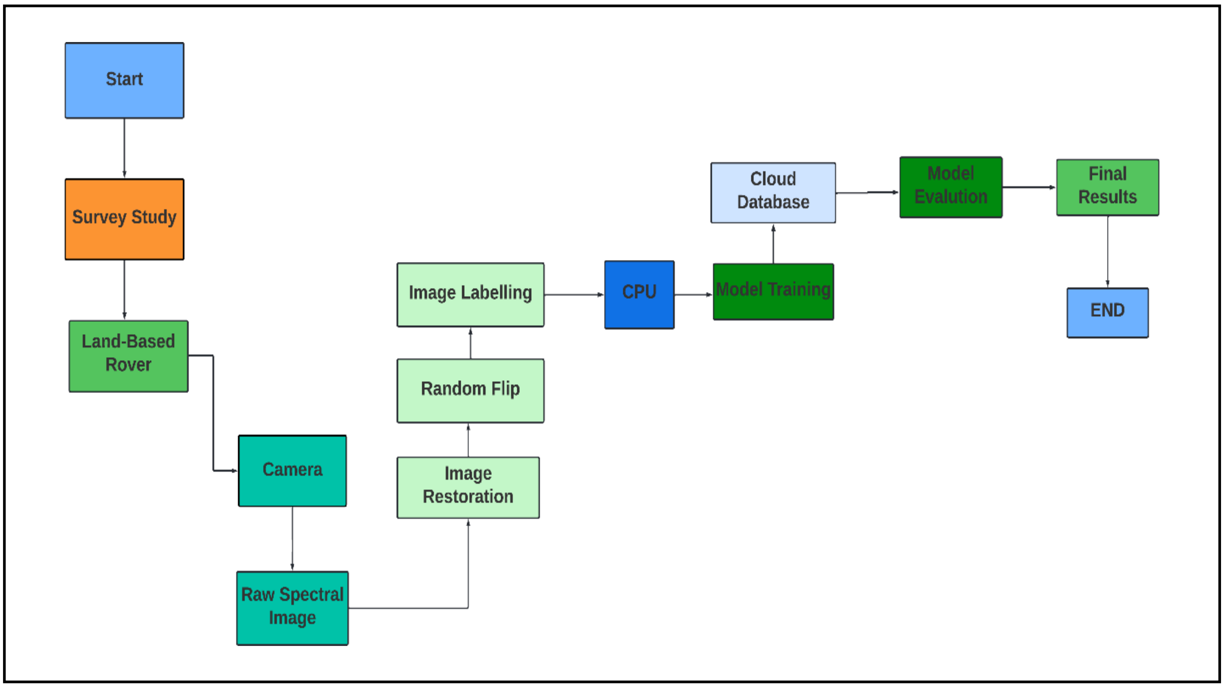


Figure 2: Land-Based Rover Approach

2.2.3 Design Approach 3: Flying Drone Approach

The flying drone is capable of capturing numerous different images and collecting other data at various different levels. The various spectral cameras are used in order to capture spectral images, essential for finding several different parameters. Image processing is done at all 3 levels, from low to high. The image attributes are then known to be fed to the processor. Subsequent to which, the machine learning process commences. Historical data is used from the cloud database. Additionally, at a stage in between the whole process of this image processing, after image restoration, for the case of image recognition, the data is augmented and the image is labelled, and training and evaluation of data commences in order to understand a certain crop disease progression. The digital temperature and humidity sensor is required for measuring its respective parameters (of humidity and temperature), The data is fed to the necessary processor, in this case, the CPU of the computer.

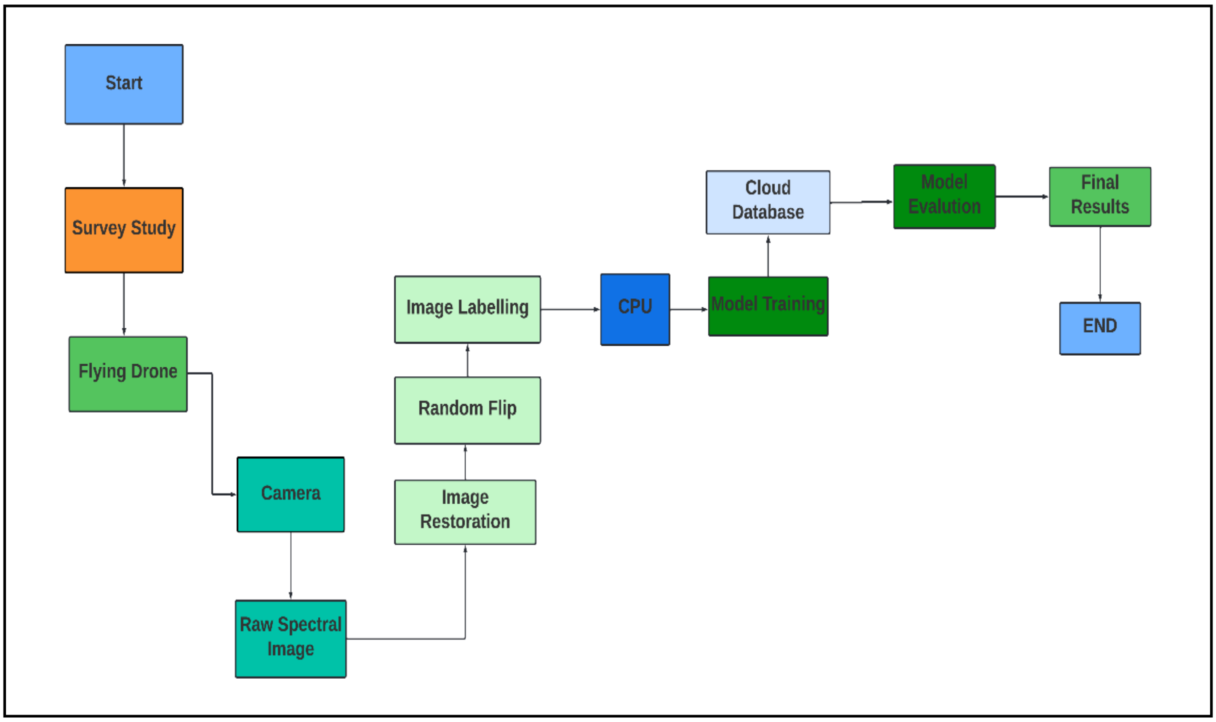


Figure 3: Flying Drone Approach

2.3 Describe multiple design approach

2.3.1 Overview of Design Approach 1: Satellite Approach

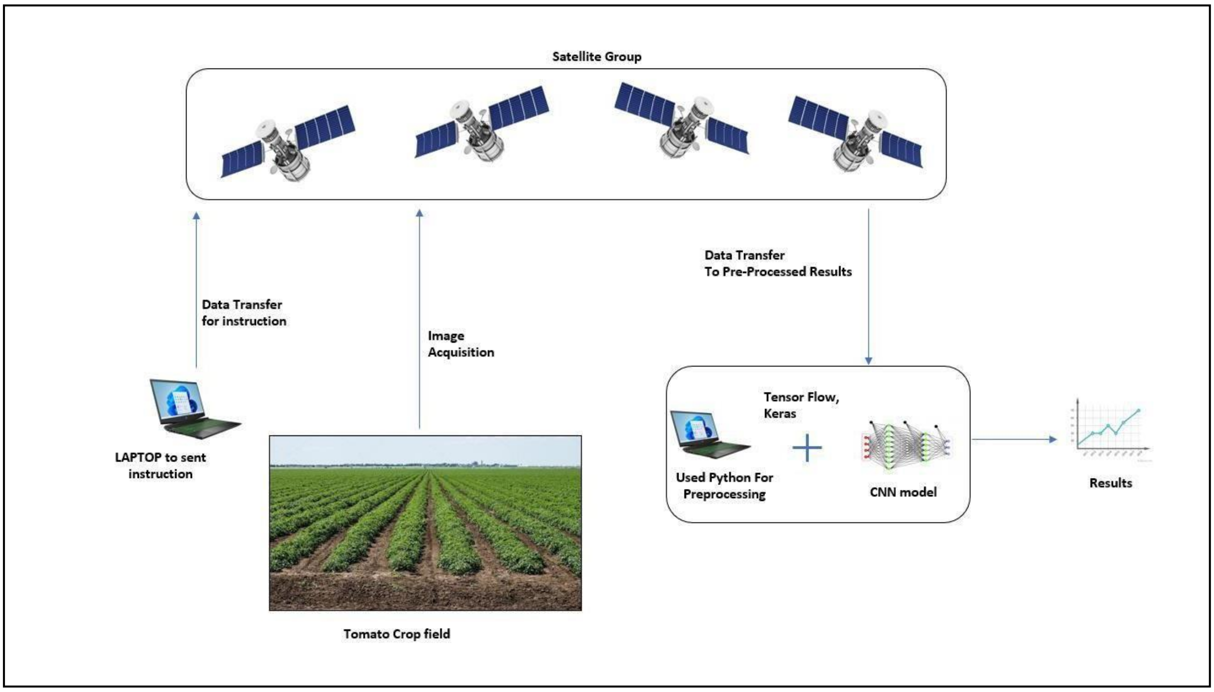


Figure 4: Diagram for the Overview of Satellite Crop Monitoring Approach

Satellite crop monitoring approach using machine learning with image processing involves the use of satellite imagery to monitor and analyze crops' growth and health. The approach employs machine learning algorithms to process and analyze satellite images, which provide information about crop health, vegetation growth, and other key parameters.

The process begins with the acquisition of satellite imagery, which is often collected on a regular basis to track changes in crop health over time. Image processing techniques are then used to clean and enhance the images, making it easier to extract meaningful data. Machine learning algorithms are then used to analyze the images and extract key features, such as crop type, vegetation density, and soil moisture content.

The resulting data can be used to generate a range of crop monitoring and management insights, including identifying areas of crop stress, predicting crop yields, and assessing the impact of environmental factors such as drought or flooding. This information can be used by farmers to optimize crop management practices, improve yields, and reduce environmental impact.

Furthermore, satellite crop monitoring using machine learning with image processing offers a powerful tool for improving crop management and increasing agricultural productivity. With the help of this technology, farmers can gain a better understanding of their crops' health and performance, leading to more efficient and sustainable agricultural practices.

2.3.2 Overview of Design Approach 2: Land-Based Rover Approach

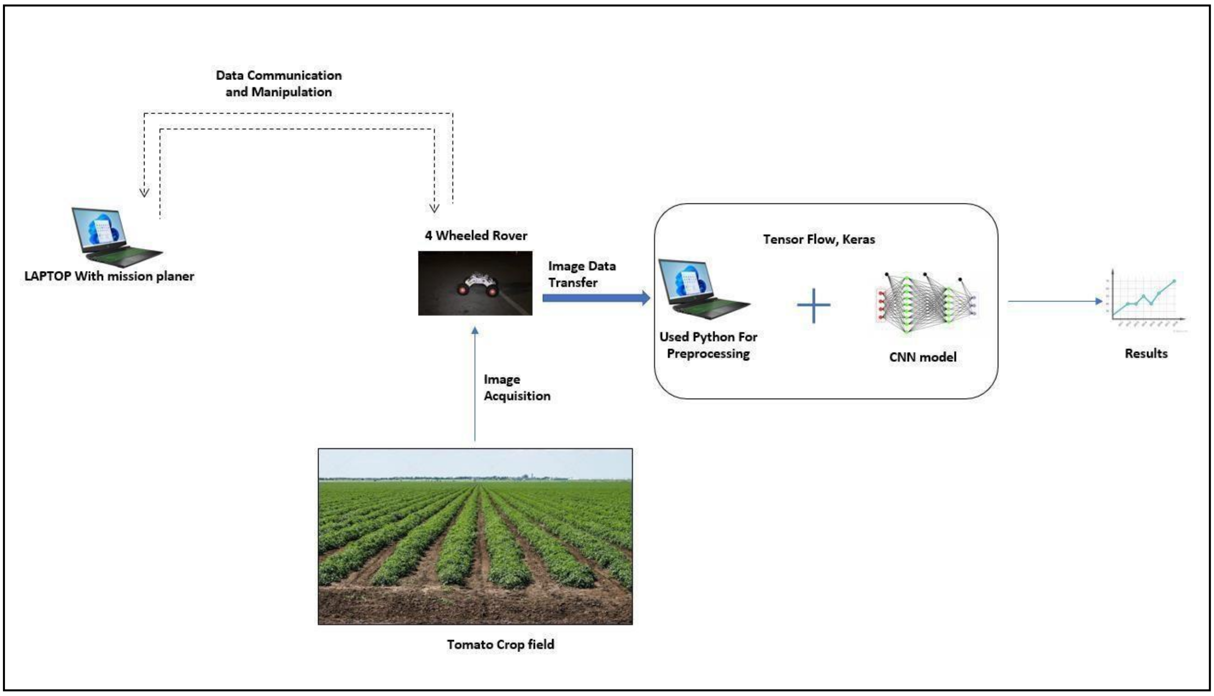


Figure 5: Diagram for the Overview of Land-based Rover Crop Monitoring Approach

Land-based rover crop monitoring approach using machine learning with image processing involves the use of robotic rovers equipped with cameras and sensors to collect data on crops. The rovers are programmed with machine learning algorithms that use image processing techniques to analyze the data and provide insights into crop health, growth, and other key parameters.

The rovers are equipped with high-resolution cameras that capture images of the crops at regular intervals, often several times per day. These images are then processed using image processing techniques, such as image segmentation, object detection, and feature extraction, to extract relevant data from the images.

Machine learning algorithms are then applied to the extracted data to analyze the crops' health, growth, and other key parameters. These algorithms can identify patterns and anomalies in the data, which can be used to generate insights into crop performance.

The resulting data can be used by farmers to optimize crop management practices, such as adjusting irrigation or fertilization schedules, identifying pest or disease outbreaks, and predicting crop yields. This information can help farmers make data-driven decisions to improve crop productivity and reduce environmental impact.

Overall, land-based rover crop monitoring using machine learning with image processing offers a powerful tool for precision agriculture. With the help of this technology, farmers can gain a more comprehensive understanding of their crops' health and performance, leading to more efficient and sustainable agricultural practices.

2.3.3 Overview of Design Approach 3: Flying Drone Approach

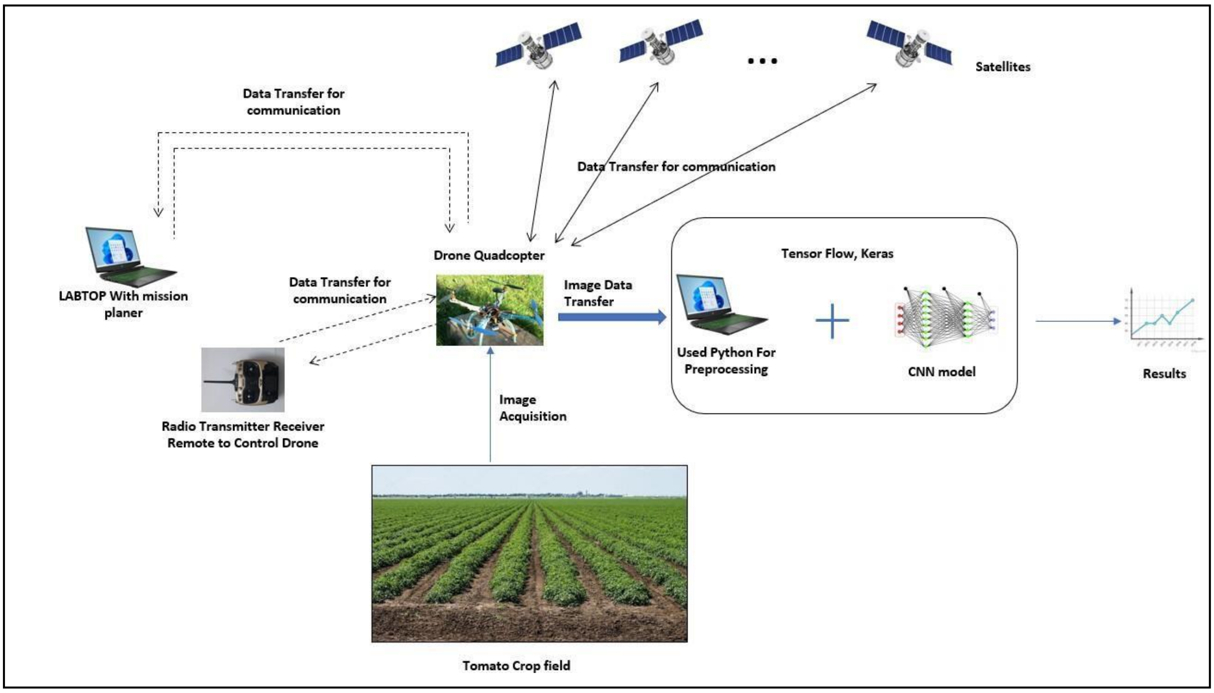


Figure 6: Diagram for the Overview of Drone Crop Monitoring Approach

Unmanned aerial vehicles (UAVs) or drones equipped with cameras and sensors are used in the drone crop monitoring strategy that combines machine learning with image processing to gather data on crops. The drones are equipped with machine learning algorithms that evaluate the data using image processing methods in order to gain knowledge about the health, growth, and other important aspects of the crops.

Many times, per day, the drones fly over the crops and take high-resolution pictures of the fields at regular intervals. Then, in order to extract pertinent information from the photos, image processing techniques including image segmentation, object detection, and feature extraction are used.

The health, growth, and other important factors of the crops are then analyzed using machine learning algorithms on the retrieved data. The data can be analyzed using these algorithms to find trends and anomalies that can be utilized to create insights regarding the performance of crops. Farmers can make the most of crop management strategies by using the obtained data to alter irrigation or fertilization schedules, spot pest or disease outbreaks, or forecast crop yields. Farmers can use this information to support data-driven decisions that increase crop output while minimizing environmental impact.

Using machine learning and image processing, drone crop monitoring is a potent tool for precision agriculture. Farmers can develop more effective and sustainable agricultural methods with the aid of this technology by gaining a more thorough grasp of the health and performance of their crops. Drones are a more effective way to monitor crops since they can cover more crop fields in less time than land-based methods.

2.4 Analysis of multiple design approach

Table 8: Analysis of Multiple Design Approach

Parameter of assessment	**Design 1**	**Design 2**	**Design 3**
Data Collection Rate	Fast	Fast	Very Fast
Ease of Mobility	Mobile in fixed orbits	Moderate but problematic	Very Mobile and Convenient
Budget	Highest	High as some parts for rover require to be made manually from scratch	Comparatively Lowest as parts of drone are
Manpower	Humans are required to operate control room	Low as one human is required for drone manipulation	Low as one human is required for drone manipulation
Damage Possibility	Damage is due to space debris is likely as medium is space	Sensors and Camera are more likely to be damaged as rover is mobile	Less Likely to be damaged
Convenance of Data Collection	Data is collected with a greater degree of freedom with a mobile rover	Data is collected with a greater degree of freedom with a mobile rover	Data Collection at Different Levels

2.4.1 Design Comparison Subsequent to Simulation with respect to internal and external parameters:

Table 9: Design Comparison Subsequent to Simulation with Respect to Internal and External Parameters

	Assessment of Parameters	**Design 1**	**Design 2**	**Design 3**
External Environment parameters	Wind Condition	No Simulation	Effect due to wind is small due to it being very wind resistant	Issues minor and negligible innormal wind conditions but effect in terrible weather condition (where it is usually notused)
	Humidity	No Simulation	Nil	Minor
	Temperature	No Simulation	Nil	Nil
	Land Unevenness	No Simulation	Effected	Unaffected
	Mist	No Simulation	Slightly Effected	Slightly More Effected
	Mud and Debre of land build up	No Simulation	Significant affectedin mobility	No effect due to it being flightbased
	Communication Disturbance	No Simulation		
Internal Environment parameters	Overheating	No Simulation	Likelihood higher	Likelihood Lower
			Damage to Components: higher likelihood	Damage to Components: lowerlikelihood
			Low power electrical components at greater risk	Lower risk for low Powerelectrical Components
			High power Electrical components at lower risk but higher compared to design3	High power Electrical components at lower risk but lower compared to design 2

2.4.2 Design Comparison Subsequent to Finalization of analysis and understanding specific Types of Parameters upon simulation of Multiple design solution:

Table 10: Design Comparison Subsequent to Finalization of Analysis and Understanding Specific Types of Parameters upon Simulation

Parameters of Assessment	**Design 1**	**Design 2**	**Design 3**
Cost	Highest	High	Lowest
Efficiency	Inefficient	Efficient	Most Efficient
Usability	Not Usable	Usable	Usable
Manufacturability	Not Manufacturable	Difficult to do so	Easy to do so
Impact	No Impact	Large Impact	Highest Impact on all areas
Sustainability	Not Sustainable	Fairly Sustainable	Very Sustainable
Maintainability	Not Maintainable	Fairly	Easiest Comparatively
Degrees of freedom	No Simulation	Four-Degrees	Six-Degree
Battery Power Duration	No Simulation	Lasts for a shorter time	Last for longer time
Battery Power Requirement	No Simulation	Maximum battery power largest	Comparatively lowest
Number of Subsystems involved	N/A	Small Numbers of subsystems	Larger number of subsystems
Performance	N/A		

2.4.3 Design Comparison Subsequent to Simulation with respect to Nature and Properties of Each Design

Table 11: Design Comparison Subsequent to Simulation with respect to Nature and Properties

Parameters of Assessment	Design 1	Design 2	Design 3
Cost	High	Moderate	Low
Efficiency	Inefficient	Efficient	Most Efficient
Usability	Not Usable	Usable	Usable
Manufacturability	Not Manufacturable	Difficult to do so	Easy to do so
Impact	No Impact	Large Impact	Highest Impact on all areas
Sustainability	Not Sustainable	Fairly Sustainable	Very Sustainable
Maintainability	Not Maintainable	Fairly	Easiest Comparatively

<u>**Cost:**</u>

Design 1:
The Cost of renting a satellite transponder is expensive and essentially is known to be so much so it makes majority of the budget and hence the majority of the cost.

Design 2:
Certain of the parts are known to be custom made however for the more powerful motors the value of motors in cost is very high essentially despite the lower number of subsystems.

Design 3:
Nonvalue of motors in cost is very high essentially despite the lower number of subsystems.

<u>**Efficiency:**</u>

Design 1:
Cannot be simulated and is not feasible therefore in this case the efficiency in terms of mechanical as well as power related cannot be determined and hence is this multiple

Design 2:
In terms of the particular mechanical efficiency, it is understood that the 4 wheeled rover is fairly efficient though not as much as the. However, when it comes to the efficiency of the component energy efficiencies as well as the overall energy efficiency, it is less efficient compared to the particular Drone of Design Approach 3.

Design 3:
In terms of the particular mechanical efficiency, it is understood that the Quadcopter drone is very efficient. Additionally, when it comes to the efficiency of the component energy efficiencies as well as the overall energy efficiency, it is less efficient compared to the Drone of Design Approach 3.

Usability:

Intuitive design: a near-effortless comprehension of the system's architecture and navigation.

Ease of learning: how quickly and conveniently can an entity using it be experienced and used to and knowable in using it.

Efficiency of use: How fast the user can accomplish tasks.

Error frequency and severity: how frequent are errors formed when the system is in use, the severity of errors that are made how users recover from the errors.

Subjective satisfaction: Should customer satisfaction be achieved by the system**.**

Design 1:
No simulation therefore no data on understanding the usability.

Design 2:
Design is intuitive and ease of use and learning is there but there is the issue of efficiency of use as data collection rate is slower. In other words, efficiency of use is low compared to Design 3. Errors are more frequent collection through land-based means and terrain is uneven and error Recovery involves more data collection time, to gather more quality data.

Design 3:
Design is more intuitive and is the easiest to use and the ease of learning is there additionally, there is the issue of efficiency of use where data collection rate is fastest. In other words, efficiency of use is highest compared to Design 2. Errors are less frequent due to the fact that data quality is higher as Design involved data collection through air-based means.

Manufacturability:

The "Design" itself: Going through a design making sure that the design adheres to good manufacturing principles.

Manufacturing Process: The second aspect of is to review the manufacturing process of the particular design so as to have all manufacturing processes be recognized of their limitations as well as their capabilities. To make the design robust, looking into the manufacturing process isrequired.

Material Selection: The material that is to be selected based on the performance criteria of the other parts.

Environmental Considerations: Its significance and impact on the environment.

Compliance Testing: All products are subjected to different compliance and testing standards whether they be ISO,ASM and or ASTM or different standards that have to be maintained and these need to be wellunderstood in order to conduct accurate Manufacturability test.

Design 1:
Not feasible hence not manufacturable.

Design 2:
The Design is manufacturable. The Design adheres to good manufacturing principles and standards that is necessary for it. Material and components selected are easily obtainable. Material Selection here is very crucial but here the performance of other parts criteria is in question. Its state, compared to Design 3, is less favorable due to the fact some components are required to be custom made from scratch and are always not, compatible with others. It adheres to most particular standards as well. Its impact on the environment adversely is minimum.

Design 3:
The Design is manufacturable. The Design adheres to good manufacturing principles and standards that is necessary for it. Material and components selected are easily obtainable. Material Selection here is very crucial and here the performance of other parts criteria influenced is more favorable due to the fact some components are indeed easily compatible with others. It adheres to all particular standards as well. Its impact on the environment adversely is minimum.

Impact:

Design 1:

There is no significant impact as there is no simulation of the design.

Design 2:

Through survey study it is found that there is a fairly large impact social cultural and societal as well as economic in case of Design 2.

Design 3:

Through survey study it is found that there is a huge impact social cultural and societal as well as economic in case of Design 3.

Sustainability:

Design 1:

The Sustainability of Design 1 is known to be not possible due to the fact that not only that this is not feasible but it is not possible to simulate it and therefore there is no relevance left for it to be sustainable.

Design 2:

The Design 2 is sustainable however, there is essentially a difference between it and Design 3 Where with accordance to SWOT box and the understanding of priorities, values and desirability it is fairly Sustainable.

Design 3:

The Design 3 is sustainable however, there is essentially a difference between it and Design 3 Where with accordance to SWOT box and the understanding of priorities, values and desirability it is very Sustainable.

Maintainability:

Corrective maintenance involves fixing issues. The amount of time needed to identify and resolve issues with a system may be used to gauge its maintainability.

Preventive maintenance: Actions taken for preventive maintenance to lower future maintenance expenditures. Actions to cut down on upcoming maintenance costs are meant by this.

Perfective maintenance: The work required to implement necessary system improvements can also be used to gauge a system's maintainability. This can be tested by keeping track of how long it takes to implement a new, recognizable piece of functionality, such as changing the database, etc. The average time should be determined after doing several comparable tests. The result will be that it is possible to put out the minimal amount of work necessary to accomplish the requested feature. This can be compared to a goal effort, and whether requirements are reached can be determined.

Adaptive maintenance: Adjusting to environmental changes. The effort necessary to make the necessary adjustments to a system can also be used to gauge its maintainability. This can be assessed using the perfective maintainability testing method previously mentioned.

Design 1:

According to Corrective maintenance, Perfective maintenance, Adaptive maintenance, and Preventive maintenance there is no maintainability of Design 1.

Design 2:

According to Corrective maintenance, Perfective maintenance, Adaptive maintenance, and Preventive maintenance it is fairly maintainable for Design 2.

Design 3:

According to corrective maintenance, Perfective maintenance, Adaptive maintenance and preventive maintenance design 3 is the easiest to maintain.

2.5 Conclusion

In conclusion, creating a crop monitoring system necessitates a methodical and well-planned strategy. Determining the scope and objectives, defining the issue and user needs, choosing the best technology, creating a strategy for data collecting, gathering the data, analyzing it, conveying the findings, and reviewing and iterating the system are all part of the process.

Essentially assessing through a thorough comparison of multiple design approaches the most optimum design solution is the drone crop monitoring system.

By adopting this strategy, you may create a crop monitoring system that offers insightful information on the health and productivity of crops, supports farmers in making wise decisions, and promotes sustainable agricultural practices.

Chapter 3: Use of Modern Engineering and IT Tool. [CO9]

3.1 Introduction

By using a variety of IT tools, we may extract the desired results from the simulation and assess them in a way that reveals the machine's efficiency. There is a plethora of resources available online, and numerous industry-standard programs can be used to get the job done as well. But, before using a tool, it is important to learn as much as possible about it and evaluate its accuracy. We did our homework, compared several alternatives, and settled on the best combination of hardware and software for our needs.

3.2 Select Appropriate Engineering and IT Tools

Table 12: List of Selected Engineering IT Tools

Hardware	Software
Pixhawk PX4 Autopilot PIX 2.4.8 32 Bit Flight Controller Update Barometer	ROS (robot operating system)
Ublox NEO 8M GPS module with Compass and Antenna	Gazebo
Original DJI 2312A 800KV BLDC Motors (4 pieces)	Jupyter Notebook
S500 Glass Fiber Quadcopter Frame	TensorFlow (Python Library)
1045 Self-locking Propellers (2 CW, 2 CCW)	Keras (Python Library)
APM 2.6 Pixhawk Power Module	Matplotlib (Python Library)
Lipo Battery 2200mAh 3S 25C	Numpy (Python Library)
APM Shock Vibration Absorber	OpenCV (Python Library)
Skydroid Mini OTG Receiver 5.8G 150CH Mini FPV Receiver	Flask API (Python Library)
Original Caddx Turbo EOS2 1200TVL CMOS FPV Camera	CNN (Convolutional Neural Network) Algorithm
HSKRC BLHeli_S 2-4S 30A ESC (4pieces)	HTML & CSS
B3 Pro Lipo Balance Charger	Django (Python Framework)
FPV Radio Telemetry Kit 433Mhz 100mW For APM /Pixhawk	Mission Planner Software
Radiolink AT9S Pro 2.4GHz RC Transmitter and Receiver	

3.3 Use of Modern Engineering and IT tools:

<u>Hardware Section:</u>

Essentially the following are the Hardware Components Required:

- Pixhawk PX4 Autopilot PIX 2.4.8 32 Bit Flight Controller Update Barometer
- Ublox NEO 8M GPS module with Compass and Antenna
- Original DJI 2312A 800KV BLDC Motors (4 pieces)
- S500 Glass Fiber Quadcopter Frame
- 1045 Self-locking Propellers (2 CW, 2 CCW)
- APM 2.6 Pixhawk Power Module
- Lipo Battery 2200mAh 3S 25C
- APM Shock Vibration Absorber
- Skydroid Mini OTG Receiver 5.8G 150CH Mini FPV Receiver
- Original Caddx Turbo EOS2 1200TVL CMOS FPV Camera
- HSKRC BLHeli_S 2-4S 30A ESC (4pieces)
- B3 Pro Lipo Balance Charger
- FPV Radio Telemetry Kit 433Mhz 100mW For APM /Pixhawk
- Radiolink AT9S Pro 2.4GHz RC Transmitter and Receiver

Here the B3 Li-Po battery charger is not a component direct associated to be involved to be a part of the quadcopter drone when parts are to be assembled and then calibrated to form it for the prototype i.e. the optimal design approach in the association and assembly. Hence a second, list is provided that indicates only those components that consists of ones that are, indeed directly associated.

However, the Components that are to be assemble and calibrated to form the Quadcopter Drone of the Design 3 Approach are as Follows:

- Pixhawk PX4 Autopilot PIX 2.4.8 32 Bit Flight Controller Update Barometer
- Ublox NEO 8M GPS module with Compass and Antenna
- Original DJI 2312A 800KV BLDC Motors (4 pieces)
- S500 Glass Fiber Quadcopter Frame
- 1045 Self-locking Propellers (2 CW, 2 CCW)
- APM 2.6 Pixhawk Power Module
- Lipo Battery 2200mAh 3S 25C
- APM Shock Vibration Absorber
- Skydroid Mini OTG Receiver 5.8G 150CH Mini FPV Receiver
- Original Caddx Turbo EOS2 1200TVL CMOS FPV Camera
- HSKRC BLHeli_S 2-4S 30A ESC (4pieces)
- FPV Radio Telemetry Kit 433Mhz 100mW For APM /Pixhawk
- Radiolink AT9S Pro 2.4GHz RC Transmitter and Receiver

Pixhawk PX4 Autopilot PIX 2.4.8 32 Bit Flight Controller:

The Pixhawk PX4 Autopilot PIX 2.4.8 32 Bit Flight Controller is a microcontroller-based device designed to provide advanced control and stability to quadcopters and other unmanned aerial vehicles (UAVs). The major functions of the Pixhawk PX4 Autopilot:

- **Flight Control:** The Pixhawk PX4 Autopilot is responsible for controlling the flight of the quadcopter. It receives sensor data from various sources such as GPS, accelerometers, gyroscopes, and magnetometers, and processes this data to determine the orientation, position, and speed of the quadcopter. It then uses this information to adjust the rotational speed of the motors to maintain stability and balance during flight.
- **Navigation:** The Pixhawk PX4 Autopilot is equipped with a GPS module that provides accurate location data to the flight controller. This allows the quadcopter to navigate to specific waypoints and follow predetermined flight paths. It can also adjust its flight path in real-time to avoid obstacles or adjust to changing environmental conditions.
- **Autonomous Flight:** The Pixhawk PX4 Autopilot has advanced autonomous flight capabilities, allowing the quadcopter to fly without direct human control. This is achieved through the use of advanced algorithms and programming, allowing the quadcopter to perform tasks such as takeoff, landing, and waypoint navigation automatically.
- **Communication:** The Pixhawk PX4 Autopilot can communicate with other devices such as ground control stations and telemetry systems through wireless connections. This allows the operator to monitor the status and performance of the quadcopter in real-time and adjust flight parameters as needed.
- **Payload Control:** The Pixhawk PX4 Autopilot can also control the payload of the quadcopter, such as cameras or sensors used for data acquisition. It can adjust the orientation of the camera or activate the sensors at specific times during the flight, ensuring that the data is collected accurately and efficiently.

Moreover, the Pixhawk PX4 Autopilot is a powerful and versatile flight controller that provides advanced control, stability, and autonomy to quadcopters and other UAVs.

Now, in the context of for the **Prototype** Designed**:**

The Pixhawk PX4 Autopilot PIX 2.4.8 32 Bit Flight Controller serves as the main most important major controlling component of the quadcopter, responsible for controlling its flight and navigation, as well as the collection of data from sensors and cameras mounted on the drone. Here are the key functions of the Pixhawk PX4 Autopilot in this scenario:

1. **Flight Planning:** The Pixhawk PX4 Autopilot can be used to plan and execute flight paths for the quadcopter to ensure that it covers the entire area of interest for leaf disease detection. The autopilot can be programmed to fly a pre-determined path at a specific altitude and speed to optimize the collection of data from the onboard sensors and cameras.

2. **Sensor Data Collection:** The Pixhawk PX4 Autopilot can collect data from sensors such as GPS, accelerometers, and gyroscopes, which can be used to determine the precise location, orientation, and movement of the quadcopter. This information can be used to correct for any drift or error in the position or orientation of the camera, which can improve the accuracy of the image processing algorithms.

3. **Camera Control:** The Pixhawk PX4 Autopilot can control the orientation of the camera mounted on the quadcopter to ensure that it captures images of the entire area of interest. The camera can be programmed to take images at specific intervals or when triggered by a particular event or condition, such as the presence of a particular type of leaf disease.

4. **Data Transfer:** The Pixhawk PX4 Autopilot can transfer data collected by the sensors and cameras to a ground station or computer for further processing and analysis. This can be done in real-time or after the flight has been completed.

5. **Autonomous Flight:** The Pixhawk PX4 Autopilot can be programmed to fly autonomously, allowing the quadcopter to fly over large areas and collect data without the need for direct human control. This can be particularly useful for covering large areas of agricultural land or forests where manual monitoring would be time-consuming and expensive.

Overall, the Pixhawk PX4 Autopilot is a critical component in the leaf disease detection data acquisition phase of the design, providing advanced control, stability, and autonomy to the quadcopter, ensuring that it can collect accurate data from the sensors and cameras mounted on the drone.

Ublox NEO 8M GPS module with Compass and Antenna:

The Ublox NEO 8M GPS module with Compass and Antenna is an important component of the quadcopter for leaf disease detection during the data acquisition phase. This GPS module is responsible for providing accurate and reliable GPS coordinates to the quadcopter. It comes with a built-in compass that provides the direction of the quadcopter's orientation. This helps the quadcopter to navigate and maintain its position accurately. One of the key features of the Ublox NEO 8M GPS module is its high accuracy. It can track up to 3 satellites at the same time and provides location data with an accuracy of up to 2.5 meters. This makes it ideal for outdoor use, especially in areas with open skies. Its high accuracy ensures that the quadcopter can capture precise location data for the leaf disease detection process.

Another advantage of the Ublox NEO 8M GPS module is its fast update rate. It has a refresh rate of up to 10 Hz, which means that it can update the location data ten times in a second. This is crucial for the quadcopter to maintain accurate positioning during its flight. The fast update rate ensures that the quadcopter can quickly and accurately adjust its position as it moves through the field, capturing location data for the leaf disease detection process.

Therefore, the Ublox NEO 8M GPS module with Compass and Antenna plays a critical role in the quadcopter's data acquisition phase for leaf disease detection. Its high accuracy and fast update rate ensure that the quadcopter can capture precise location data while maintaining accurate positioning during its flight.

Integration with Flight Controller:

The Ublox NEO 8M GPS module with Compass and Antenna is a crucial component for the quadcopter's flight control system. The module provides accurate location data that is used by the flight controller to determine the quadcopter's position, altitude, and speed. With the help of this information, the flight controller can navigate the quadcopter to a specific location, such as a field of crops, and keep it stable in the air. The module also includes a compass that allows the flight controller to know the quadcopter's orientation, which is necessary for stable flight.

The Ublox NEO 8M GPS module is also important for the data acquisition phase of leaf disease detection. The module provides accurate GPS data that is used to geotag the images captured by the quadcopter's camera. This data allows for the precise mapping of the area being surveyed, which is critical for identifying the location of diseased plants. Additionally, the GPS data can be used to create detailed maps of the crop field, which can aid in future crop management decisions. The compass also plays a crucial role in ensuring that the quadcopter flies in the correct direction during the survey, which helps to ensure that the entire field is thoroughly surveyed.

The Ublox NEO 8M GPS module with Compass and Antenna works in conjunction with the Pixhawk flight controller to provide precise and stable flight control. The GPS data provided by the module is used by the Pixhawk to calculate the quadcopter's position and altitude, which are used to adjust the quadcopter's flight path in real-time. The compass data is used by the Pixhawk to know the quadcopter's orientation, which helps to ensure that it flies in the correct direction. By working together, the GPS module and the Pixhawk flight controller ensure that the quadcopter is stable and responsive, even in challenging flying conditions.

Skydroid Mini OTG Receiver 5.8G 150CH Mini FPV Receiver:

The Skydroid Mini OTG Receiver is a compact and lightweight FPV receiver that is designed to work with most Android devices. It operates at a frequency range of 5.8G and can receive signals from up to 150 different channels, making it highly versatile and capable of picking up signals from a wide range of sources. The receiver features a USB interface, which allows it to be easily connected to an Android device using an OTG cable.

One of the main benefits of the Skydroid Mini OTG Receiver is its small size and portability. It can easily fit in a pocket or backpack and can be taken with you wherever you go. This makes it a great option for anyone who needs to travel light and doesn't want to carry around a bulky receiver.

Another advantage of the Skydroid Mini OTG Receiver is its compatibility with most Android devices. This makes it a versatile option that can be used with a variety of different devices, including smartphones and tablets.
The receiver also has a high-quality video output, which ensures that you get clear and smooth video footage even when you're flying at high speeds or in challenging conditions. This is especially important for FPV flying, where clear and reliable video is essential for a safe and enjoyable flying experience.
In addition to its compact size and high-quality video output, the Skydroid Mini OTG Receiver is also very easy to use. It requires no special software or drivers, and can be quickly and easily connected to your Android device using an OTG cable.

Parameter to assess the Skydroid Mini OTG Receiver:

- Frequency range: 5.8G
- Number of channels: 150
- Compatibility: Android devices with OTG support
- Video output quality: High-quality video output for clear and smooth video footage
- Interface: USB interface for easy connection to Android devices
- Size and portability: Compact and lightweight for easy transport and use on the go
- Ease of use: No special software or drivers required for easy setup and use.

Overall, the Skydroid Mini OTG Receiver is a great choice for anyone looking for a compact, portable, and easy-to-use FPV receiver that offers high-quality video output and wide compatibility with most Android devices. Its small size and versatility make it a great option for anyone who needs to travel light or wants a receiver that can be used with a variety of different devices.

Original DJI 2312A 800KV BLDC Motors (4 pieces):
The quadcopter uses the combination of the 2 CW and 2 CCW motors to maintain stability and maneuverability during flight. The motors are arranged in pairs, with one CW and one CCW motor rotating in opposite directions to cancel out the torque generated by each other. During takeoff, the quadcopter uses the motor's rotational speed to generate lift and gain altitude.

By increasing the speed of one set of motors (for example, the CW motors) and decreasing the speed of the other set (the CCW motors), the quadcopter can pitch forward or backward. Similarly, by increasing the speed of one set of motors while decreasing the other, the quadcopter can roll to the left or right.
To turn, the quadcopter uses differential thrust, where it increases the speed of one set of motors while decreasing the other, causing the quadcopter to yaw (rotate around its vertical axis). This combination of movements allows the quadcopter to move in any direction and maintain stability and balance during flight.

During the data acquisition phase for the Drone Crop Monitoring System, the quadcopter uses the 2 CW and 2 CCW motors to maintain a stable and controlled flight path. The motors' ability to rotate at different speeds and directions allows the quadcopter to adjust its orientation and maintain its position in the air while capturing images of the plants below. This stable and controlled flight path is important for capturing clear and accurate images for disease detection and analysis.

When it comes to data acquisition for Design Approach 3 the Optimal Design Solution, the use of 2 clockwise (CW) and 2 counterclockwise (CCW) motors can have several significant benefits:

- **Stability:** Quadcopters rely on the rotational speed of their motors to maintain stability and balance in flight. By using both clockwise and counterclockwise motors, the quadcopter can maintain balance and stability in all directions.

- **Maneuverability:** The use of both CW and CCW motors allows the quadcopter to perform complex maneuvers and change direction quickly and smoothly. This is especially important when flying close to plants to capture images for disease detection.

- **Image capture:** The quadcopter's ability to remain stable and maneuverable with the use of CW and CCW motors can help ensure that the images captured for disease detection are clear and in focus, allowing for more accurate analysis and diagnosis.

- **Redundancy:** Having both CW and CCW motors also provides a level of redundancy in case of motor failure. If one motor fails, the quadcopter can still remain stable and fly with the other three motors.

Overall, the use of 2 CW and 2 CCW motors in a quadcopter can provide important benefits for data acquisition in case of the Prototype that is to be designed, helping to provide assurance of stable flight, accurate image capture, and increased reliability.

S500 Glass Fiber Quadcopter Frame

In the context of Data Acquisition Phase, the S500 Glass Fiber Quadcopter Frame's durability and compatibility make it an excellent choice. The frame's durability ensures that it can withstand the stresses and impacts of flying in different environments, which is important during data acquisition flights that can take place in different weather conditions and terrains.

Additionally, the S500 frame's compatibility with a wide range of motor sizes makes it a suitable frame for carrying the necessary equipment for leaf disease detection, such as the camera, GPS module, and telemetry kit. The frame's lightweight construction also helps to improve the quadcopter's flight performance and endurance, which is essential for capturing high-quality images during the data acquisition phase.

Furthermore, the S500 frame's vibration damping feature helps to reduce the impact of vibrations on the quadcopter's components, such as the camera, which is essential for capturing clear images during flights. The frame's ample space for mounting various components, such as the flight controller, GPS module, and battery, also makes it easy to customize and upgrade the quadcopter according to specific data acquisition needs.

1045 Self-locking Propellers (2 CW, 2 CCW):
The 1045 Self-locking Propellers are designed to provide high efficiency and stable performance during flight, which is essential for capturing clear images during data acquisition. The use of 2 CW and 2 CCW propellers is to ensure balanced thrust and stability during flight. The propellers work in tandem with the motor to provide lift and thrust, which is essential for the quadcopter's overall performance.
Parameters that make the 1045 Self-locking Propellers a good choice for data acquisition include their length of 10 inches, which provides high thrust and stability during flight, and their self-locking design, which ensures easy installation and removal. The propellers are made of high-quality materials that are durable and can withstand wear and tear during flight.

The parameters of the 1045 Self-locking Propellers:

- **Length**: 10 inches
- **Type**: Self-locking propellers
- **Quantity**: 4 (2 CW, 2 CCW)
- **Purpose:** Provide high efficiency and stable performance during flight for data acquisition
- **Balance:** Ensures balanced thrust and stability during flight
- **Function:** Work in tandem with the motor to provide lift and thrust
- **Material:** Made of high-quality, durable materials
- **Wear and tear:** Capable of withstanding wear and tear during flight
- **Installation:** Self-locking design ensures easy installation and removal

These parameters make the 1045 Self-locking Propellers a good choice for data acquisition, as they provide the necessary stability and thrust for capturing clear images during flight. The self-locking design also makes them easy to install and remove, which is a crucial feature for quadcopter enthusiasts who want to save time during the assembly process. The durable materials used in their construction ensure that they can withstand wear and tear during flight, making them a reliable and long-lasting option.

APM 2.6 Pixhawk Power Module:
The APM 2.6 Pixhawk Power Module is a high-quality power module that is designed to provide stable and reliable power to your quadcopter. This module can handle up to 10A of current and provides a voltage range of 6-36V, making it ideal for use with a variety of different batteries. The module also features a built-in DC/DC converter, which ensures that the power supplied to the APM is clean and stable.

In addition, the module has a built-in 90A current sensor, which can be used to monitor the current being supplied to the APM. This feature is particularly important for quadcopter enthusiasts who want to ensure that their system is functioning optimally and to prevent any potential damage caused by overloading or underloading. The APM 2.6 Pixhawk Power Module is a reliable and efficient power source that can help ensure stable and smooth performance for your quadcopter. With its high-quality design and advanced features, it is a great choice for anyone who wants to take their quadcopter experience to the next level.

The parameters of the APM 2.6 Pixhawk Power Module:

- **Maximum current: 10A**
- **Voltage range: 6-36V**
- **Built-in DC/DC converter: Provides clean and stable power to the APM**
- **Built-in 90A current sensor: Monitors the current being supplied to the APM**

These parameters make the APM 2.6 Pixhawk Power Module a reliable and efficient power source for quadcopters. Its ability to handle up to 10A of current and provide a voltage range of 6-36V makes it compatible with a wide range of batteries, which is crucial for quadcopter enthusiasts who want to customize their power supply. The built-in DC/DC converter ensures that the power supplied to the APM is clean and stable, which is essential for the proper functioning of the quadcopter. Additionally, the built-in 90A current sensor can be used to monitor the current being supplied to the APM, which can help prevent damage to the system and ensure its longevity. Overall, the APM 2.6 Pixhawk Power Module is a high-quality power source that can help ensure stable and reliable performance for your quadcopter.

Quadcopter Frame and the Power Module:

The S500 Quadcopter frame being highly a durable and lightweight in frame that hence upon providing stability and maneuverability during flight, its unique design provides allowance for easy installation of various components, such as the power module, motor, and electronic speed controller. The frame is additionally, compatible with wide variety of different flight controllers, including the APM 2.6 Pixhawk.

Now, for the APM 2.6 Pixhawk Power Module, as previously mentioned, is a high-quality power module that provides stable and reliable power to the quadcopter. Its ability to handle up to 10A of current and provide a voltage range of 6-36V makes it an ideal power source for the S500 quadcopter frame. The built-in DC/DC converter ensures that the power supplied to the APM is clean and stable, while the built-in 90A current sensor allows for real-time monitoring of power consumption, ensuring that the system operates within safe limits.

When used together, the S500 quadcopter frame and the APM 2.6 Pixhawk Power Module can provide a stable and reliable quadcopter system that is easy to assemble and customize. The compatibility of these two components allows for a seamless integration and optimal performance during flight, making them a popular choice among hobbyists and professionals alike.

Lipo Battery 2200mAh 3S 25C:

The Lipo Battery 2200mAh 3S 25C is an important component in the leaf disease detection system, as it provides power to the quadcopter during flight. The battery's compact size and high energy density make it an ideal choice for powering small unmanned aerial vehicles like quadcopters. The battery's 2200mAh capacity and 3S configuration provide enough power to keep the quadcopter in the air for a reasonable amount of time, while the 25C discharge rate ensures that the battery can provide the high current required by the quadcopter's motors and other components.

During the data acquisition phase of the leaf disease detection system, the quadcopter is flown over the field of crops to capture images of the plants using the onboard camera. The battery powers the quadcopter's motors and other components, allowing it to fly and maneuver in the air. The battery voltage is monitored by the APM 2.6 Pixhawk Power Module to ensure that the battery does not become over-discharged or damaged during flight. The battery is also equipped with a balance connector, which allows it to be charged using the B3 Pro Lipo Balance Charger.

The Lipo Battery 2200mAh 3S 25C is securely mounted to the quadcopter frame using the included battery strap, which ensures that the battery does not move or shift during flight. The battery is also protected by a hard plastic case, which helps to prevent damage from impacts or crashes. Additionally, the battery is equipped with a set of XT60 connectors, which provide a secure and reliable connection to the quadcopter's power distribution board.

Overall, the Lipo Battery 2200mAh 3S 25C is an essential component of the leaf disease detection system, providing the necessary power to keep the quadcopter in the air during data acquisition. Its compact size, high energy density, and high discharge rate make it an ideal choice for powering small unmanned aerial vehicles like quadcopters.
Parameters to consider when assessing the Lipo Battery 2200mAh 3S 25C:

- **Capacity:** The capacity of the battery refers to the amount of energy it can store. In this case, the Lipo Battery 2200mAh 3S 25C has a capacity of 2200mAh, which means it can provide a current of 2.2 amps for 1 hour.
- **Voltage:** The voltage of the battery is another important parameter. The Lipo Battery 2200mAh 3S 25C has a nominal voltage of 11.1V, which is suitable for powering the quadcopter.
- **Discharge Rate:** The discharge rate is the maximum current that the battery can provide. The Lipo Battery 2200mAh 3S 25C has a discharge rate of 25C, which means it can provide a current of 55 amps (25C x 2.2Ah) continuously.
- **Cell Count:** The Lipo Battery 2200mAh 3S 25C has a 3-cell configuration, which is denoted by the "3S" in the name. This means the battery has 3 lithium polymer cells connected in series to provide a nominal voltage of 11.1V.
- **Connector Type:** The battery comes with a JST-XH balance connector and a Deans T-connector for power delivery.

Overall, the Lipo Battery 2200mAh 3S 25C is an ideal choice for the leaf disease detection quadcopter as it provides a high discharge rate of 25C, which ensures a stable and reliable power supply to the quadcopter. The compact size and weight of the battery also make it easy to carry and install on the quadcopter. The 3-cell configuration and nominal voltage of 11.1V are suitable for powering the quadcopter's motors and electronics. The JST-XH balance connector and Deans T-connector make it easy to connect the battery to the quadcopter's power system.

APM Shock Vibration Absorber:

The APM Shock Vibration Absorber is a specially designed mount for the APM flight controller that helps to reduce the effects of vibration on the sensor readings. This is particularly important for quadcopters, which are prone to experiencing high levels of vibration during flight. The APM Shock Vibration Absorber is made from high-quality materials that provide both shock absorption and vibration damping, which helps to ensure that the APM is able to provide accurate sensor readings and stable flight control.

The APM Shock Vibration Absorber is designed to work specifically with the APM flight controller, making it an ideal accessory for quadcopters that use this controller. The mount is easy to install and features a flexible design that allows it to be used with a wide range of different frames and configurations.

The APM Shock Vibration Absorber features a high-quality rubber construction that provides excellent shock absorption and vibration damping. This helps to reduce the effects of vibrations on the APM flight controller, which can improve the accuracy of sensor readings and enhance flight stability.

The mount is designed to isolate the APM flight controller from the rest of the frame, which helps to prevent vibrations from being transmitted to the controller. This is particularly important for quadcopters, which are prone to experiencing high levels of vibration during flight.

The APM Shock Vibration Absorber is a lightweight and compact accessory that does not add significant weight to the quadcopter. This helps to ensure that the quadcopter remains agile and responsive during flight, even with the mount attached.

The APM Shock Vibration Absorber is compatible with a wide range of different quadcopter frames and configurations, making it a versatile accessory that can be used in a variety of different applications.

The mount is easy to install and can be quickly and easily removed if necessary. This makes it a convenient accessory that can be added or removed depending on the needs of the user. Overall, the APM Shock Vibration Absorber is an essential accessory for quadcopters that use the APM flight controller. It helps to improve the accuracy of sensor readings and enhance flight stability by reducing the effects of vibrations on the flight controller.

Parameters to assess APM Shock Vibration Absorber:

- **Material:** The quality of the material used in the mount is important in determining its shock absorption and vibration damping capabilities. High-quality rubber is preferred as it provides better vibration damping than other materials.
- **Compatibility:** The mount should be compatible with the APM flight controller and a wide range of different quadcopter frames and configurations.
- **Weight:** The mount should be lightweight and compact so as not to significantly add weight to the quadcopter.
- **Installation:** The mount should be easy to install and remove, making it a convenient accessory that can be quickly added or removed depending on the needs of the user. **Easy Installation:** Another advantage of the APM Shock Vibration Absorber is its easy installation. It can be easily mounted between the APM and the frame using the included hardware. This makes it easy to install even for those who are new to quadcopter assembly.

- **Cost-Effective:** Despite its many features, the APM Shock Vibration Absorber is also cost-effective. It is an affordable solution for those who want to reduce the vibration levels of their quadcopter and improve its performance without breaking the bank. In summary, the APM Shock Vibration Absorber is an important component of the quadcopter as it helps to reduce vibration levels, improve flight stability, and prevent damage to the APM. Its compact size, lightweight, and easy installation make it an ideal choice for quadcopter enthusiasts. Its cost-effectiveness also makes it accessible to those on a budget.

Overall, the APM Shock Vibration Absorber is a must-have for anyone who wants to improve the performance and durability of their quadcopter. As for the parameters to assess the APM Shock Vibration Absorber, here are some key ones:

- **Size and weight:** The APM Shock Vibration Absorber should be compact and lightweight to avoid adding extra weight to the quadcopter.
- **Material:** The material used to make the APM Shock Vibration Absorber should be sturdy and durable to withstand the vibrations and shocks that it will encounter during flight.
- **Vibration damping:** The APM Shock Vibration Absorber should have high vibration damping capabilities to effectively reduce vibration levels and improve flight stability.
- **Installation:** The APM Shock Vibration Absorber should be easy to install and should come with all the necessary hardware.
- **Compatibility:** The APM Shock Vibration Absorber should be compatible with the APM and the quadcopter frame to ensure proper functionality. By meeting these parameters, the APM Shock Vibration Absorber is an ideal choice for reducing vibration levels and improving the performance of quadcopters.

Original Caddx Turbo EOS2 1200TVL CMOS FPV Camera:

The Original Caddx Turbo EOS2 1200TVL CMOS FPV Camera is a small and lightweight camera that is designed for use in FPV quadcopters. It features a high-quality 1/3" CMOS sensor that provides a clear and stable image, even in low light conditions. The camera has a 2.1mm lens with a wide 160° field of view, which is ideal for capturing a wide view of the surroundings. The camera is designed with a durable plastic case that is resistant to impact and can withstand rough handling. It has a voltage range of 3.3V to 6V and consumes very little power, making it suitable for use with small batteries. The camera also has an adjustable OSD menu that allows the user to adjust the settings to their preferences. The camera's small size and lightweight design make it ideal for use in quadcopters, where weight and size are critical factors. The wide field of view allows the user to see more of the surroundings, making it easier to navigate through tight spaces and obstacles. The high-quality CMOS sensor provides a clear and stable image, which is essential for FPV flying, where a clear view of the surroundings is necessary.

Parameter to assess this camera and corresponding description:

- **Sensor**: The Caddx Turbo EOS2 camera features a high-quality 1/3" CMOS sensor that provides a clear and stable image even in low light conditions. The sensor resolution of 1200TVL ensures a high-quality image for FPV flying.
- **Lens**: The camera has a 2.1mm lens with a wide 160° field of view, which is ideal for capturing a wide view of the surroundings. The lens is adjustable and can be focused to suit the user's preferences.
- **Voltage range**: The camera has a voltage range of 3.3V to 6V and consumes very little power, making it suitable for use with small batteries. This is important for quadcopter design, as weight and size are critical factors.
- **OSD menu**: The camera has an adjustable OSD menu that allows the user to adjust the settings to their preferences. The OSD menu provides easy access to settings such as brightness, contrast, and color balance.
- **Case material**: The camera is designed with a durable plastic case that is resistant to impact and can withstand rough handling. This is important for quadcopter design, where the camera is subject to vibration and impact.

Overall, the Caddx Turbo EOS2 camera is a high-quality and reliable camera that is ideal for use in FPV quadcopters. Its small size and lightweight design, along with its wide field of view and high-quality sensor, make it an excellent choice for capturing clear and stable images during flight.

HSKRC BLHeli_S 2-4S 30A ESC (4pieces):

1. The HSKRC BLHeli_S 2-4S 30A ESC is a high-performance electronic speed controller designed for quadcopters. It has a compact and lightweight design, which makes it easy to install and use. The ESC features BLHeli_S firmware, which is known for its smooth and responsive throttle performance. The ESC also has a built-in 5V/2A BEC that provides stable power to the flight controller and other onboard electronics.
2. The HSKRC BLHeli_S 2-4S 30A ESC is designed to be used with a 2-4S LiPo battery, which makes it compatible with a wide range of quadcopters. The ESC has a continuous current rating of 30A and a peak current rating of 35A, which means it can handle high current loads without overheating. The ESC also features high-quality components, including MOSFETs and ceramic capacitors, which ensure long-lasting reliability and performance.
3. The HSKRC BLHeli_S 2-4S 30A ESC is equipped with advanced features that make it easy to use and customize. It has a programmable PWM frequency that can be adjusted to optimize motor performance. The ESC also has a startup power protection feature, which ensures that the motors do not start suddenly and cause damage to the quadcopter. Additionally, the ESC has a motor rotation feature that allows you to easily reverse the direction of the motor.
4. The HSKRC BLHeli_S 2-4S 30A ESC is compatible with a wide range of flight controllers, including the APM and Pixhawk. It can be easily connected to the flight controller using a three-wire servo cable. The ESC also has a convenient LED indicator that provides status information, including motor direction and ESC programming mode.
5. The HSKRC BLHeli_S 2-4S 30A ESC is an ideal choice for quadcopter builders who are looking for a high-performance, reliable, and customizable electronic speed controller. It is designed to provide smooth and responsive throttle performance, and it can handle high current loads without overheating. Additionally, the ESC has advanced

features that make it easy to use and customize.
6. The HSKRC BLHeli_S 2-4S 30A ESC is also an affordable option for quadcopter builders who are on a tight budget. It is priced competitively, making it an excellent value for its performance and features. The ESC is also widely available from many online retailers, making it easy to find and purchase.
7. In summary, the HSKRC BLHeli_S 2-4S 30A ESC is a high-performance electronic speed controller that is designed for quadcopters. It is compatible with a wide range of quadcopters and flight controllers, and it has advanced features that make it easy to use and customize. The ESC is also reliable and affordable, making it an ideal choice for quadcopter builders who are looking for a high-quality ESC at an affordable price.

FPV Radio Telemetry Kit 433Mhz 100mW For APM /Pixhawk:
The FPV Radio Telemetry Kit is an essential component of the quadcopter as it allows communication between the drone and the ground station. This particular kit operates at a frequency of 433MHz with a power output of 100mW. The telemetry data is transmitted wirelessly from the drone to the ground station, providing real-time data on the drone's status such as battery voltage, altitude, GPS coordinates, and more.

The kit consists of two components: a transmitter and a receiver. The transmitter is installed on the drone, while the receiver is connected to the ground station. The kit has a range of up to 1 kilometer, depending on the environmental conditions. The 433MHz frequency allows for a more reliable signal than higher frequency options.
One of the advantages of this kit is its compatibility with the APM and Pixhawk flight controllers, which are commonly used in the construction of drones. The kit also supports both MAVLink and FrSky telemetry protocols, making it a versatile option for different applications.

Parameter to assess this FPV Radio Telemetry Kit 433Mhz 100mW For APM /Pixhawk and the corresponding description --to hence deduce why is it used:
1. **Frequency:** The frequency determines the range and reliability of the telemetry data transmission. The FPV Radio Telemetry Kit operates at 433MHz, which is a lower frequency that allows for better penetration through obstacles and interference.
2. **Power output:** The power output determines the strength of the signal transmitted by the telemetry kit. The FPV Radio Telemetry Kit has a power output of 100mW, which provides a reliable signal up to 1 kilometer.
3. **Compatibility:** The kit's compatibility with the APM and Pixhawk flight controllers makes it a popular choice for drone enthusiasts and professionals alike. The kit also supports both MAVLink and FrSky telemetry protocols, making it versatile for different applications.
4. **Range:** The range is an important parameter to consider when selecting a telemetry kit. The FPV Radio Telemetry Kit has a range of up to 1 kilometer, depending on the environmental conditions.
5. **Telemetry data:** The FPV Radio Telemetry Kit provides real-time data on the drone's status, such as battery voltage, altitude, GPS coordinates, and more. This data is essential for monitoring the drone's performance and making informed decisions during the flight.

Overall, the FPV Radio Telemetry Kit is a crucial component of a drone's communication system. Its compatibility with popular flight controllers and support for different telemetry protocols make it a versatile option. The kit's 433MHz frequency and 100mW power output provide reliable telemetry data transmission up to 1 kilometer. The real-time data provided by the kit allows for informed decision-making during the flight, making it a valuable tool for drone enthusiasts and professionals.

Radiolink AT9S Pro 10/12 Channels 2.4GHz RC Transmitter and Receiver Mode 2:

The Radiolink AT9S Pro 2.4GHz RC Transmitter and Receiver is a high-quality, reliable remote control system that is designed to provide precise and responsive control of your quadcopter. It operates on a 2.4GHz frequency, which provides a strong and stable signal that is less prone to interference from other devices. The transmitter has a range of up to 3km, which allows you to fly your quadcopter at long distances without losing control. The receiver is compact and lightweight, making it easy to install on your quadcopter without adding extra weight.

The Radiolink AT9S Pro 2.4GHz RC Transmitter and Receiver is essential for controlling your quadcopter during the data acquisition phase of leaf disease detection using image processing. It allows you to remotely control the quadcopter's movements and position, which is critical for capturing high-quality images of the leaves from different angles. The precise and responsive control provided by the transmitter ensures that the quadcopter moves smoothly and accurately, allowing you to capture clear images without any blurring or distortion. The long-range capability of the transmitter also ensures that you can fly the quadcopter at a safe distance from the leaves, reducing the risk of damage to both the quadcopter and the leaves.

The technical parameters of the Radiolink AT9S Pro 2.4GHz RC Transmitter and Receiver:

- Transmission Frequency: 2.4GHz ISM band (2400MHz to 2483.5MHz)
- Channels: 10
- Operating Voltage: 7.4V to 18V DC
- Operating Current: 80mA to 120mA
- RF Power: <100mW
- Transmission Range: Up to 2km (unobstructed, open ground)
- Receiver Sensitivity: -105dBm
- Antenna Length: 26mm (single antenna)
- Weight: 0.88lbs (400g)
- Dimensions: 190mm x 115mm x 215mm

The Radiolink AT9S Pro 2.4GHz RC Transmitter and Receiver is a high-quality radio control system that is designed for use in quadcopters and other unmanned aerial vehicles. It operates on the 2.4GHz ISM band, which provides a stable and reliable signal with minimal interference. The system has 10 channels, which allows for precise control over the quadcopter's movements and functions.

The operating voltage range of 7.4V to 18V DC makes it compatible with a wide range of batteries, and the low operating current of 80mA to 120mA ensures long battery life. The transmission range of up to 2km (unobstructed, open ground) provides plenty of room for the quadcopter to operate without losing control.

The receiver sensitivity of -105dBm ensures that even weak signals can be received, and the single antenna design keeps the weight and size of the system to a minimum. The transmitter and receiver are also lightweight, with a weight of only 0.88lbs (400g), making them easy to carry and transport. Overall, the Radiolink AT9S Pro 2.4GHz RC Transmitter and Receiver is a reliable and high-quality control system that is essential for the safe and effective operation of a quadcopter.

Software Section:

Simply said, we are downloading the dataset from the internet, training the models with code, and then displaying the results graphically on a website.
The Python programming language and several of its machine learning packages are being used for this project's coding.
Also, we need the data to train the. Kaggle is where we're going to get them.

Kaggle: A large dataset is required for effective training and testing of the model. The machine learning models are provided the allowance to earn and make predictions pertaining to whatever objective they have, upon dataset training and testing. Hence, for the model, the main and most important data is the dataset. A machine learning engineer uses this dataset, which accounts for more than 70% of all the data utilized for the project, to construct the algorithm. In order to obtain the best results, a large number of datasets are used for model training at the highest level. Thus, Kaggle is the website that is typically selected for this purpose.

Python Libraries:

For training and testing of the images for the image processing purpose we needed some libraries and using those libraries we can put a shape on those image data and make those image compatible for our training purpose.

TensorFlow: Best practises for data augmentation, model tracking, performance monitoring, and model retraining are widely implemented using TensorFlow. The best way to describe it is as an open-source machine learning platform.

Keras: Keras is mostly just TensorFlow's High-Level API. An extremely efficient UI for dealing with machine learning problems. In a nutshell, it supplies the building blocks required to solve deep learning problems using a sophisticated neural network model.

Matplotlib: Matplotlib is a library that may be used to make any type of visualisation, from simple images to complex simulations. Its primary function is to create 2D visualisations of arrays in Python.

Numpy: NumPy is a Python package that may be used to create arrays. As its name implies, its primary use is to manage arrays of data in several dimensions, and it supports a broad variety of mathematical operations on such arrays. It can perform Fourier transforms and linear algebra as well.

Open CV: It stands for open-source computer vision library. It refers to a library for computer vision that is available for free to the public. Mostly, it is employed to facilitate the increased application of machine perception by providing real-time computer vision infrastructure. Object detection, facial recognition, and tracking are just a few of the many image processing features available.

Web Page Development:

HTML & CSS: Both HTML and CSS refer to the hypertext markup language and the cascading style sheet, respectively. HTML, along with CSS and scripting languages like JAVA Script, is used to display content in a web browser.

Django Framework: Django is a free and open-source Python web framework that provides a safe and efficient means of creating websites. It can be started out by constructing simpler projects, and then later improved upon to perform more complex tasks. In addition, its high traffic capacity ensures that it is available to everyone.

Flask API: An extremely lightweight web application framework written in Python. In both werkzeug and Jinja2, it is now fully functional. Reasons for its popularity include its small footprint and the inclusion of both a development server and a speedy debugging tool, both of which are necessary for creating a web application.

Convolutional Neural Network:

Convolutional Neural Network is basically a set of layers which is mainly for image processing. It's a specialized deep learning algorithm for getting maximum output from it.

Convolution Layer: This layer is basically some filters of various type which can perform some convolution operations.

Rectified Linear Unit (ReLU): This layer is basically for rectified linear map. This layer is based on the equation: $\mathbf{F(x)=x^{+}= max\ (0.x)}$

Pooling Layer: After getting the rectified featured map from the ReLU layer then it's fed to the pooling layer for reduce the dimension for down sampling the featured map.

The pooling layer then uses a linear vector to flatten the resulting two-dimensional array of pooled features. When data is fed into a fully linked layer, a flattened matrix is formed that can be used to identify the images.

SoftMax Function: This activation function is used at the last layer which is the output layer. It is similar to sigmoid as the function is called linear function but to identify multiclass it is widely used.

Gazebo: An open-source 3D robotics simulator is called Gazebo. It combined the ODE physics engine with OpenGL rendering and support code for simulating sensors and controlling actuators. ODE, Bullet, and other powerful physics engines are just a few of the ones that Gazebo can employ (the default is ODE). It renders settings with realism and includes excellent lighting, shadows, and textures. It may replicate sensors like wide-angle cameras, laser range finders, Kinect-style sensors, and others that can "see" the simulated world. Gazebo makes use of the OGRE engine for 3D rendering.

Mission Planner: Mission Planner is a free and open-source software used for mission planning, configuration, and monitoring of unmanned aerial vehicles (UAVs) or quadcopters. It is compatible with a wide range of UAV platforms, including drones, helicopters, and planes. Mission Planner is typically used by drone enthusiasts, researchers, and commercial operators for mission planning and execution, data analysis, and vehicle configuration. Mission Planner provides a variety of features and capabilities for quadcopter manipulation, including mission planning, Real-time Telemetry, Configuration and Calibration, Data Analysis and Logging, Camera Control, Flight Modes. Moreover, Mission Planner is a powerful tool for quadcopter manipulation, providing a range of features and capabilities for mission planning, execution, and analysis.

Mission Planner 1.3.80 Software: Mission Planner 1.3.80 is a valuable software tool that can be used to program and configure the APM 2.6 Pixhawk Flight Controller. It provides a user-friendly interface for mission planning, calibration, and monitoring of the drone during operation. Some of the significance, features, andrelevance of Mission Planner 1.3.80 in this context are:

Significance:

- Mission Planner 1.3.80 is a free, open-source software tool that is compatible with Windows, Linux, and Mac OS X.
- It provides a comprehensive set of features for programming and configuring the APM 2.6 Pixhawk Flight Controller, including the ability to plan autonomous missions, configure sensors and peripherals, and analyze telemetry data.
- It supports a wide range of drones, including quadcopters, hexacopters, octocopters, and fixed-wing aircraft.
- It allows for real-time monitoring of the drone's flight status and telemetry data, which isessential for detecting any abnormalities or issues during operation.

Features:

- Mission Planner 1.3.80 provides a user-friendly interface for mission planning, calibration,

  and configuration of the drone's flight controller.
- It allows for the creation and execution of autonomous missions, including the ability to setwaypoints, adjust flight parameters, and define complex flight paths.
- It includes a flight simulator that allows users to test their mission plans and flight configurations before deploying the drone in the field.
- It provides a comprehensive set of tools for analyzing telemetry data, including live graphsof altitude, airspeed, GPS position, and battery voltage.
- It supports a variety of sensors and peripherals, including GPS, compass, accelerometer, andbarometer.

Relevance:

- Mission Planner 1.3.80 is a crucial tool in the development and deployment of drone-basedleaf disease detection systems.

- It allows for the programming and configuration of the APM 2.6 Pixhawk Flight Controller,which is the heart of the drone's control system.
- It provides a user-friendly interface for planning and executing autonomous missions, whichis essential for covering large areas of crops and detecting disease outbreaks.
- It allows for real-time monitoring of the drone's flight status and telemetry data, which iscrucial for ensuring safe and effective operation.
- It provides a comprehensive set of tools for analyzing telemetry data, which can be used toidentify patterns and trends in the data and improve the accuracy of disease detection.

3.4 Conclusion:

The creation of numerous types of powerful and cutting-edge complex software has enhanced modern engineering. These instruments enable us to achieve our particular objectives. These software programs have improved over time in terms of efficiency and reliability, and the results they produce are precise. In order to create this prototype, make sure it functions as intended, and guarantee that it meets our objectives, we also require skill with certain tools and technologies.

Chapter 4: Optimization of Multiple Design and Finding the Optimal Solution. [CO5, CO6, CO7]

4.1 Introduction

In order to obtain the desired result of our project, we have proposed three design approaches. Each of the designs are capable of obtaining the final result but their working methodology is completely different from one another. In other words, their process of reaching the goal is different. For the first design approach we have explained the working methodology. For the second and third approaches that are the four wheeled rover and the quadcopter; we have implemented simulations through which we have obtained some parameters such as angular and linear velocities, acceleration etc. Finally by comparing those parameters we obtained our optimal design.

4.2 Optimization of multiple design approach

Functional Verification of Multiple Design Solutions (CO5)

The simulation results of each of the alternative designs are explained below along with the graphs showing different parameters.

4.2.1 Design Approach 1: Satellite Crop Monitoring

This approach can meet our goal of monitoring crop health. As we know there are numerous satellites orbiting earth from different levels of orbits and taking data periodically of the earth in hyperspectral bands. We can use those pieces of information for our cause.

First of all, we know that satellite image forms using artificial intelligence.

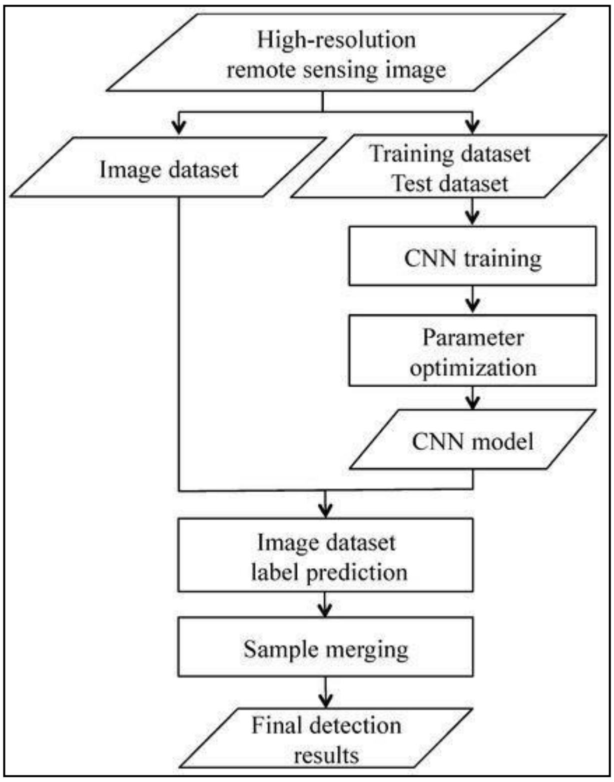


Figure 7: Satellite image formation process

This figure shows the methodology of how satellite image forms through this process before we get to use it. We have chosen 30 cm spatial resolution as it is the highest spatial resolution that civilians cause for their purpose and that means our satellite can detect a minimum length of 30cm objecton the ground. So as the satellite uses hyperspectral bands or channels for capturing images, we can see the reflectance of our crops in the infrared bands. Seeing the reflectance of our crops fields we can decide whether it is healthy or not. Because the photosynthesis of weakor unhealthy plants is less and reflects more RGB bands than IR whereas healthy plants absorb lighter and reflect in IR bands. So, looking at this mapping as a whole we can say specificallywhich area malnutrition is if spatial resolution supports.

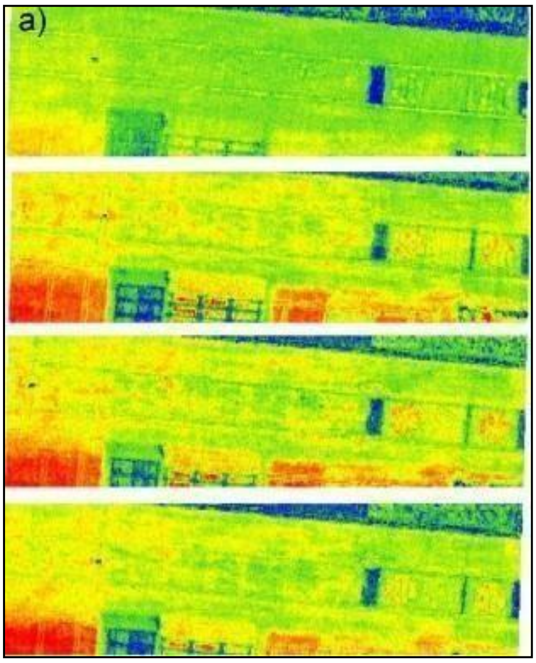


Figure 8: Reflectance image of 2.5m spatial resolution satellite image

By looking at the picture we can say which area needs to be cared for and where is a dry portion. It can also say the driest area which is at risk of fire ignition.

Limitations: first of all, as we mentioned that every satellite has its own solution capacity. What we need for our crop health monitoring purpose is a better solution image for disease detection which lies in leaves or bodies of crops. As spatial resolution or per pixel resolution is limited for civilian satellites is 30cm to 5m, for each pixel, our 30cm spatial resolution length satellite cannot detect even a for example tomato leaf which is approximately 10-25cm .

Secondly, the resolution gets best when our test fields are aligned perpendicular to the satellite which is not feasible every time.

Thirdly, we cannot control satellites according to our convenience and each satellite has its own temporal resolution (periodic time for the same location). If plants are attacked by leaf-eating insects, and we are measuring the health of crops in terms of reflectance, then it may not show in the first few observations. When we will find out then it may get too late due to its temporal resolution.

4.2.2 Design Approach 2: The 4 Wheeled Rover

Acceleration:

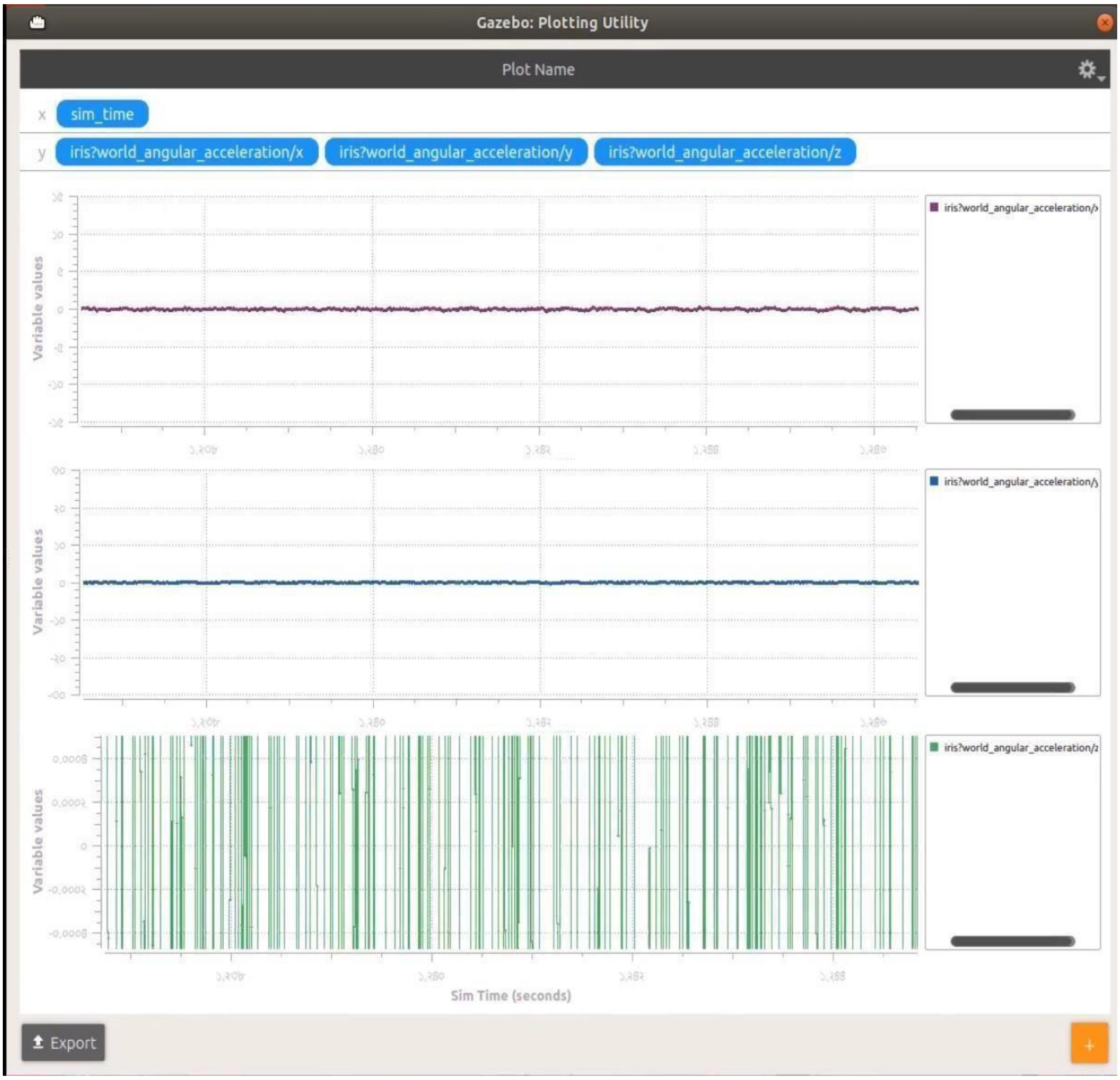


Figure 9: Angular Acceleration along X, Y and Z

The above Plot shows the various X, Y and Z axis component angular acceleration of the rover. Essentially the magnitude and direction such quantities i.e. parameters are in effect influenced by the type of movement mode the simulated rover is in and therefore, the changes indicate the current corresponding nature movement status.

Figure 10: Linear Acceleration along X, Y and Z

The above Plot shows the various X, Y and Z axis component linear acceleration of the rover. Essentially the magnitude and direction such quantities i.e. parameters are in effect influenced by the type of flight mode the simulated drone is in and therefore, the changes indicate the current corresponding nature movement status.

Velocity:

Figure 11: Angular Velocity along X, Y and Z

The above Plot shows the various X, Y and Z axis component angular velocity of the rover. Essentially the magnitude and direction such quantities i.e. parameters are in effect influenced by the type of movement mode the simulated drone is in and therefore, the changes indicate the current corresponding nature movement status.

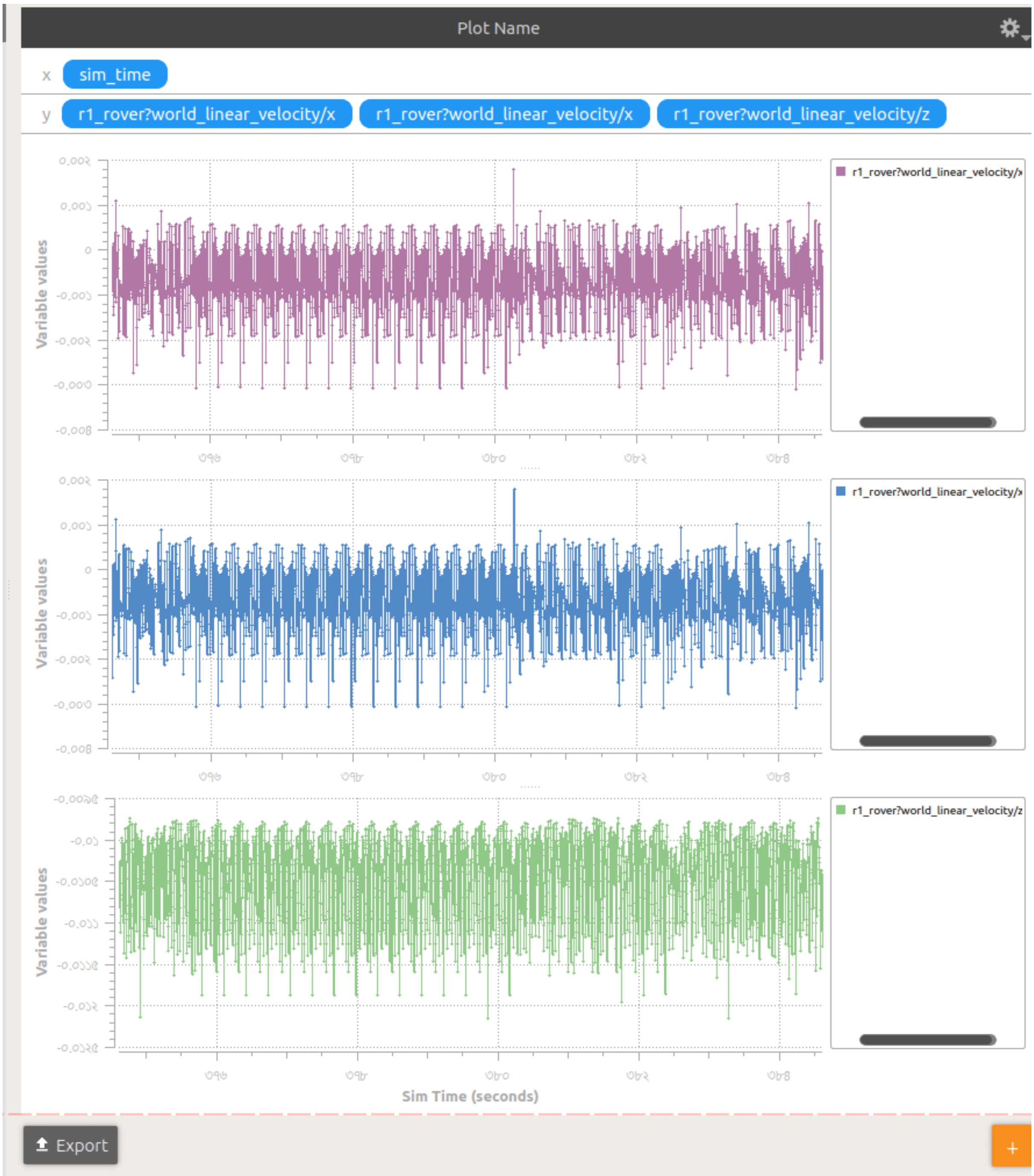


Figure 12: Linear Velocity along X, Y and Z

The above Plot shows the various X, Y and Z axis component linear velocity of the rover. Essentially the magnitude and direction such quantities i.e. parameters are in effect influenced by the type of movement mode the simulated drone is in and therefore, the changes indicate the current corresponding nature movement status.

POSE:

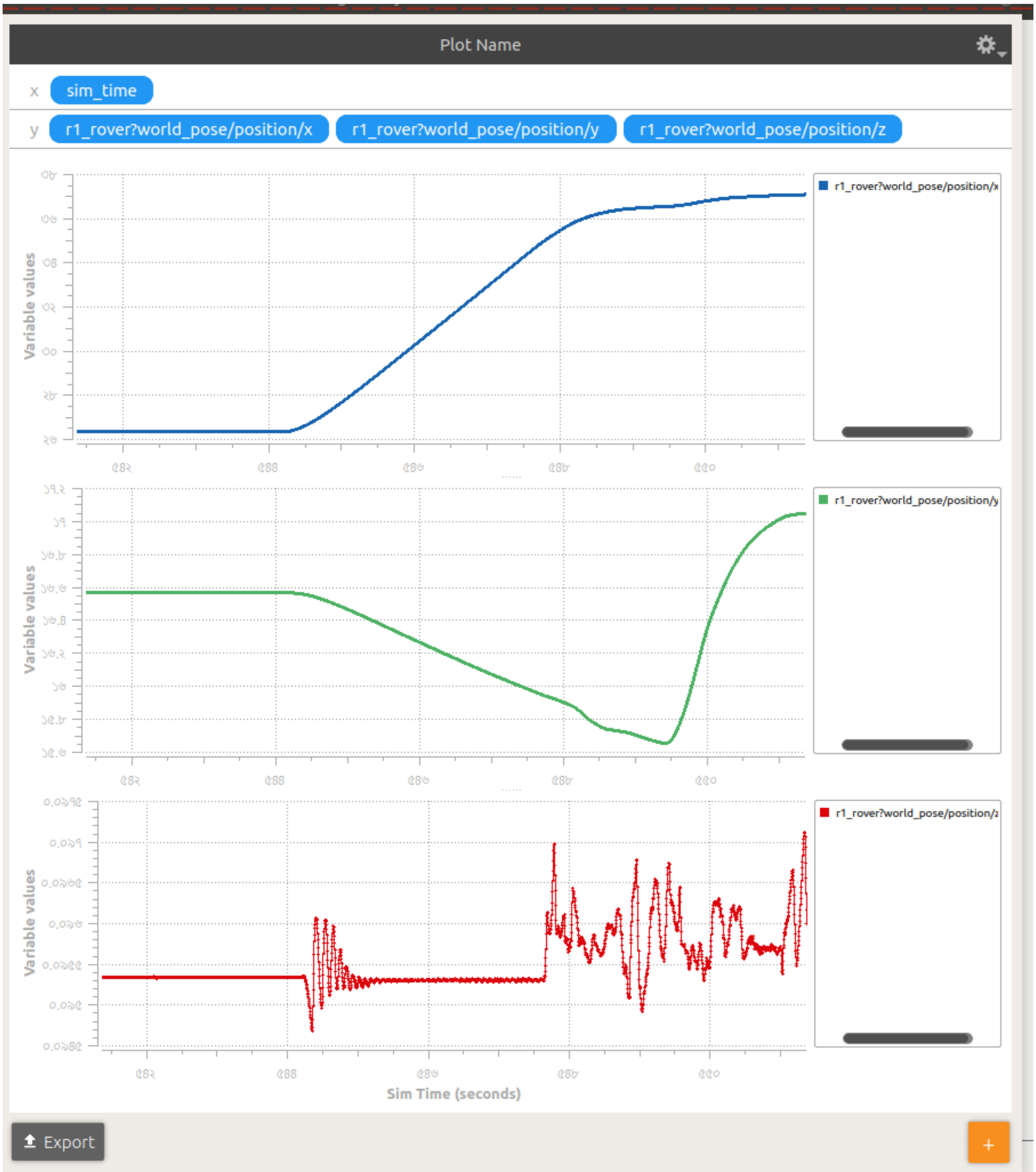


Figure 13: Position along X, Y and Z

The above Plot shows the various X, Y and Z axis component position of the rover. Essentially the magnitude and direction such quantities i.e. parameters are in effect influenced by the type of flight mode the simulated rover is in and therefore, the changes indicate the current corresponding nature movement status.

Orientation

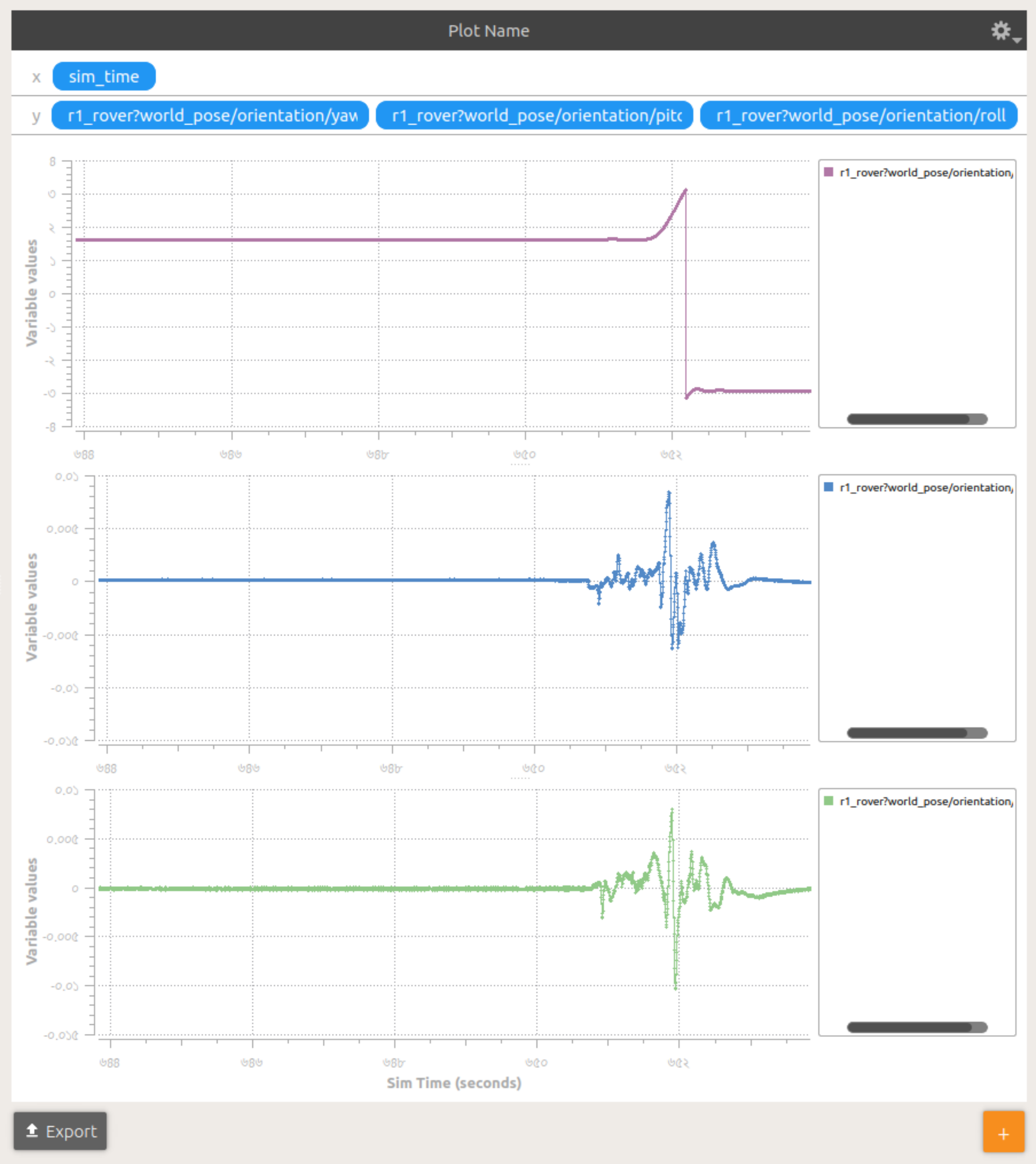


Figure 14: Yaw, Pitch and Roll

The above Plot shows the various Yaw, Pitch and Roll, orientation of the rover. Essentially the magnitude and direction such quantities i.e. parameters are in effect influenced by the type of movement mode the simulated rover is in, and therefore, the changes indicate the current corresponding nature movement status.

4.2.3 Design Approach 3: The flying drone

Acceleration

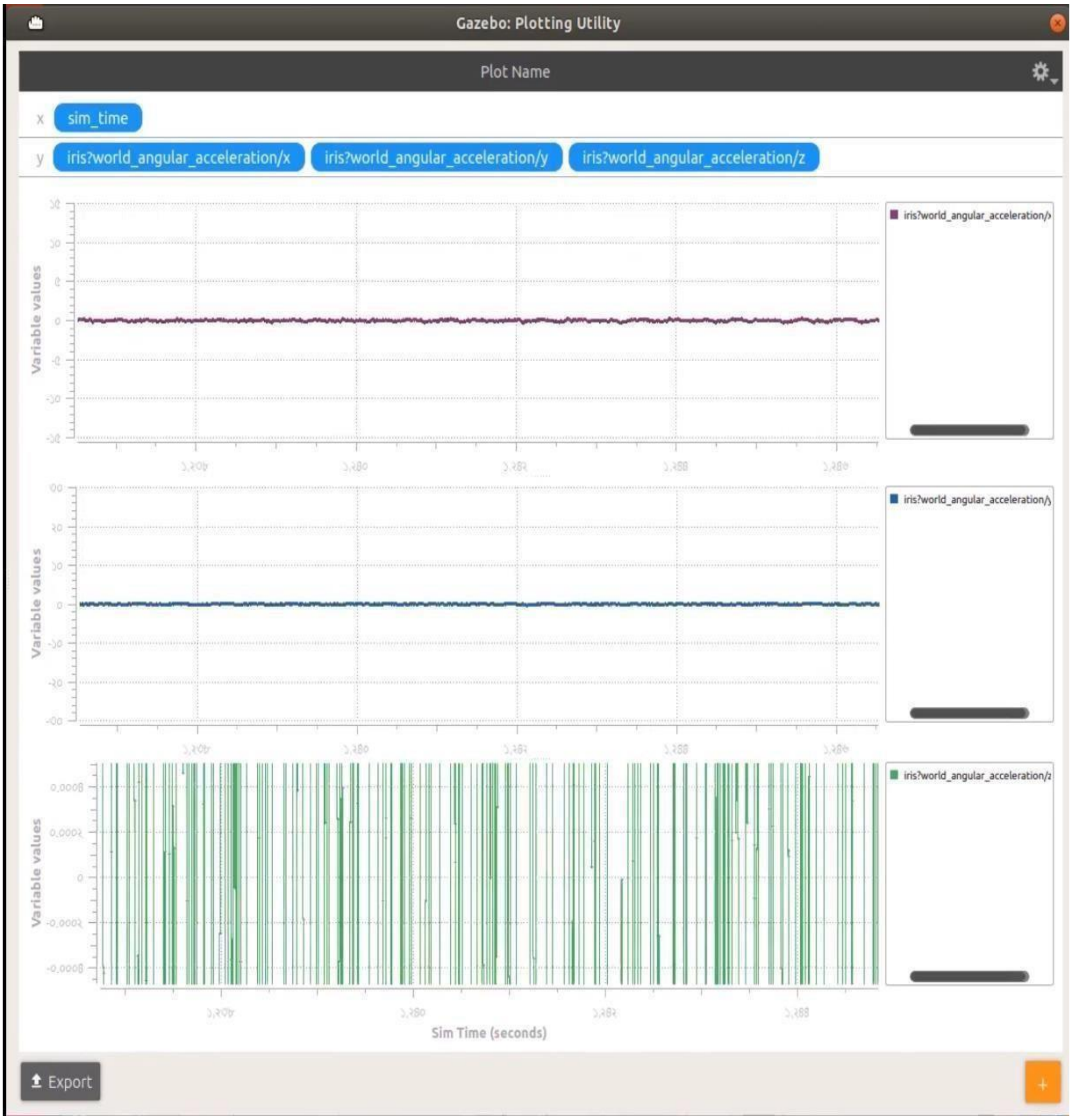


Figure 15: Angular Acceleration along X, Y and Z

The angular acceleration components along the X, Y, and Z axes for a drone quadcopter can provide information about its rotational movements.

The X-axis component of angular acceleration represents the rate of change of angular velocity around the X-axis. In the context of a drone quadcopter, this could correspond to its roll movement, which is the rotation of the drone along its longitudinal axis. If the X-axis component of angular acceleration is positive, it indicates that the drone is rotating counterclockwise around the X-axis, whereas a negative value indicates clockwise rotation.

The Y-axis component of angular acceleration represents the rate of change of angular velocity around the Y-axis. This could correspond to the pitch movement of the drone, which is the rotation of the drone along its lateral axis. If the Y-axis component of angular acceleration is positive, it indicates that the drone is rotating counterclockwise around the Y-axis, whereas a negative value indicates clockwise rotation.

The Z-axis component of angular acceleration represents the rate of change of angular velocity around the Z-axis. This could correspond to the yaw movement of the drone, which is the rotation of the drone along its vertical axis. If the Z-axis component of angular acceleration is positive, it indicates that the drone is rotating counterclockwise around the Z-axis, whereas a negative value indicates clockwise rotation.

Monitoring these components of angular acceleration can help in controlling and stabilizing the drone's movements and ensuring safe and accurate operation during tasks such as crop monitoring.

For angular acceleration components, the curve plots typically show the magnitude and direction of the drone's rotational movements around the X, Y, and Z axes over time. These plots can be used to monitor the drone's stability, detect any deviations or abnormalities in its movements, and make adjustments as necessary.

For example, if the X-axis angular acceleration curve suddenly increases in magnitude, it may indicate that the drone is rolling to one side. In this case, the drone operator or flight controller may need to adjust the drone's orientation to bring it back to a stable position. Similarly, if the Y-axis angular acceleration curve suddenly decreases in magnitude, it may indicate that the drone is pitching forward, and adjustments may need to be made to bring it back to a level flight path.

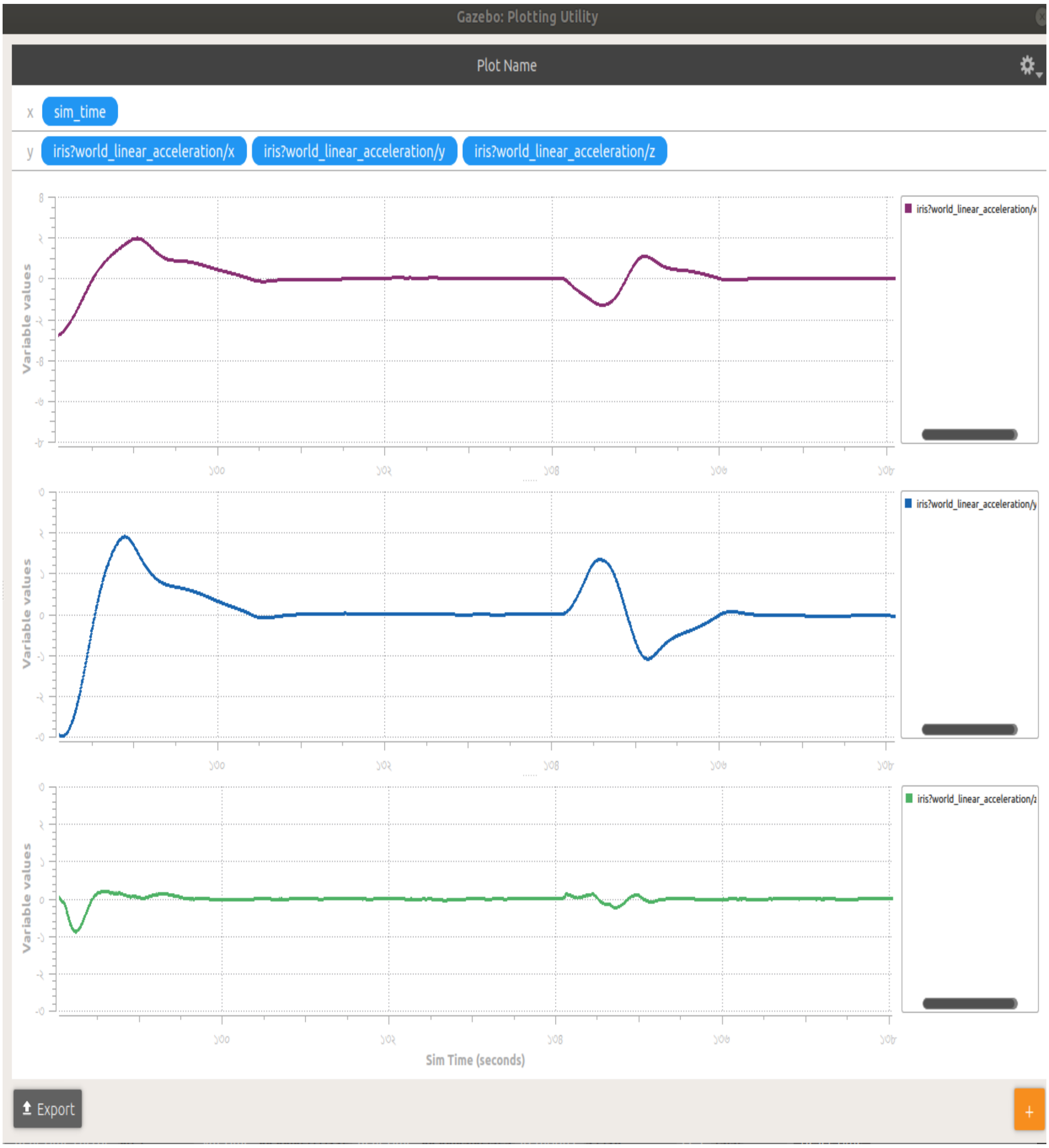


Figure 16: Linear Acceleration along X, Y and Z

Linear acceleration refers to the rate of change of velocity of an object or system. It is a vector quantity that has both magnitude and direction. The linear acceleration components along the X, Y, and Z axes for a quadcopter can provide information about its translational movements.

The X-axis component of linear acceleration represents the rate of change of velocity in the X-axis direction. In the context of a quadcopter, this could correspond to its movement along the lateral axis. If the X-axis component of linear acceleration is positive, it indicates that the quadcopter is accelerating forward in the X-axis direction, whereas a negative value indicates acceleration in the opposite direction.

The Y-axis component of linear acceleration represents the rate of change of velocity in the Y-axis direction. This could correspond to the quadcopter's movement along the longitudinal axis. If the Y-axis component of linear acceleration is positive, it indicates that the quadcopter is accelerating forward in the Y-axis direction, whereas a negative value indicates acceleration in the opposite direction.

The Z-axis component of linear acceleration represents the rate of change of velocity in the Z-axis direction. This could correspond to the quadcopter's movement along the vertical axis. If the Z-axis component of linear acceleration is positive, it indicates that the quadcopter is accelerating upwards in the Z-axis direction, whereas a negative value indicates acceleration downwards.

Monitoring these components of linear acceleration can help in controlling and stabilizing the quadcopter's movements, especially during maneuvers such as takeoff, landing, and changes in direction. Additionally, these measurements can be useful for drone crop monitoring applications to ensure that the quadcopter is flying at the appropriate height and speed over the crop fields.

For linear acceleration components, the curve plots typically show the magnitude and direction of the drone's translational movements along the X, Y, and Z axes over time. These plots can be used to monitor the drone's speed, altitude, and flight path, and make adjustments as necessary.

For example, if the X-axis linear acceleration curve suddenly increases in magnitude, it may indicate that the drone is accelerating forward, while a sudden decrease in magnitude may indicate that it is slowing down. Similarly, if the Z-axis linear acceleration curve suddenly increases in magnitude, it may indicate that the drone is ascending, while a sudden decrease in magnitude may indicate that it is descending.

By monitoring the variation of these curve plots over time, drone operators and engineers can ensure the safe and stable operation of the drone, make adjustments to its flight path and maneuvers as necessary, and maintain the quality of data collected during drone crop monitoring or other applications.

Velocity:

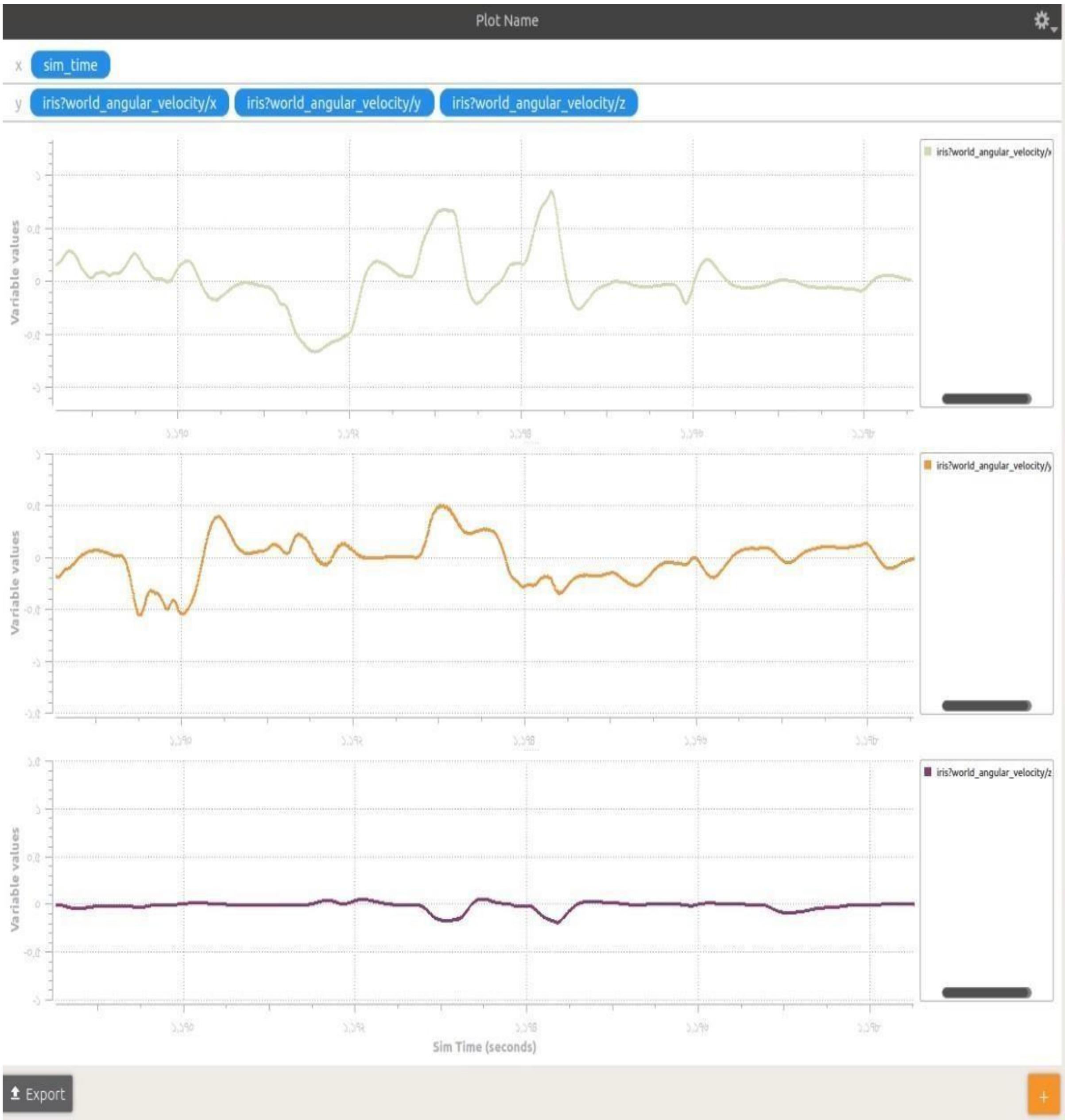


Figure 17: Angular Velocity along X, Y and Z

Angular velocity refers to the rate at which an object or system rotates around a particular axis. The angular velocity of a drone along the X, Y, and Z axes can provide valuable information about the drone's rotational movements and stability.

For angular velocity components, the X-axis component represents the rate of rotation around the lateral axis of the drone. In the context of a quadcopter, this could correspond to the drone's rolling motion. If the X-axis component of angular velocity suddenly increases, it may indicate that the drone is rolling to one side, and adjustments may need to be made to stabilize its flight.

The Y-axis component of angular velocity represents the rate of rotation around the longitudinal axis of the drone. In a quadcopter, this could correspond to the drone's pitching motion. If the Y-axis component of angular velocity suddenly increases, it may indicate that the drone is pitching forward, and adjustments may need to be made to bring it back to a level flight path.

The Z-axis component of angular velocity represents the rate of rotation around the vertical axis of the drone. In a quadcopter, this could correspond to the drone's yaw motion. If the Z-axis component of angular velocity suddenly increases, it may indicate that the drone is turning or changing direction, and adjustments may need to be made to ensure its stability during flight.

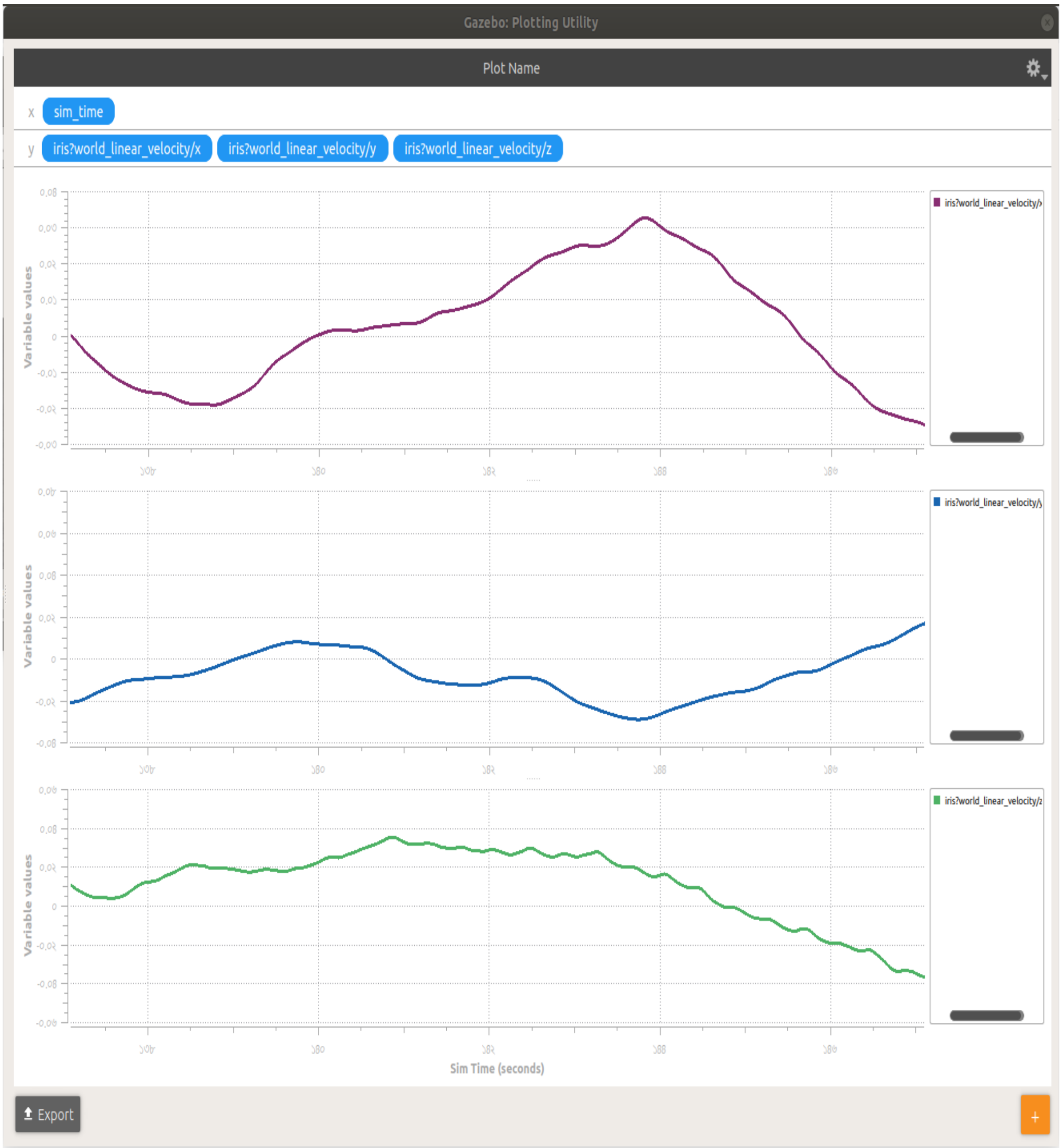


Figure 18: Linear Velocity along X, Y and Z

Linear velocity, on the other hand, refers to the rate at which an object or system moves in a particular direction. The linear velocity of a drone along the X, Y, and Z axes can provide valuable information about the drone's translational movements and speed.

For linear velocity components, the X-axis component represents the drone's forward or backward motion. If the X-axis component of linear velocity suddenly increases, it may indicate that the drone is accelerating forward, while a sudden decrease in magnitude may indicate that it is slowing down or reversing.

The Y-axis component of linear velocity represents the drone's lateral or sideways motion. If the Y-axis component of linear velocity suddenly increases, it may indicate that the drone is moving to one side, while a sudden decrease in magnitude may indicate that it is returning to a central position.

The Z-axis component of linear velocity represents the drone's vertical motion or altitude. If the Z-axis component of linear velocity suddenly increases, it may indicate that the drone is ascending, while a sudden decrease in magnitude may indicate that it is descending. Monitoring the variation of these curve plots over time can help drone operators and engineers ensure the safe and stable operation of the drone and make necessary adjustments to maintain its flight path and maneuvers.

POSE

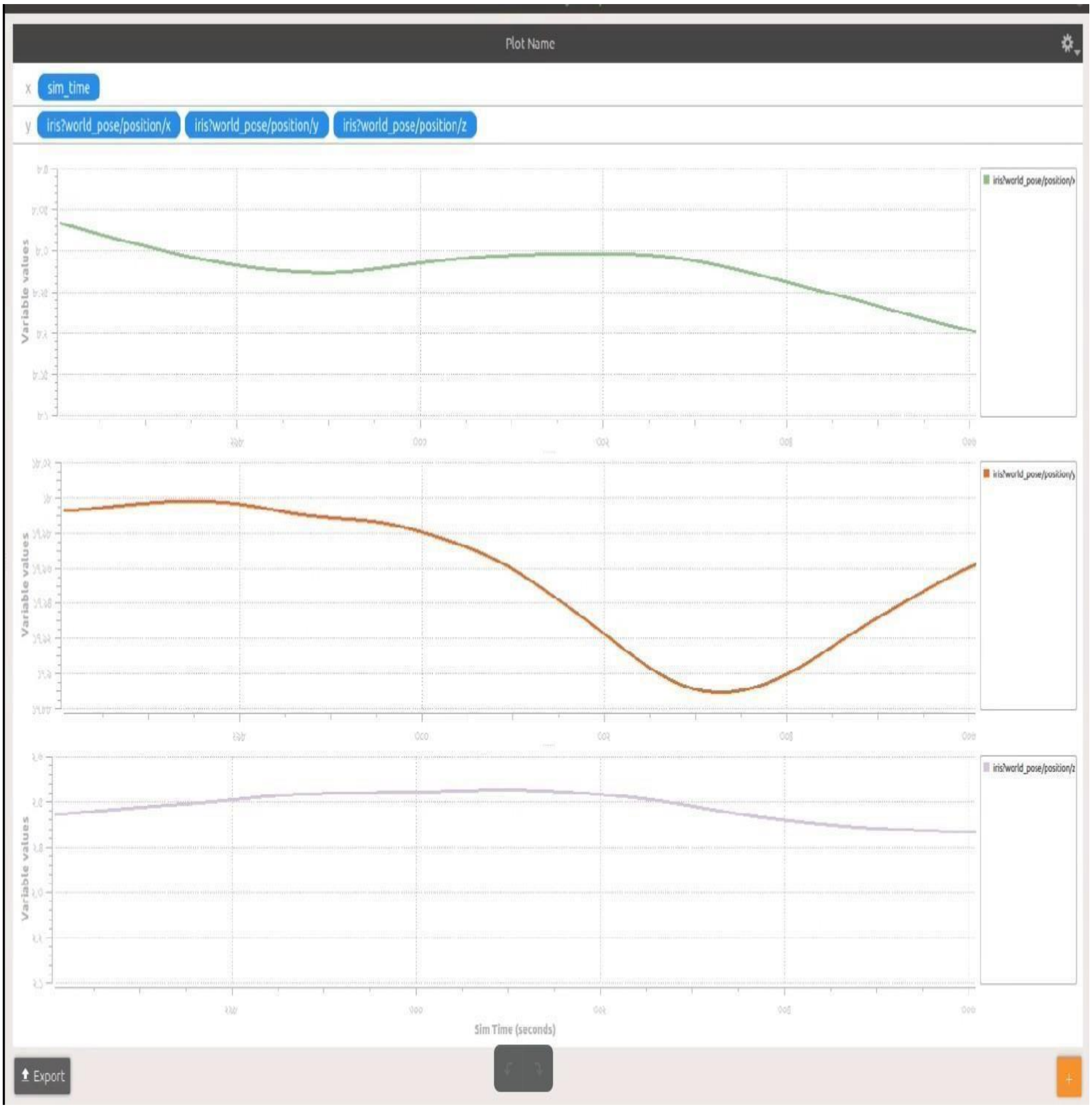


Figure 19: Position along X, Y and Z

The above Plot shows the various X, Y and Z axis component Position of the drone. Essentially the magnitude and direction such quantities i.e. parameters are in effect influenced by the type of flight mode the simulated drone is in and therefore, the changes indicate the current corresponding nature flight status.

Position along X, Y, and Z axes refers to the location of the drone in a three-dimensional space. In a quadcopter, the X-axis corresponds to the forward/backward direction, the Y-axis corresponds to the left/right direction, and the Z-axis corresponds to the up/down direction.

The X-axis component of position indicates the drone's displacement along the forward/backward direction. If the drone's X-axis position suddenly increases, it means the drone is moving forward, while a sudden decrease in X-axis position may indicate that it is moving backward.

The Y-axis component of position indicates the drone's displacement along the left/right direction. If the drone's Y-axis position suddenly increases, it means the drone is moving to the right, while a sudden decrease in Y-axis position may indicate that it is moving to the left.

The Z-axis component of position indicates the drone's displacement along the up/down direction or altitude. If the drone's Z-axis position suddenly increases, it means the drone is ascending, while a sudden decrease in Z-axis position may indicate that it is descending.

Orientation

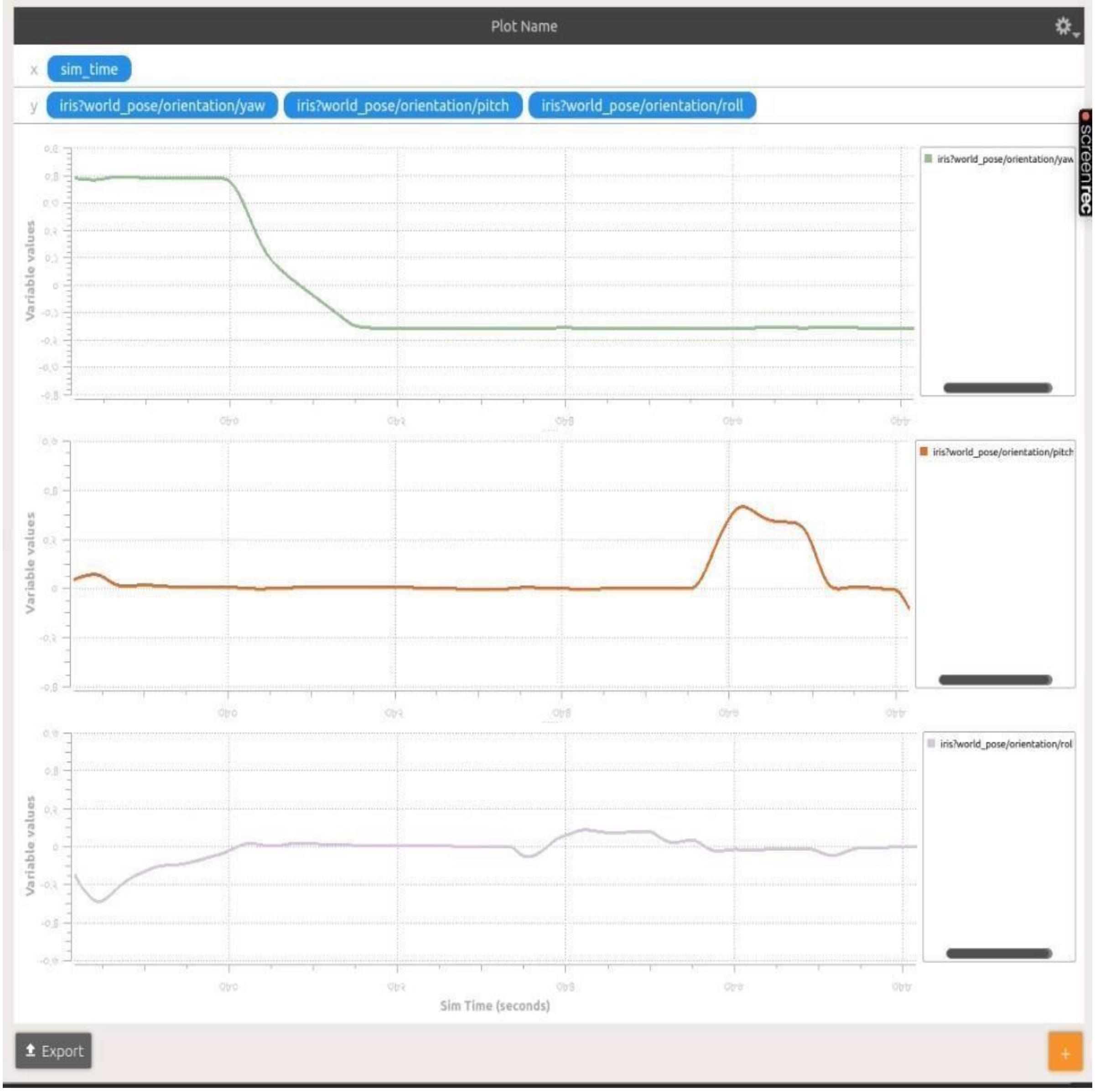


Figure 20: Yaw, Pitch and Roll

The above Plot shows the various Orientations Yaw, Pitch, Roll of the drone. Essentially the magnitude and direction such quantities i.e. parameters are in effect influenced by the type of flight mode the simulated drone is in and therefore, the changes indicate the current corresponding nature flight status.

Yaw, pitch, and roll are the three fundamental rotational movements of a quadcopter.

Yaw refers to the rotation of the drone around the vertical axis. A sudden change in yaw can indicate a change in the drone's direction.

Pitch refers to the rotation of the drone around the lateral axis. A sudden change in pitch can indicate the drone is tilting forward or backward.

Roll refers to the rotation of the drone around the longitudinal axis. A sudden change in roll can indicate the drone is tilting to the left or right.

Yaw, pitch, and roll are often represented graphically as angular position along the respective axes. Monitoring the variation of these curve plots over time can help drone operators and engineers ensure the safe and stable operation of the drone and make necessary adjustments to maintain its flight path and maneuvers.

4.2.4 Image Processing:

Deep learning, a subfield that is part of the general field of artificial neural networks, will be put to use in this context. Since the artificial neural network is a very intelligent way for processing massive amounts of data, we are employing it. It mimics the form and operation of the human brain to a large extent.

TensorFlow, Keras, and Matplotlib were selected for this project due to their intuitive design and widespread applicability, and they serve as the framework upon which the entire thing is built.

Keras is a python interface for artificial neural networks, and TensorFlow provides a mathematical array representation of higher dimensions.

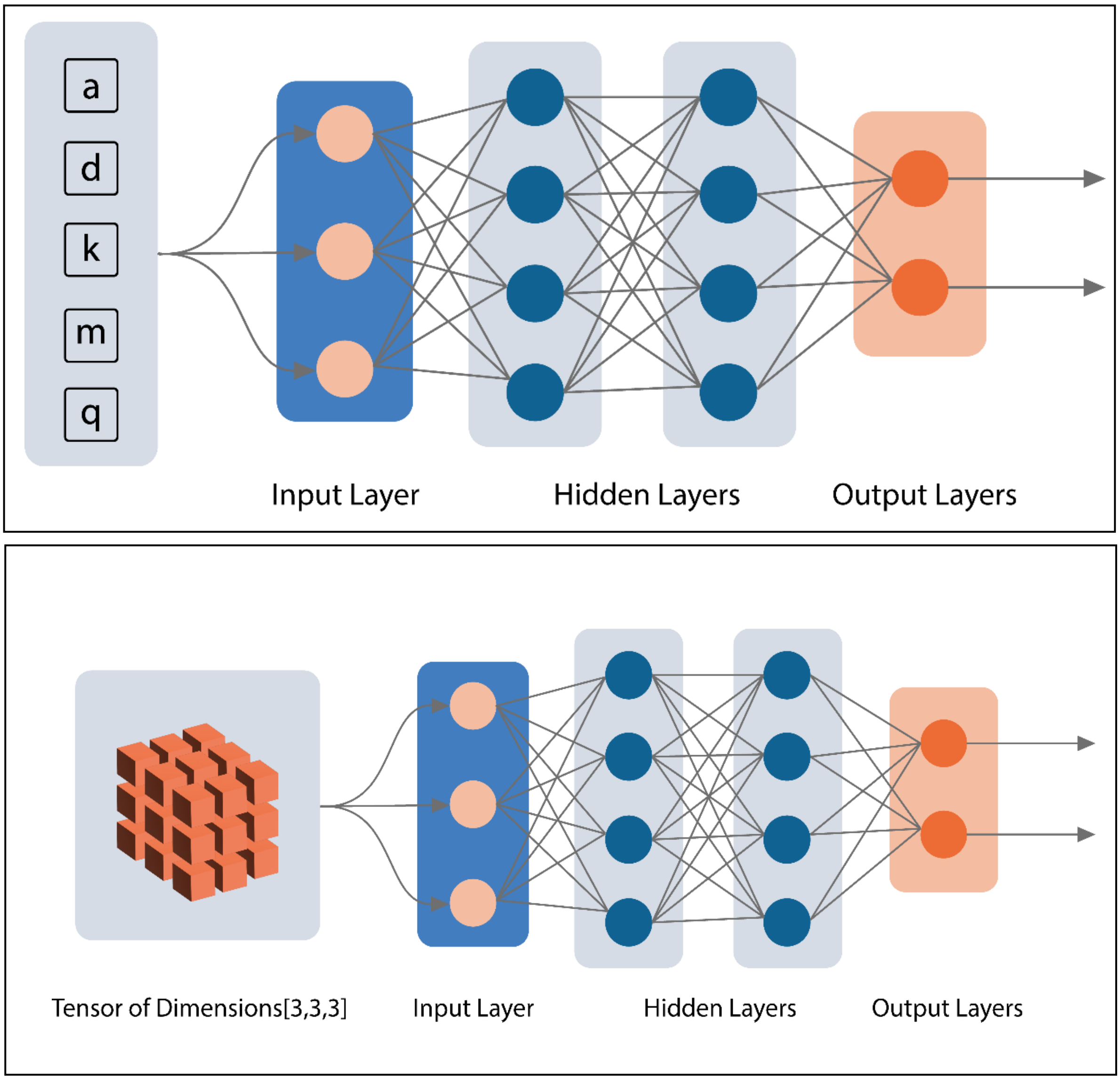


Figure 21: TensorFlow data representation [19]

The code we've created and the input image are both reflected in the upper figure, which shows how tensor flow obtains the data and how it changes it into a tensor and the specified dimension.

A neural network's architecture mimics that of a human brain, with artificial neurons (represented by nodes) stacked in layers.

- The input Layers
- The hidden Layers
- The output Layers

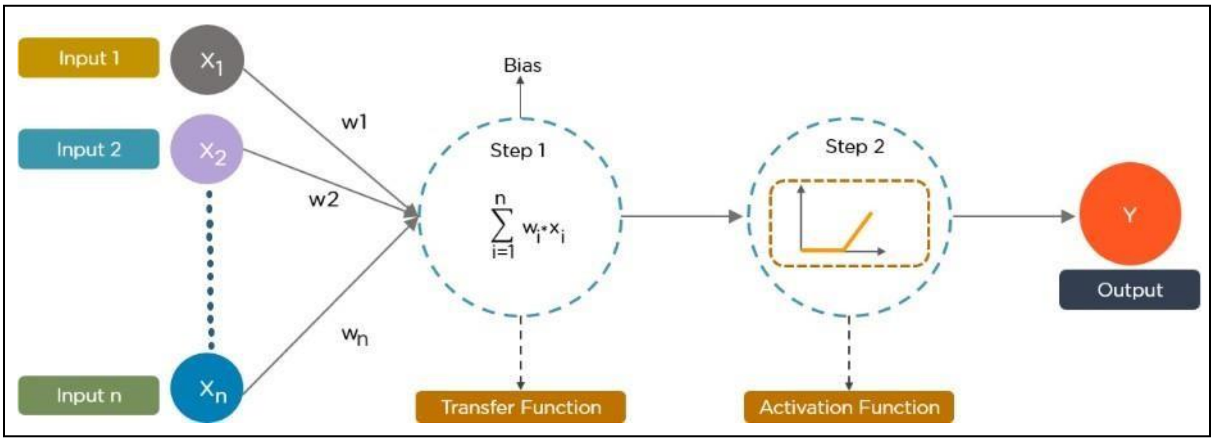


Figure 22: Layers Function of Neural Network [20]

CNN (Convolutional Neural Network)
The primary function of the layers in a Convolutional Neural Network is to process images. Specifically, we have employed the Relu activation function to address the issue of vanishing gradients, the SoftMax function to do binary optimization, and the adam optimizer to extract the most useful information from the training dataset.

Layers:
In general, there are three distinct strata. When it comes down to it, the convolutional layer is just a collection of filters that can conduct convolutions. For a linear map that has been rectified, the rectified layer serves as the backbone. Next, a pooling layer is added to the mix to further flatten the input with a linear vector, and a fully connected layer generates the input's flattened matrix.

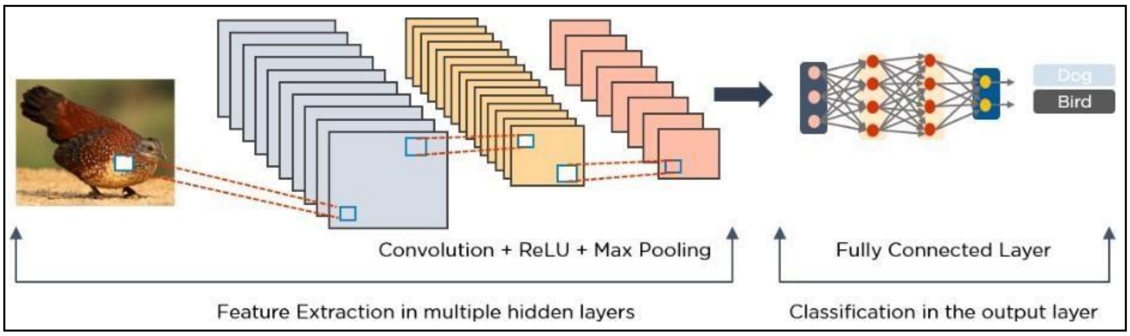


Figure 23: Process of CNN [20]

So, this upper picture is a visual representation of the process of Convolutional Neural

Network, how it converts the pictures to an array and goes through multiple layers and classify the image.

```
In [47]: resize_and_rescale = tf.keras.Sequential([
           layers.experimental.preprocessing.Resizing(IMAGE_SIZE, IMAGE_SIZE),
           layers.experimental.preprocessing.Rescaling(1./255),
         ])

In [48]: data_augmentation = tf.keras.Sequential([
             layers.experimental.preprocessing.RandomFlip("horizontal_and_vertical"),
             layers.experimental.preprocessing.RandomRotation(0.2),
             layers.experimental.preprocessing.RandomContrast(0.2),
           tf.keras.layers.experimental.preprocessing.RandomZoom(0.2),
           tf.keras.layers.experimental.preprocessing.RandomHeight(0.2),
           tf.keras.layers.experimental.preprocessing.RandomWidth(0.2)
         ])
         ])
```

```
input_shape = (BATCH_SIZE, IMAGE_SIZE, IMAGE_SIZE, CHANNELS)
n_classes = 10

model = models.Sequential([
    resize_and_rescale,
    layers.Conv2D(62, kernel_size = (3,3), activation='relu', input_shape=input_shape),
    layers.MaxPooling2D((2, 2)),
    layers.Conv2D(82,  kernel_size = (3,3), activation='relu'),
    layers.MaxPooling2D((2, 2)),
    layers.Conv2D(128,  kernel_size = (3,3), activation='relu'),
    layers.MaxPooling2D((2, 2)),
    layers.Conv2D(256, (3, 3), activation='relu'),
    layers.MaxPooling2D((2, 2)),
    layers.Conv2D(256, (3, 3), activation='relu'),
    layers.MaxPooling2D((2, 2)),
    layers.Conv2D(256, (3, 3), activation='relu'),
    layers.MaxPooling2D((2, 2)),
    layers.Flatten(),
    layers.Dense(80, activation='relu'),
    layers.Dense(n_classes, activation='softmax'),
])

model.build(input_shape=input_shape)
```

Figure 24: Main Layers of the Algorithm

To train the model, we have created an algorithm that makes use of the python programming language and a convolutional neural network.

In this case, we used images taken by a drone, a rover, and a satellite in conjunction with the same algorithm developed to estimate the plant leaves' susceptibility to disease.

The primary technique relies on a resizing and scaling of images. Next comes a layer of data augmentation, which includes things like a random flip, rotation, zoom, contrast, height, and width.

Following that, the primary CNN layers were added; these include a flattens layer, two dense layers, and six Conv2d layers.

Here, I've included the accuracy graphs for all the datasets I've trained with:

Pepper Bell Model:

```
909
Epoch 5/10
47/47 [==============================] - 9s 190ms/step - loss: 0.1809 - accuracy: 0.9304 - val_loss: 0.5200 -
182
Epoch 6/10
47/47 [==============================] - 8s 177ms/step - loss: 0.2176 - accuracy: 0.9147 - val_loss: 0.1111 -
455
Epoch 7/10
47/47 [==============================] - 8s 167ms/step - loss: 0.1364 - accuracy: 0.9441 - val_loss: 0.1133 -
545
Epoch 8/10
47/47 [==============================] - 9s 181ms/step - loss: 0.1181 - accuracy: 0.9578 - val_loss: 0.0830 -
545
Epoch 9/10
47/47 [==============================] - 9s 181ms/step - loss: 0.0915 - accuracy: 0.9657 - val_loss: 0.1327 -
545
Epoch 10/10
47/47 [==============================] - 9s 188ms/step - loss: 0.0730 - accuracy: 0.9755 - val_loss: 0.4569 -
273

In [54]: scores = model.evaluate(test_ds)

7/7 [==============================] - 1s 37ms/step - loss: 0.3497 - accuracy: 0.8247
```

Figure: 25 Accuracy of Pepper Bell

In this case, we consulted the pepper bell data set. We've trained the model with 10 epochs using the same technique. In order to train, test, and validate the model, an algorithm uses a time unit called an epoch. Hence, the same thing happens at each epoch, and this is required to achieve the best accuracy possible given the size of the dataset. As a result of our investigation, we have got the accuracy of 82%.

jupyter pepperTrain Last Checkpoint: a minute ago (unsaved changes)

File Edit View Insert Cell Kernel Widgets Help

Run Code

```
plt.plot(range(EPOCHS), val_acc, label='Validation Accuracy')
plt.legend(loc='lower right')
plt.title('Training and Validation Accuracy')

plt.subplot(1, 2, 2)
plt.plot(range(EPOCHS), loss, label='Training Loss')
plt.plot(range(EPOCHS), val_loss, label='Validation Loss')
plt.legend(loc='upper right')
plt.title('Training and Validation Loss')
plt.show()
```

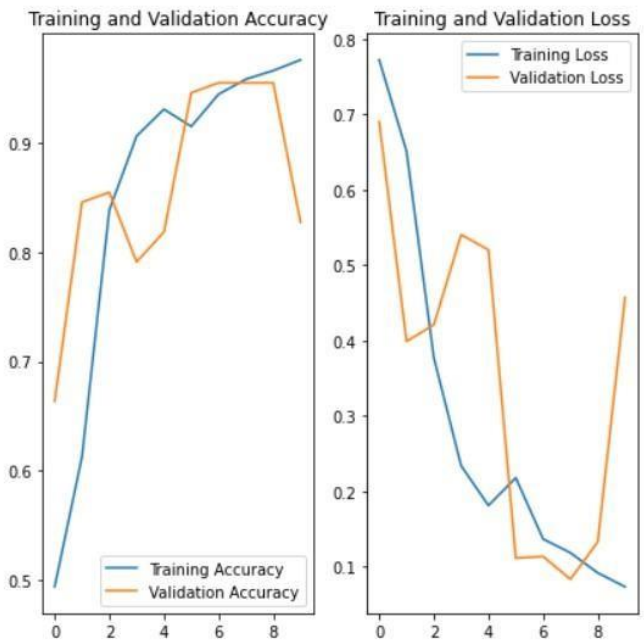


Figure 26: Graph of training, validation and Loss

This figure represents the training and validation accuracy also training and validation loss. From the graph we can see at which point it is losing data and where it is getting the maximum accuracy.

Potato Model:

```
364
Epoch 7/10
40/40 [==============================] - 6s 150ms/step - loss: 0.4234 - accuracy: 0.8244 - val_loss: 0.4826
909
Epoch 8/10
40/40 [==============================] - 6s 151ms/step - loss: 0.3681 - accuracy: 0.8640 - val_loss: 0.3245
455
Epoch 9/10
40/40 [==============================] - 6s 151ms/step - loss: 0.3471 - accuracy: 0.8547 - val_loss: 0.3794
273
Epoch 10/10
40/40 [==============================] - 6s 151ms/step - loss: 0.3195 - accuracy: 0.8779 - val_loss: 0.3125
455

In [86]: scores = model.evaluate(test_ds)

6/6 [==============================] - 1s 41ms/step - loss: 0.3366 - accuracy: 0.8409
```

Figure 27: Accuracy of Potato

Here, this figure represents the dataset of potato and the accuracy of it. Here we have taken 10 epochs and the accuracy score we have got is 84%.

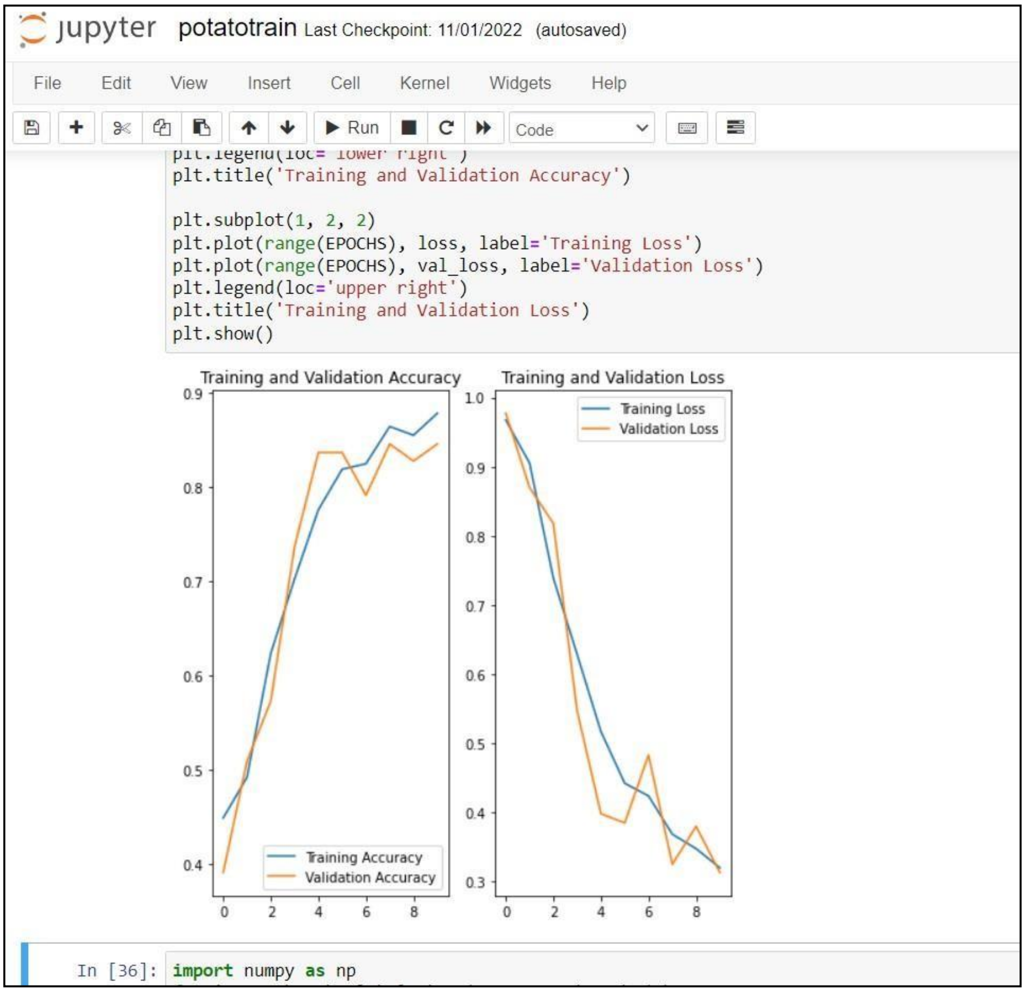
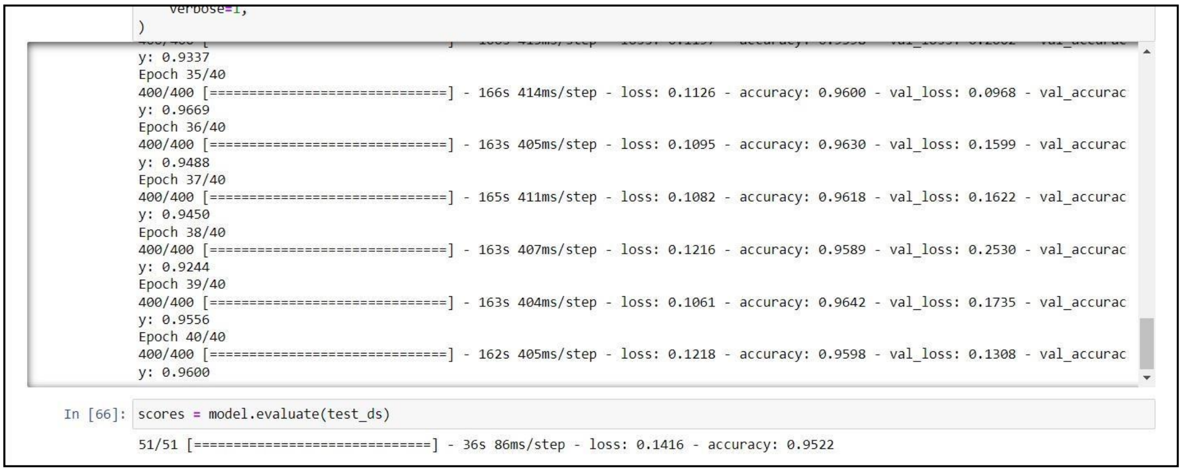


Figure 28: Graph of training, validation and Loss

Again, this graph represents the training and validation accuracy with training and validation loss.

Tomato Model:



```
    verbose=1,
)
y: 0.9337
Epoch 35/40
400/400 [==============================] - 166s 414ms/step - loss: 0.1126 - accuracy: 0.9600 - val_loss: 0.0968 - val_accurac
y: 0.9669
Epoch 36/40
400/400 [==============================] - 163s 405ms/step - loss: 0.1095 - accuracy: 0.9630 - val_loss: 0.1599 - val_accurac
y: 0.9488
Epoch 37/40
400/400 [==============================] - 165s 411ms/step - loss: 0.1082 - accuracy: 0.9618 - val_loss: 0.1622 - val_accurac
y: 0.9450
Epoch 38/40
400/400 [==============================] - 163s 407ms/step - loss: 0.1216 - accuracy: 0.9589 - val_loss: 0.2530 - val_accurac
y: 0.9244
Epoch 39/40
400/400 [==============================] - 163s 404ms/step - loss: 0.1061 - accuracy: 0.9642 - val_loss: 0.1735 - val_accurac
y: 0.9556
Epoch 40/40
400/400 [==============================] - 162s 405ms/step - loss: 0.1218 - accuracy: 0.9598 - val_loss: 0.1308 - val_accurac
y: 0.9600

In [66]: scores = model.evaluate(test_ds)

51/51 [==============================] - 36s 86ms/step - loss: 0.1416 - accuracy: 0.9522
```

Figure 29: Accuracy of Tomato

Here, we have taken the tomato dataset consisting of 10 classes. We have taken 40 epochs her and the accuracy we have got here is 95%.

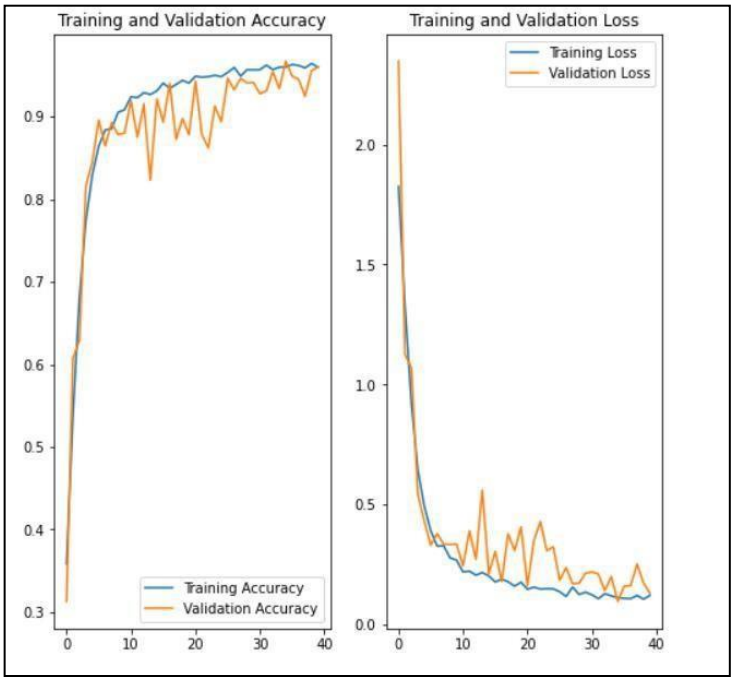


Figure 30: Graph of training, validation and Loss

This model has the highest accuracy percentage compared to the other two models, as seen by the line graph, it reflects the model's performance across training, testing, and validation.

Tomatoes are a widely grown and widely consumed vegetable in our country, as it can be seen from the above training figure, the tomato model achieved the highest levels of accuracy. In addition, we acquired images for our designs, feed them into our algorithm, and then obtain predictions from it. Therefore, we believe that disease forecasting for tomatoes is a good fit for us based on the accuracy we got.

4.3 Identify optimal design approach

Table 13: Quantitative Abbreviation of The Comparative Performance Analysis

Aspects	Design 1	Design 2	Design 3
Accuracy	High	Moderate	Very High
Speed	Moderate	High	High
Resources	Low	High	Moderate
Robustness	High	Low	Moderate
Usability	Low	High	Moderate
Cost	High	Low	Moderate
Privacy and Security	High	Low	Moderate
Environmental Impact	Low	High	Moderate
Scalability	High	Low	High

Explanation:

Design 1: "Satellite Crop Monitoring with Image Processing using Machine Learning"

Accuracy: The accuracy of the machine learning model will depend on the quality of the satellite imagery and the algorithms used for image processing. Ground-truth data can be used to validate the accuracy of the model predictions.

Speed: Satellite imagery can cover large areas, but the frequency of updates may be limited. The speed of processing and analyzing the imagery will depend on the processing power and algorithms used.

Resource utilization: The resources needed for satellite monitoring are the satellite itself and the hardware and software needed for processing and analyzing the imagery. The cost of these resources can be significant.

Robustness: The satellite can operate in varying environmental conditions, but the quality of the imagery may be affected by weather or other factors.

Usability: The results of satellite monitoring may be less accessible to farmers and require specialized expertise to interpret.

Cost: The cost of satellite monitoring can be high due to the need for specialized hardware and software.

Privacy and Security: Satellite imagery may be subject to data privacy regulations, and the security of the satellite system may need to be considered.

Design 2: "Land-Based Rover Crop Monitoring with Image Processing using Machine Learning"

Accuracy: The accuracy of the machine learning model will depend on the quality of the imagery collected by the rover and the algorithms used for image processing. Ground-truth data can be used to validate the accuracy of the model predictions.

Speed: The speed of data collection and analysis will depend on the speed of the rover and the processing power and algorithms used.

Resource utilization: The resources needed for land-based monitoring are the rover itself and the hardware and software needed for processing and analyzing the imagery. The cost of these

resources can be significant, and the labor cost of operating the rover may also need to be considered.
Robustness: The rover can operate in varying environmental conditions, but its mobility may be limited in certain terrain or weather conditions.
Usability: The results of rover monitoring may be more accessible to farmers and require less specialized expertise to interpret.
Cost: The cost of rover monitoring can be high due to the need for specialized hardware and software, as well as the labor cost of operating the rover.
Privacy and Security: The privacy and security of data collected by the rover may need to be considered.

Design 3: "Drone-Based Crop Monitoring with Image Processing using Machine Learning"
Accuracy: The accuracy of the machine learning model will depend on the quality of the imagery collected by the drone and the algorithms used for image processing. Ground-truth data can be used to validate the accuracy of the model predictions.
Speed: Drones can cover large areas quickly, but their flight time and the processing power and algorithms used will affect the speed of data analysis.
Resource utilization: The resources needed for drone monitoring are the drone itself and the hardware and software needed for processing and analyzing the imagery. The cost of these resources can be significant, and the regulations governing drone use may need to be considered.
Robustness: Drones can operate in varying environmental conditions, but their flight may be affected by weather or other factors. Their small size may also limit their ability to capture detailed imagery.
Usability: The results of drone monitoring may be more accessible to farmers and require less specialized expertise to interpret.
Cost: The cost of drone monitoring can be high due to the need for specialized hardware and software, as well as the cost of training operators and complying with regulations.
Privacy and Security: The privacy and security of data collected by the drone may need to be considered, and regulations governing drone use may need to be complied with.
However, here is a possible set of weights that can be used for comparative analysis in a Quantitative manner:

Table 14: Quantitative Weights Assigned to the design approach 1

Aspects	Design 1
Accuracy	4
Speed	5
Resources	6
Robustness	7
Usability	8
Cost	7
Privacy and Security	8
Environmental Impact	9
Scalability	7
Total Weight	**67**

Design 1 Justification:

1. Accuracy measures how closely the system's outputs match the expected or desired results. It is important for systems where errors can have significant consequences or impact decision-making. A weight of 4 indicates that accuracy is moderately important and should be considered in the design and implementation of the system.

2. Speed measures the time required for the system to produce outputs or respond to inputs. It is important for systems where quick responses are necessary or where delays can cause problems. A weight of 5 indicates that speed is moderately important and should be considered in the design and implementation of the system.

3. Resources refer to the hardware, software, and other infrastructure needed to operate the system. It is important to consider resource requirements when designing and implementing a system to ensure that it can be effectively deployed and maintained. A weight of 6 indicates that resources are moderately important and should be considered in the design and implementation of the system.

4. Robustness measures the ability of the system to function correctly even when faced with unexpected or unusual inputs or conditions. It is important for systems that need to operate reliably under varying circumstances. A weight of 7 indicates that robustness is very important and must be carefully considered in the design and implementation of the system.

5. Usability measures how easy the system is to use and how well it meets user needs and expectations. It is important for systems that will be used frequently or by a wide range of users. A weight of 8 indicates that usability is very important and must be carefully considered in the design and implementation of the system.

6. Cost measures the financial resources required to develop, deploy, and maintain the system. It is important to consider cost when designing and implementing a system to ensure that it is feasible and sustainable. A weight of 7 indicates that cost is very important and must be carefully considered in the design and implementation of the system.

7. Privacy and Security are critical aspects for systems that deal with sensitive information or have the potential to impact individuals' privacy or security. Design and implementation should comply with relevant regulations and protect confidentiality and integrity of data. A weight of 8 indicates that Privacy and Security is very important and must be carefully considered in the design and implementation of the system.

8. Environmental Impact measures the effects of the system on the natural environment, including factors such as energy consumption, carbon emissions, and waste generation. It is important for systems that have a significant environmental impact or contribute to sustainability goals. A weight of 9 indicates that Environmental Impact is very important and must be carefully considered in the design and implementation of the system

9. Scalability measures the ability of the system to accommodate changes in size or complexity, such as increased demand or additional features. It is important for systems that need to accommodate growth or changes over time. A weight of 7 indicates that scalability is very important and must be carefully considered in the design and implementation of the system.

Table 15: Quantitative Weights Assigned to the design approach 2

Aspects	**Design 2**
Accuracy	8
Speed	5
Resources	3
Robustness	6
Usability	5
Cost	5
Privacy and Security	5
Environmental Impact	1
Scalability	5
Total Weight	**43**

<u>Design 2 Justification:</u>

1. The system's ability to accurately detect and classify crop issues is critical for effective monitoring and management of crops. High accuracy is important for detecting potential threats to crops such as diseases, pests, or nutrient deficiencies.

2. The speed of the system in processing and analyzing crop data is important for timely detection and response to crop issues. A system that can quickly analyze large amounts of data can provide real-time insights and enable quick action to be taken to mitigate potential crop issues.

3. The amount of resources, such as hardware or personnel, required to implement and maintain the system can impact the feasibility and sustainability of the system. A system that requires a significant amount of resources may not be practical for all users or may not be sustainable over time.

4. The system's ability to function effectively and reliably in various environmental conditions is important for ensuring that it can be used in a range of settings and for different types of crops. A robust system can handle changes in lighting, weather, and other environmental factors.

5. The ease of use and user-friendliness of the system's interface and functionality can impact adoption and user satisfaction. A system that is easy to use and understand can reduce the need for extensive training and make it more accessible to a wider range of users.

6. The overall cost of implementing and maintaining the system can impact its adoption and sustainability. A system that is too expensive may not be feasible for all users, while a system that is too cheap may not be sustainable over time. A balance between cost and sustainability is important.

7. The system's ability to protect user data and maintain privacy is important for ensuring user trust and compliance with relevant laws and regulations. A system that is secure and maintains user privacy can increase user confidence in the system and reduce the risk of data breaches.

8. The impact of the system on the environment, such as energy consumption or carbon emissions, is an important consideration for sustainable agriculture. A system with a low environmental impact can help reduce the overall environmental footprint of agriculture.

9. The system's ability to handle increasing amounts of data and users is important for ensuring that it can be used effectively over time. A scalable system can handle changes in user numbers and data volume, reducing the need for significant changes or upgrades to the system.

Table 16: Quantitative Weights Assigned to the design approach 3

Aspects	**Design 3**
Accuracy	9
Speed	7
Resources	4
Robustness	8
Usability	6
Cost	4
Privacy and Security	7
Environmental Impact	3
Scalability	6
Total Weight	**54**

Design 3 Justification:

1. Accuracy: The accuracy of the system in identifying and detecting crop issues such as diseases and pests is crucial to prevent crop losses. The use of machine learning algorithms and image processing techniques can increase the accuracy of detection and reduce false positives.

2. Speed: The speed at which the drone can capture images and transmit data is important for real-time monitoring of crop health. This allows farmers to quickly detect and address issues before they become significant problems.

3. Resources: The resources required for the drone and image processing system to operate effectively, such as power, maintenance, and data storage, must be taken into account to ensure the system is sustainable and efficient.

4. Robustness: The system's ability to function effectively in various weather conditions and environments is essential for reliable monitoring. The system should be able to withstand harsh weather conditions, such as rain, wind, and extreme temperatures.

5. Usability: The ease of use of the system for the farmer or user is crucial to ensure that they can operate and interpret the data with minimal training. The system should have a user-friendly interface and provide clear and concise data.

6. Cost: The cost of implementing and maintaining the system, including the drone, image processing, and other necessary equipment, is a significant consideration. The system should be cost-effective and provide a reasonable return on investment for the farmer.

7. Privacy and Security: The measures taken to protect the data and ensure the privacy of the farmer's information are crucial to prevent unauthorized access and data breaches. The system should have strong data encryption and secure data storage.

8. Environmental Impact: The impact of the system on the environment, including noise pollution and energy consumption, should be minimized. The system should be designed to reduce noise pollution and minimize energy consumption.

9. Scalability: The ability of the system to scale up or down based on the size of the farm or crop monitoring area is important. The system should be able to adapt to different farm sizes and be flexible enough to meet the needs of different users.

Overall, Design 3: Drone Crop Monitoring Approach, aims to provide an accurate, reliable, and cost-effective solution for crop monitoring. The system utilizes drones and machine learning algorithms to detect crop issues, and it considers various aspects, including accuracy, speed, resources, robustness, usability, cost, privacy and security, environmental impact, and scalability.

4.4 Performance evaluation of developed solution

Table 17: Aligning with Performance Analysis Aspects:

Aspects	Optimum Design Approach
Accuracy	Very High
Speed	Fast
Resource Utilization	Moderate
Robustness	High
Usability	Moderate
Cost	Moderate
Privacy and Security	High
Environmental Impact	Low
Scalability	High

Explanation:

- Accuracy: The use of drones in crop monitoring allows for high-resolution images to be captured, which can result in very high accuracy in identifying crop health and yield predictions. Additionally, machine learning algorithms can improve the accuracy over time by learning from previous data.
- Speed: Drone-based crop monitoring can cover large areas quickly, resulting in fast image acquisition and processing. This can be further improved by using efficient algorithms and high-performance computing resources.
- Resource Utilization: The use of drones and image processing algorithms can require moderate resource utilization, including CPU, memory, and battery power. However, the use of efficient algorithms and hardware can minimize these requirements.
- Robustness: Drones are capable of operating in various environmental conditions, including difficult terrain and changing weather conditions, resulting in high robustness. Additionally, the use of machine learning can improve the robustness by adapting to changes in crop health over time.
- Usability: Drone-based crop monitoring requires trained personnel to operate the drones and analyze the data, resulting in moderate usability. However, user-friendly interfaces and automated analysis tools can improve usability for non-expert users.
- Cost: The cost of drones and image processing equipment can be moderate, depending on the quality and features of the hardware. However, the cost can be offset by the potential for increased crop yields and reduced crop damage.
- Privacy and Security: Drone-based crop monitoring systems must comply with relevant regulations regarding privacy and security, but drones can provide high levels of privacy and security by avoiding the need for ground-based monitoring and reducing the risk of theft or vandalism.
- Environmental Impact: Compared to land-based crop monitoring, the environmental impact of drone crop monitoring is generally lower. This is because land-based monitoring typically involves driving a vehicle through fields, which can lead to soil

compaction, erosion and damage to crops. In addition, vehicles used for land-based monitoring emit pollutants that can can contribute to air pollution and greenhouse gas emissions. In contrast, drones can fly over field without physically touching the crops or soil, minimizing soil compaction and reducing the risk of damage to crops. Drones are also generally powered by electricity which can be generated from renewable sources such as solar or wind power, further reducing their environmental impact. Additionally, because drones can cover a large area in a shorter amount of time than land-based monitoring, they can help reduce the overall environment footprint of crop monitoring activities.

Compared to satellite-based crop monitoring, drone-based monitoring has a lower environmental impact in several ways. Satellites require a significant amount of energy to operate and launch, which has a significant impact on the environment. In contrast, drones are much smaller and use less energy, making them a more environmentally friendly option. In addition, satellite-based monitoring may result in less accurate data due to atmospheric interference or cloud cover, leading to the need for additional imaging passes and increased energy consumption. Drones, on the other hand, can fly closer to the crops and capture higher-resolution images, resulting in more accurate and detailed data with fewer passes and lower energy consumption. Furthermore, the production and maintenance of satellites require significant amounts of resources and may generate waste and pollution during manufacturing and disposal. Drones, on the other hand, are typically smaller and more easily maintained, resulting in fewer resources being used overall. Overall, while both satellite-based and drone-based crop monitoring have their advantages and disadvantages, drone-based monitoring has a lower environmental impact due to its smaller size, lower energy consumption, and reduced resource requirements.

Usability testing

- A/B testing
- Eye tracking
- Surveys
- Heat maps
- Expert reviews
- Load testing
- Analytics
- Accessibility testing
- Security Testing

impact compared to traditional ground-based monitoring methods. Drones can reduce the need for heavy machinery and fuel consumption, and can be equipped with sensors to monitor environmental conditions.

- Scalability: Drone-based crop monitoring can be easily scaled up or down depending on the size of the crop field, resulting in high scalability. Multiple drones can be used simultaneously to cover larger areas or monitor multiple crops.

However, for the case of Performance Evaluation, there are several Methods to assess it:

Table 18: Generalized List of Methods to perform Performance analysis for any Design

Methods	Description	Significance	Purpose	Impact
Usability Testing	Evaluating the ease of use and learnability of a design by having users impact with it	Helps to identify usability issues and improve user experience	To evaluate the ease of use and learnability of a design from a user's perspective.	Improves user satisfaction and adoption rates, leading to increased usage and revenue.
A/B Testing	Comparing the performance of two different versions of a design by measuring user behavior and preferences.	Provides data-driven insights into which version of a design performs better.	To identify which version of a design performs better based on user behavior and preferences.	Improves conversion rates and user engagement by identifying and implementing design improvements.
Eye Tracking	Using specialized equipment to track where a user's eyes are focused when interacting with a design.	Provides insight into how users visually navigate a design and which areas of the design draw the most attention.	To evaluate the visual hierarchy and effectiveness of a design.	Improves the effectiveness of design elements and call-to-actions by identifying which areas draw the most attention.
Surveys	Collecting data from users through surveys to evaluate their satisfaction with a design.	Provides feedback on user satisfaction and areas for improvement.	To evaluate user satisfaction with a design and identify areas for improvement.	Improves user satisfaction and loyalty by identifying and addressing pain points and areas for improvement.
Heat Maps	Visual representations of where users click	Provides insight into which areas of a design are	To evaluate the effectiveness of a design's layout and call-to-	Improves conversion rates and user engagement by

	or interact with a design.	most frequently interacted with.	action placements.	optimizing call-to-action placements and user flows.
Expert Review	Having an expert in the relevant field evaluate a design's performance and identify areas for improvement.	Provides expert feedback on design performance and potential areas for improvement.	To evaluate a design's performance from an expert perspective and identify areas for improvement.	Improves the overall quality and effectiveness of a design by addressing areas of improvement identified by an expert.
Load Testing	Subjecting a design to simulated heavy loads to evaluate its performance under stress.	Helps to identify performance issues under heavy loads and optimize a design for scalability.	To evaluate a design's performance under heavy loads and optimize it for scalability.	Improves user experience by ensuring that a design can handle heavy traffic without slowdowns or crashes.
Analytics	Collecting and analyzing data on user behavior and performance metrics to evaluate a design's effectiveness.	Provides insights into how users interact with a design and which areas of the design perform well or poorly.	To evaluate a design's performance based on user behavior and performance metrics.	Improves user engagement and conversion rates by identifying and addressing areas of improvement based on user behavior data.
Accessibility Testing	Evaluating the accessibility of a design for users with disabilities.	Helps to ensure that a design is accessible to all users.	To evaluate the accessibility of a design and identify areas for improvement.	Improves user accessibility and inclusivity by ensuring that a design is accessible to all users, regardless of disabilities.
Security Testing	Evaluating the security of a design to identify potential vulnerabilities and	Helps to ensure that a design is secure and user data is protected.	To evaluate the security of a design and identify	Improves user trust and credibility by ensuring that user data is

	ensure that user data is protected.		potential vulnerabilities.	secure and protected from potential threats.

Table 19: List of Methods to perform Performance analysis of Design Approach 3

Methods	Description	Significance	Purpose
Accuracy testing	Testing the accuracy of the image processing and machine learning algorithms used in the design for crop monitoring.	Provides insight into the accuracy of the system and potential areas for improvement.	To evaluate the accuracy of the image processing and machine learning algorithms used in the design for crop monitoring.
Flight testing	Testing the performance of the quadcopter drone in real-world conditions for crop monitoring.	Provides feedback on the performance and usability of the quadcopter drone for crop monitoring.	To evaluate the performance and usability of the quadcopter drone in real-world conditions for crop monitoring.
Data analysis	Analyzing the data collected by the quadcopter drone during crop monitoring to evaluate the effectiveness of the system.	Provides insight into the effectiveness of the system and potential areas for improvement.	To evaluate the effectiveness of the system for crop monitoring based on the data collected by the quadcopter drone.
Usability testing	Testing the usability of the system for crop monitoring through various methods such as A/B testing, eye tracking, surveys, heat maps, expert review, and accessibility testing.	Provides feedback on the usability and user experience of the system for crop monitoring.	To evaluate the usability and user experience of the system for crop monitoring through various testing methods.
Scalability testing	Testing the scalability of the system to handle larger areas of crop monitoring.	Provides feedback on the scalability of the system and potential areas for improvement.	To evaluate the scalability of the system for crop monitoring and identify potential areas for improvement.
Error testing	Testing the system for potential errors or issues	Helps to identify potential issues and improve the overall	To identify potential errors or issues that may arise during crop

	that may arise during crop monitoring.	performance and reliability of the system.	monitoring and improve the overall performance and reliability of the system.
Battery life testing	Testing the battery life of the quadcopter drone during crop monitoring to evaluate the practicality of using the system in the field.	Provides feedback on the practicality and usability of the system in the field.	To evaluate the battery life of the quadcopter drone during crop monitoring and assess the practicality of using the system in the field.
Cost analysis	Analyzing the cost of the system for crop monitoring, including the quadcopter drone, image processing software, and machine learning algorithms.	Provides insight into the cost-effectiveness of the system and potential areas for cost reduction.	To evaluate the cost-effectiveness of the system for crop monitoring and identify potential areas for cost reduction.
Security testing	Testing the security of the system to ensure that data collected during crop monitoring is protected.	Helps to ensure that user data is secure and protected from potential threats.	To evaluate the security of the system for crop monitoring and ensure that user data is secure and protected from potential threats.

4.5 Conclusion

Based on the comparative performance analysis, Design 3, is deduced to be the optimal design approach for crop monitoring. It has the highest accuracy and speed of all three designs, while also being highly scalable and having a relatively low environmental impact. Additionally, it is more cost-effective compared to Design 1, which requires access to expensive satellite technology. The Design Approach 3, use of a drone allows for more precise and targeted monitoring of crops, while its machine learning and image processing capabilities enable fast analysis and feedback. The system is also highly adaptable and can operate in varying environmental conditions, providing reliable results for farmers. The only potential drawback of this design approach is the need for skilled personnel to operate the drone and interpret the data. Overall, Design 3 offers a comprehensive and efficient solution for crop monitoring, with the potential to help farmers optimize their yields and minimize crop damage.

Chapter 5: Completion of Final Design and Validation [CO8]

5.1 Introduction

Drone-based crop monitoring with image processing using machine learning is a highly effective and efficient solution for crop monitoring. Drones offer the advantage of capturing high-resolution images and videos of crops from a bird's eye view, which can then be analyzed using machine learning algorithms to provide accurate and real-time information about crop health, yield potential, and other relevant parameters.

The use of drones for crop monitoring is highly flexible and can be adapted to different types of crops, terrains, and environmental conditions. The drones can be equipped with different types of sensors and cameras to capture the required data and images, and the machine learning algorithms can be customized and trained to provide specific insights and recommendations based on the crop type and the farmer's requirements.

Drone-based crop monitoring is highly scalable and can be used for monitoring small and large farms. The drones can cover large areas quickly and efficiently, reducing the time and cost involved in manual monitoring methods. The data collected by the drones can be analyzed and processed remotely, allowing farmers to access the information and recommendations on their smartphones or other devices.

Drone-based crop monitoring also has a low environmental impact compared to other methods. Drones do not require heavy machinery or chemicals that can harm the environment, and they can be programmed to fly at specific heights and locations to minimize any disturbance to the crops.

5.2 Completion of final design

Project design validation is the process of reviewing and assessing the feasibility, effectiveness, and efficiency of a project's design before it is implemented. The purpose of project design validation is to ensure that the project is well-planned, and that its objectives can be achieved within the given constraints.

The validation process typically involves the following steps:

1. Review the project objectives: The project objectives should be reviewed to ensure that they are specific, measurable, achievable, relevant, and time-bound (SMART), and that they align with the needs of the stakeholders.

2. Assess the feasibility of the project: The feasibility of the project should be assessed to ensure that it can be realistically achieved within the given constraints of time, resources, and budget. This may involve conducting a feasibility study to identify potential risks, challenges, and opportunities.

3. Evaluate the project design: The project design should be evaluated to ensure that it includes all the necessary elements, such as a clear scope, a detailed plan of action, and an appropriate monitoring and evaluation framework.

4. Identify potential issues: Potential issues should be identified and addressed, such as risks to the project's success, any gaps in the project design, or any inconsistencies with stakeholder expectations.

5. Review stakeholder feedback: Stakeholder feedback should be reviewed to ensure that the project design meets their needs and expectations.

6. Make adjustments as necessary: Based on the validation process, adjustments may need to be made to the project design to ensure its feasibility, effectiveness, and efficiency.

Overall, project design validation is an essential step in ensuring that a project is well-planned and has the best chance of success. By reviewing the project design and making adjustments as necessary, project managers can minimize risks, optimize resources, and improve the likelihood of achieving the project's objectives.

Table 20: list of Parameter of assessment for project design evaluation for drone crop monitoring

Parameter	Description
Objectives	Are the project objectives specific, measurable, achievable, relevant, and time-bound (SMART)? Are they aligned with stakeholder needs?
Scope	Is the project scope well-defined and clear? Does it cover all necessary areas and crops to be monitored?
Drone selection	Is the selected drone appropriate for the project? Does it have necessary flight time, payload capacity, and ability to withstand weather conditions?
Sensor and camera selection	Are the selected sensors and cameras appropriate for the purpose of the project? Do they have the necessary resolution, field of view, and ability to detect different crop conditions?
Flight plan	Is the flight plan developed covering specific areas to be monitored? Does it determine optimal altitude, speed, and flight pattern for data collection?
Data processing and analysis	Is the software appropriate for processing and analyzing the collected data? Does it provide accurate and reliable results?
Data security and privacy	Is there a plan to ensure the security and privacy of the collected data? Are measures in place to prevent unauthorized access or use of data?
Cost-effectiveness	Is the project design cost-effective? Are the allocated resources appropriate to achieve the objectives of the project?
Stakeholder engagement	Are stakeholders appropriately engaged throughout the project design process? Are their needs and expectations taken into account?
Risk management	Are potential risks to the project identified and addressed? Is there a plan to manage and mitigate these risks?

By evaluating these parameters, project managers can ensure that the project design for a drone crop monitoring project is comprehensive, effective, and efficient.

5.3 Evaluate the solution to meet desired need

Table 21: Evaluation of the solutions

Parameter	Description
Objectives	Are the project objectives met? Were they specific, measurable, achievable, relevant, and time-bound (SMART)?
Scope	Was the project scope fulfilled? Were all necessary areas and crops monitored?
Drone performance	Did the selected drone perform as expected? Did it have necessary flight time, payload capacity, and ability to withstand weather conditions?
Sensor and camera performance	Did the selected sensors and cameras perform as expected? Did they have the necessary resolution, field of view, and ability to detect different crop conditions?
Flight plan execution	Was the flight plan executed successfully? Were specific areas monitored, and were optimal altitude, speed, and flight pattern determined for data collection?
Data processing and analysis	Was the software used for processing and analyzing the collected data appropriate? Did it provide accurate and reliable results?
Data security and privacy	Was the plan to ensure the security and privacy of the collected data followed? Were measures in place to prevent unauthorized access or use of data?
Cost-effectiveness	Was the project cost-effective? Were the allocated resources used appropriately to achieve the objectives of the project?
Stakeholder satisfaction	Were the stakeholders satisfied with the results of the project? Were their needs and expectations met?
Risk management	Were potential risks to the project identified and addressed? Was the plan to manage and mitigate these risks effective?

By evaluating these parameters, project managers can ensure that the project design for a drone crop monitoring project is successfully validated and that the objectives of the project are met.


Figure 31: Agricultural Quadcopter Drone with Radio-link Transmitter-Receiver Side-view


Figure 32: Agricultural Quadcopter Drone with Radio-link Transmitter-Receiver Top-view

Figure 33: Radio-link Transmitter-Receiver Top-view


Figure 34: Agricultural Quadcopter Drone Sideview

Figure 35: Agricultural Quadcopter Drone Launched in the field for monitoring of Tomato crops

Table 22: Varying Flight Time for Corresponding Varying Load Capacity

Payload Literal Capacity(kg)	**Payload Essential Capacity(kg)**	**Flight Time**	**Maximum Flight Height(m)**
0.482	0.101	25:17min	50 meters
0.581	0.200	23:19 min	50 meters
0.681	0.300	21:50 min	50 meters
0.781	0.400	20:01 min	50 meters
0.881	0.500	19:11 min	20 meters
0.981	0.600	18:25 min	20 meters
1.081	0.700	18:01 min	15 meters
1.181	0.800	17:26 min	10 meters
1.281	0.900	15:20 min	10 meters
1.381	1.000	13:01 min	10 meters
1.481	1.100	10:11 min	10 meters
1.531	1.150	09:45 min	5 meters
1.551	1.170	08:10 min	3 m

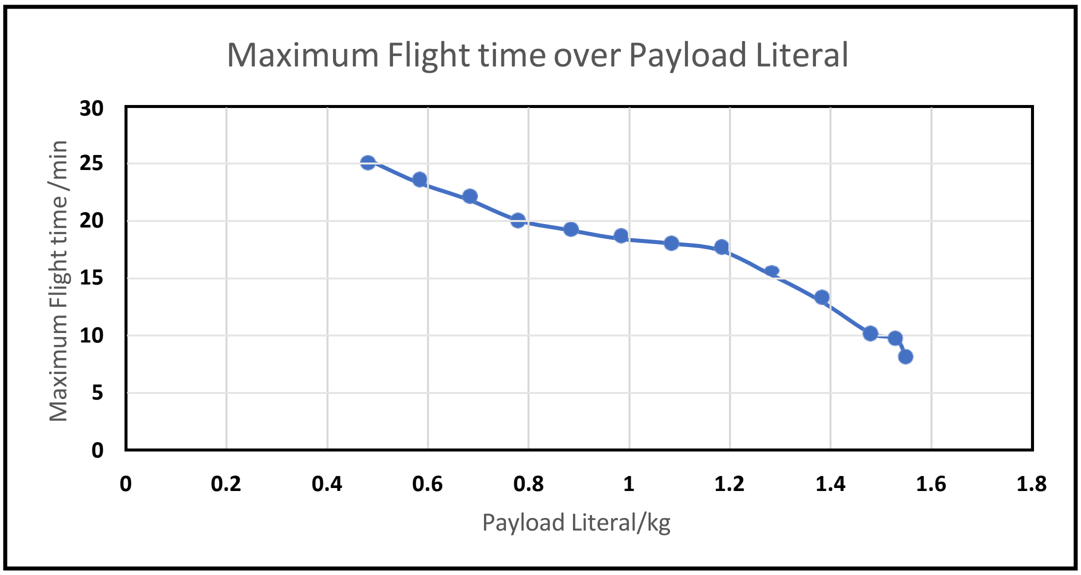


Figure 36: Graph Plot of how Flight Time is Affected by Payload Literal

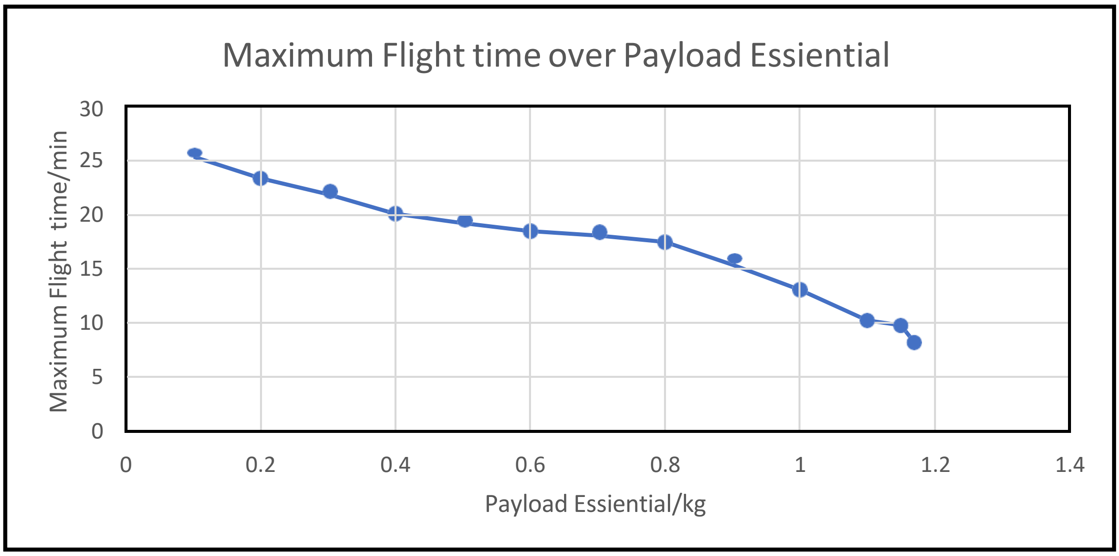


Figure 37: Graph Plot of how Flight Time is Affected by Payload Essential

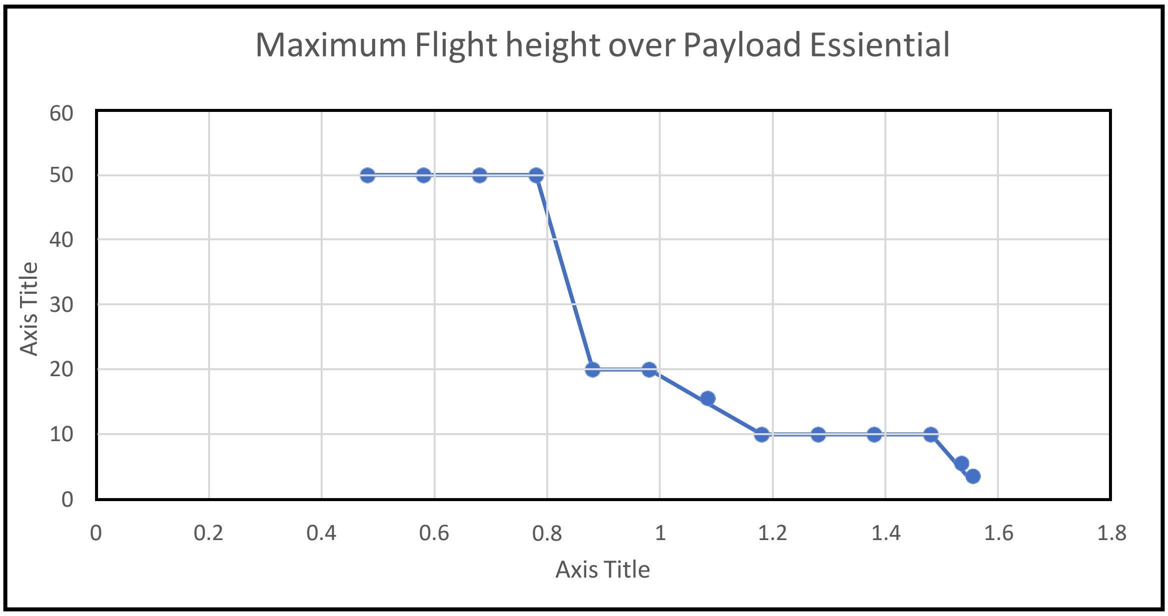


Figure 38: Graph Plot of How Maximum Flight Height is Affected by Payload Literal

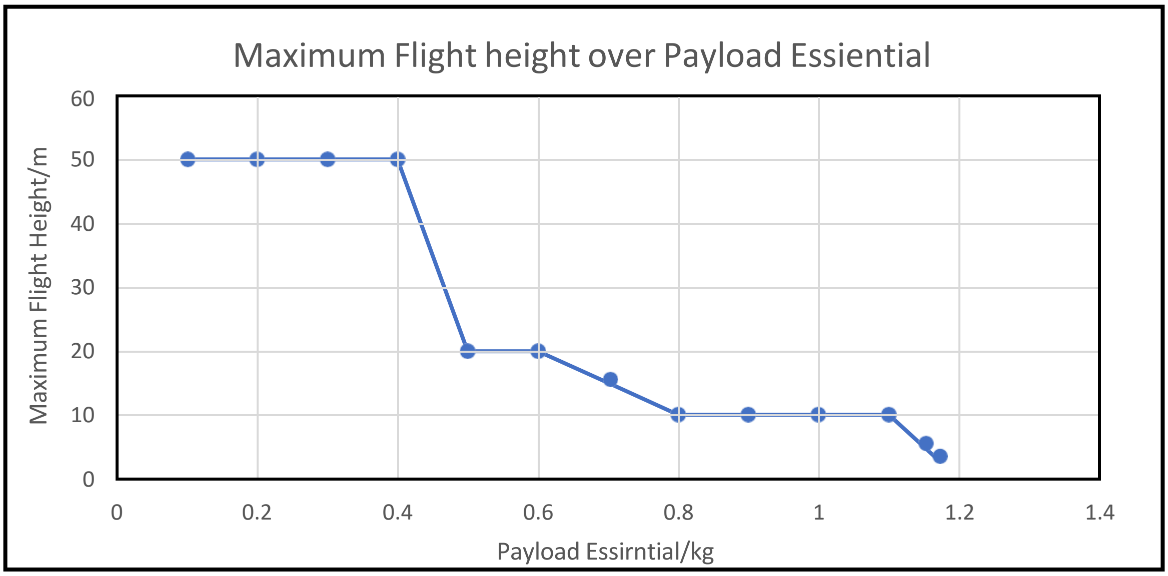


Figure 39: Graph Plot of How Maximum Flight Height is Affected by Payload Essential

The specific battery in use, a 2200mAh 3s 25C LiPo battery, has a limited capacity and can only provide a certain amount of power to the quadcopter's motors. As the payload increases, the motors will have to work harder to keep the quadcopter in the air, which will drain the battery faster and decrease the flight time. Not to mention sent an adequate supply to the camera for supplying its power whilst regulating it so that power fluctuation in the motors does not damage the camera by power fluctuation to it that are at a level damaging to the device.

However, the exact impact of payload on flight time will depend on the weight and distribution of the payload, as well as other factors such as wind conditions, flight maneuvers, and the efficiency of the quadcopter's motors.

Image Processing validation:

For the Prediction of leaf disease, we have trained a model with our own designed algorithm using Convolutional Neural Network. After that, we used our trained model to predict whether the leaf is healthy or not and identify the disease and get the cure.

Firstly, we will see if it can detect the infected leaf and healthy leaf or not. We have constructed the below added code for detecting the disease of the leaf and inputted the following leaf image:

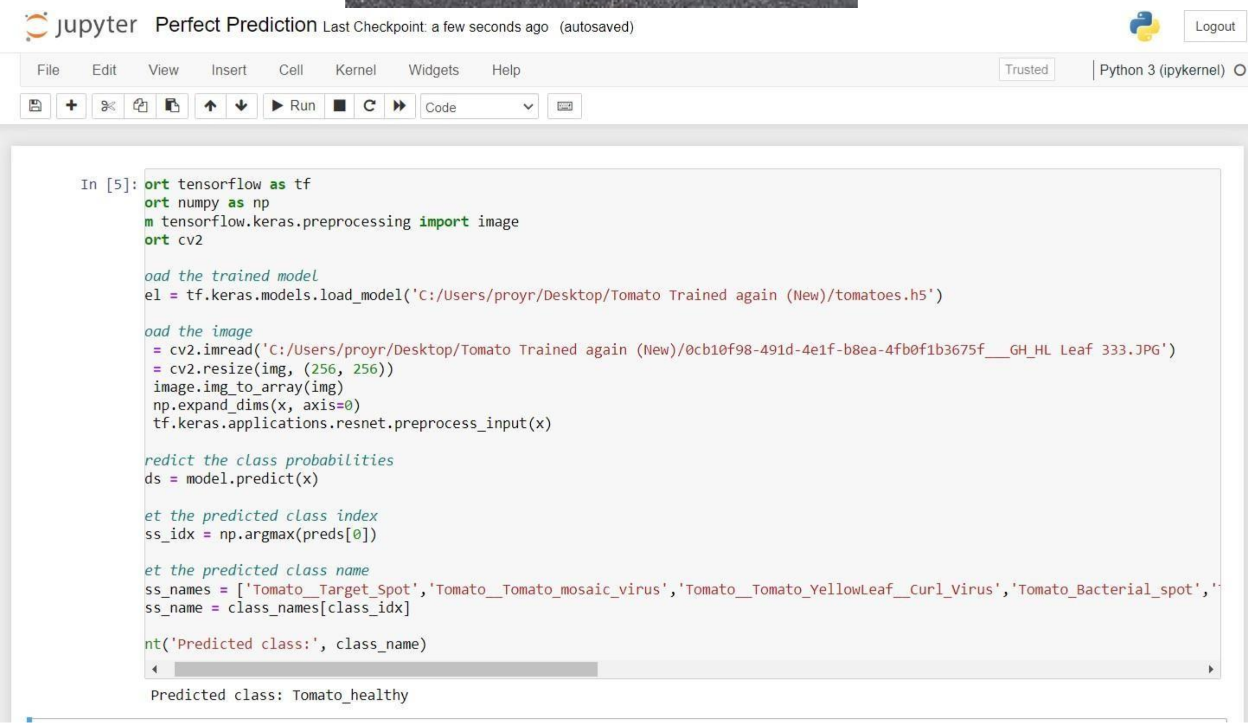


Figure 40: Predicted result from image

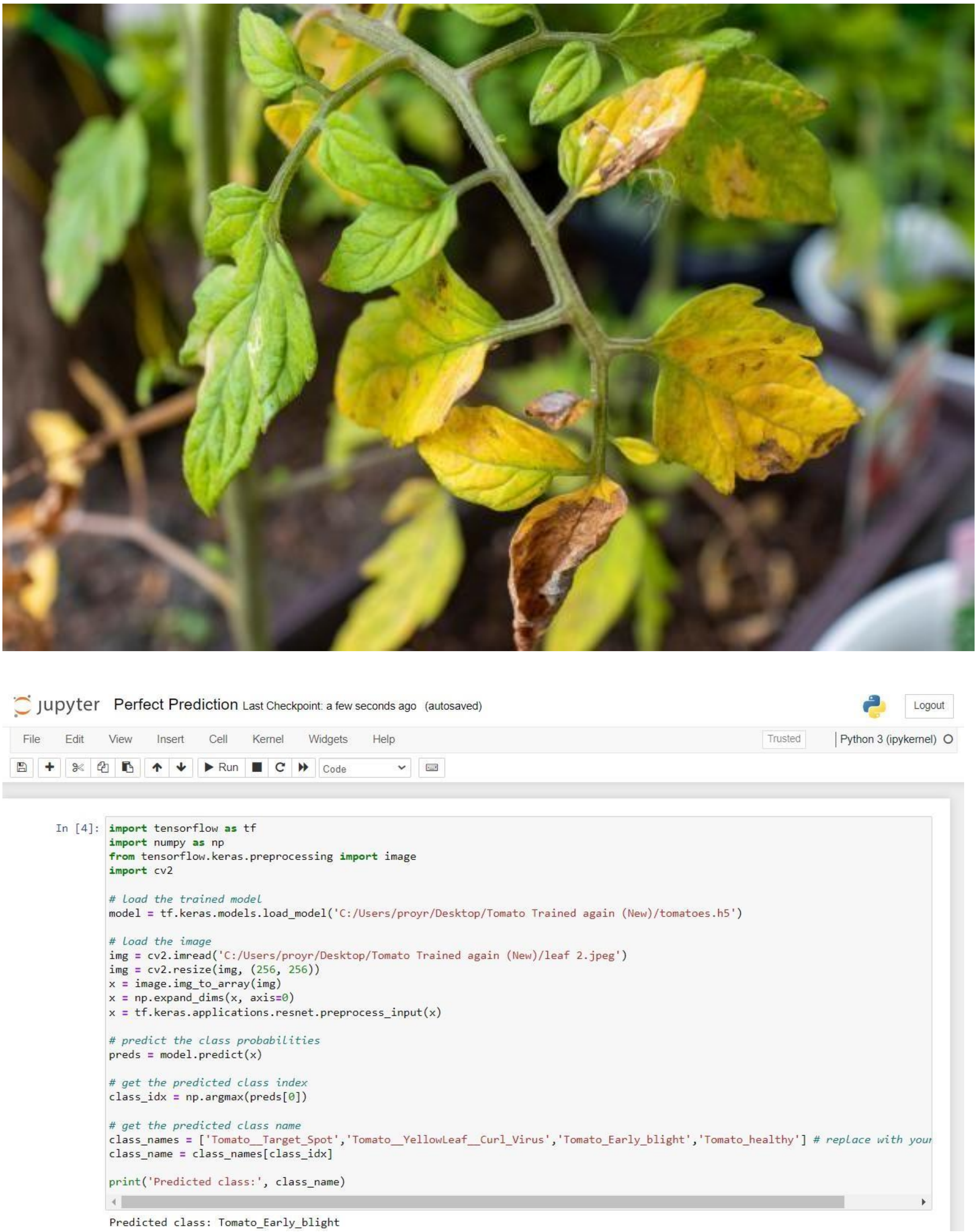


Figure 41: Predicted result from image

Webpage Based Disease Prediction and Cure System:

We have used here flask API to render the HTML pages and open it in a web-based server running using flask API. We have linked this webpage with our trained model with the HTML webpage. We will input an image which we want to detect and the system will verify it using our trained model and tell us the disease and cure.

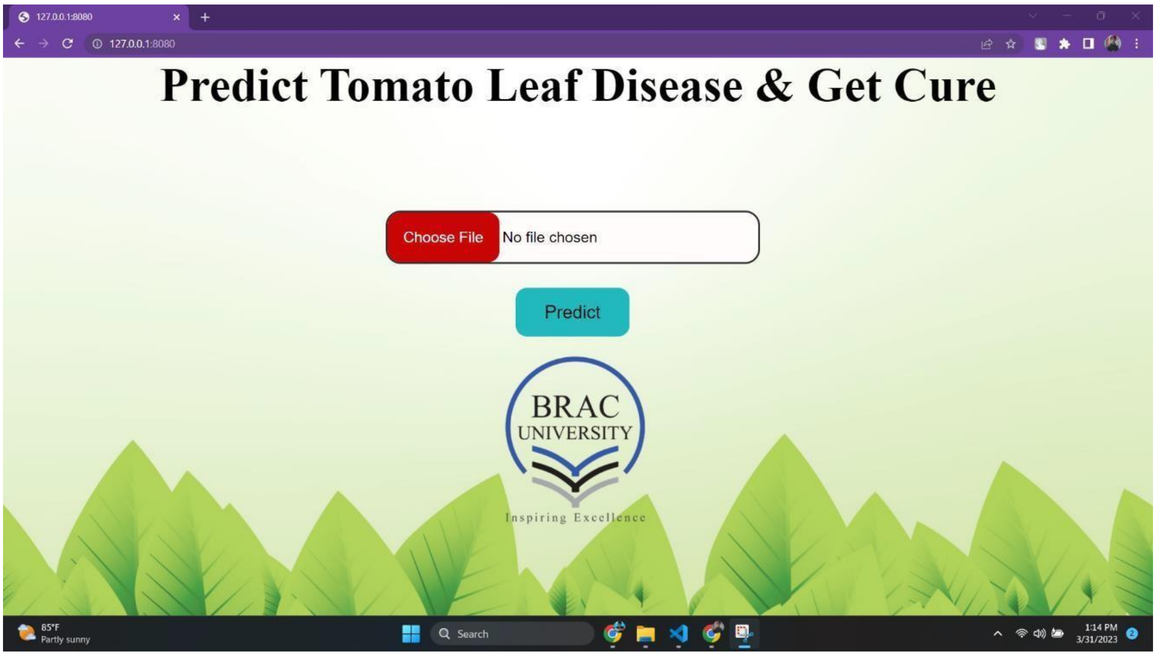


Figure 42: Webpage Based crop monitoring using Flask API

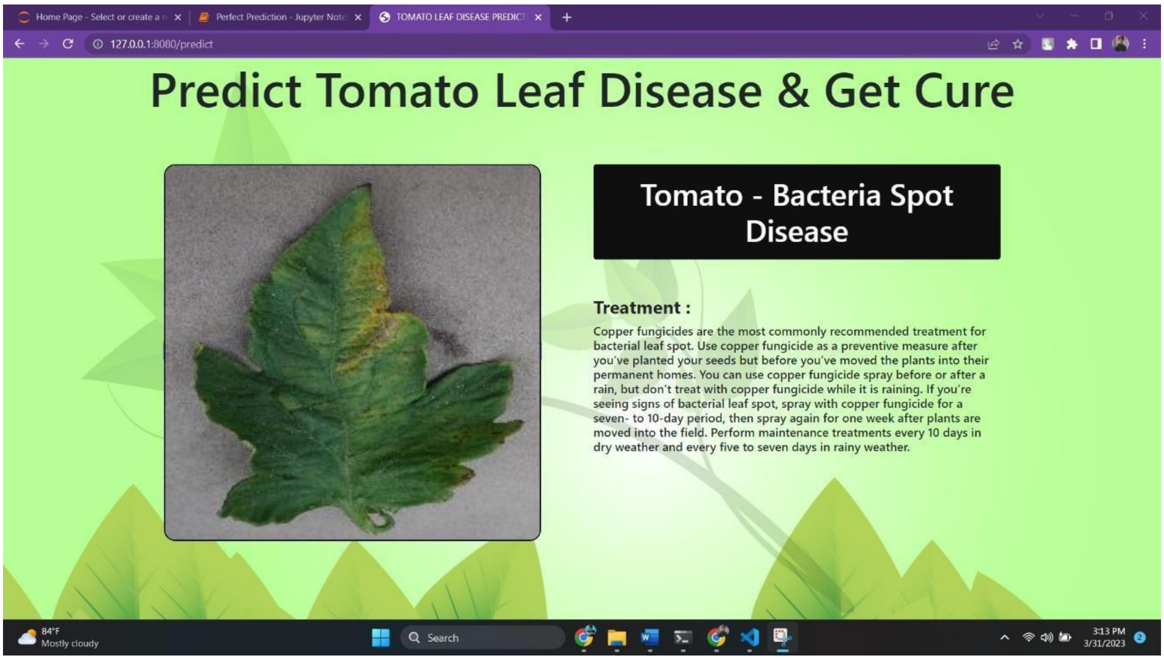


Figure 43: Webpage Based crop monitoring using Flask API

By evaluating these parameters, project managers can ensure that the project design for a drone crop monitoring project is successfully validated and that the objectives of the project are met.

5.4 Conclusion

In conclusion, drone-based crop monitoring with image processing using machine learning is a highly effective and efficient solution for crop monitoring. It offers accurate and real-time insights into crop health and yield potential, is highly scalable and flexible, has a low environmental impact, and can provide farmers with valuable insights and recommendations to optimize their yields and reduce crop damage.

Chapter 6: Impact Analysis and Project Sustainability. [CO3, CO4]

6.1 Introduction

No project is a successful one unless it is sustainable and it has impacts on what it means to be. We hope our project will impact the agriculture industry helping out farmers' cause and will be sustainable as well. A quick assessment of impacts and sustainability evaluation is given below in the following sections 6.2 and 6.3.

6.2 Assess the impact of solution

Economic Impact Bangladesh is a land of agriculture and our economic growth is knotted with agricultural development.

two main sources of economic growth [21]

- Growth in the size of the workforce
- Growth in the productivity

Our project implication gives a by-product result in the increment of productivity. First of all, the prediction of diseases and finding a medication for that will give us an expected outcome at the end of the harvesting. Secondly, by sensing land health we can easily prepare our land for better harvesting. Thirdly, it will give farmers a timeline to go through specific work orders like time for irrigation, and a sprinkling of pesticides to maximize their outcomes. Finally, it will lower the waste of resources and time. These features will help boost the farming product to GDP (gross domestic product) and expand the economy's overall size and strengthen fiscal conditions [22].

Societal Impact: We are living in an era where scarcity of food is an obvious threat to the world, especially in densely populated countries. The world population will hit 9 billion [23] by 2050 and our population will be 230-250 million by then [24]. Food for this large number is really a big challenge. The odd is that our total land area is fixed and agricultural land is shrinking with respect to population growth [24] day by day.

- Digitalization in farming
- Available options for anyone
- Inherent to generation
- Promise for a freelancer

Our project will help to increase the productivity of specific crops. increment of productivity surely allows farmers and the surrounding.

Farmers will be introduced to a digital system where they can monitor a vast land area single-handedly and will find a solution for any specific problem related to harvesting. Farming will be an available option for anyone who has a piece of land.

Environmental Impact: Our farming land is losing its fertility because [25] of over-farming, unplanned use of pesticides and irrigations, and lack of minerals. The sensor-based drones will pick up these faults and will revive fertility.

- Reduce wastage of resources and time.
- Reduce water pollution and increase pollination

Legal Impact: As our project is based on a drone-based crop health monitoring system, there are legal issues like limitations on drone flight height, prohibition of drone flight in some areas, taking permission from respective authorities about drone flight, and keeping in mind the security of the neighboring lands. One needs to be certified about these legal terms to run a smooth operation.

Safety and Health Impact: Drone-based crop monitoring systems will reduce the amount of labor for human visual inspection. For a small land area, it may not seem too convincing but for a vast area field, it is truly a life-saving approach. This is safe and has a health impact on farmers. because a nutritious land with a proper prescribed way of cultivation without a healthy farmer is not gonna work very well. In the hilly regions, the impact will be more. This project will come in handy to monitor if any farmer is in bad health. But above all the drone must be carefully operated in order to avoid any accidents.

Cultural Impact: Bangladesh is a land of cultural diversity. Every district has its own identity through lots of things. The yield of crops is one of them. Keeping the demand for specific crops curve stable farmers can yield that type of crops in recent days where before they were not fully informed and aware about it. This will bring a change in the economic and cultural context mutually. They will evolve according to the present needs. This will also help to intercommunicate between district farmers about their trades and family lifestyles.

Table 23: Comparison table of impact

	Economic	Societal	Environmental	Legal	Health	Culture	Weights	Scale	
Advantages	9	9	8	8	8	8	5	Low	1
Benefits	9	9	8	7	7	7	5	High	9
Safety	7	6	5	3	5	7	4		
Security	5	4	4	2	5	6	3		
Happiness	6	5	2	1	4	6	2		
Total	36	33	27	21	29	34	24		

6.3 Evaluate the sustainability

Sustainability:

According to the Brundtland Commission defination of sustainable development means, " development that meets the needs of the present, without compromising the ability of future generations to meet their own needs". We are living in a world where natural resources and assets are limited. So we must develop every system that considers three pillars of sustainability.

- Environmental
- Economic
- Social

Environmental sustainability: First of all, in the era of technological enrichment resources like UAV(unmanned aerial vehicles), sensors, and machine learning algorithms are sustainable resources by themselves. we are not using any fossil fuel and have no emission of toxic chemicals or gases. Our project is pure nontoxic electronic components and software-based design which does not have any adverse effects on the environment. Conservation of ecosystems and natural resources is significant to make sustainable production.

- Availability of components in moderate price ranges
- Availability of software and machine learning algorithms
- No toxic side effects
- Reduction of water and pesticide consumption
- Independent of dependency on natural resources.
- Recyclable

We can always recycle our project components for other projects or use components separately. Conservation of ecosystems and natural resources is significant to make sustainable production.

Economic sustainability: Economic sustainability is very important as our project is related to farmers. Our rural farmers are not very sound financially so a drone-based crop monitoring system may appear a bit of a luxury need to them. A well-equipped drone may cost near 1 lac which is very important for better evaluation and results. This cost may be justified if we think about the promises and compare them with the results. Economic sustainability will come if we take these steps

- Costs will be shared through the co-operative society
- Local govt. trust for farmers
- NGO's

These steps will bring agriculture into the guardianship of digitalization and most importantly the poor farmers will be benefited through digitalization. Different types of capital that keep production going should be monitored and maintained all the time.

Social sustainability: Social equity, balanced education, and happy life, social amusement centers will help our farmer's life in a way that they will take challenges for new goals. A well-developed crop management system will always attract farmers more than anything because they get hustled to too many things during the cultivation period. So if a drone-based crop monitoring system can promise good management for crop monitoring and a less hassled cultivation system then it will spread out automatically. We are not using it for the first time, in fact, this type of technology is already in use in many advanced countries[7,8] and it is in the developing stages in Bangladesh. Many of our universities are researching and developing AI (artificial intelligence), and IoT-based farming, and we are also researching and developing drone-based crop monitoring systems for specific crops. In a few years' time, a large number of stakeholders will be ready for it. After 10 to 20 years, farmers of our country will be connected to a server where the server and system will be trained and enriched by the data given by farmers themselves resulting in a system with vast knowledge of crop management system with every possible solution to any specific problem.

6.4 Conclusion

As civilization is moving towards AI-based technological development in almost every sector then why don't we challenge ourselves with the globe keeping pace neck to neck. All these capitals will ensure our project is impactful and sustained in the long run.

Chapter 7: Engineering Project Management. [CO11, CO14]

7.1 Introduction

Our Final Year Design Project is segmented into P (proposal Writing), D (Design Report), and C (Completion) stages with helpful guidelines and instructions to be completed. In each stage, we have maintained a gantt chart and logbook where we have scheduled things to do list in it. We manage to do what we supposed to do in due time fairly enough. In any case, if we lagged behind our schedule for some reason, we might have already anticipated that and we also had a solution for that. Every week meeting with our respective faculty members helps us to keep our visions straight.

7.2 Define, plan and manage engineering project

EEE 400P

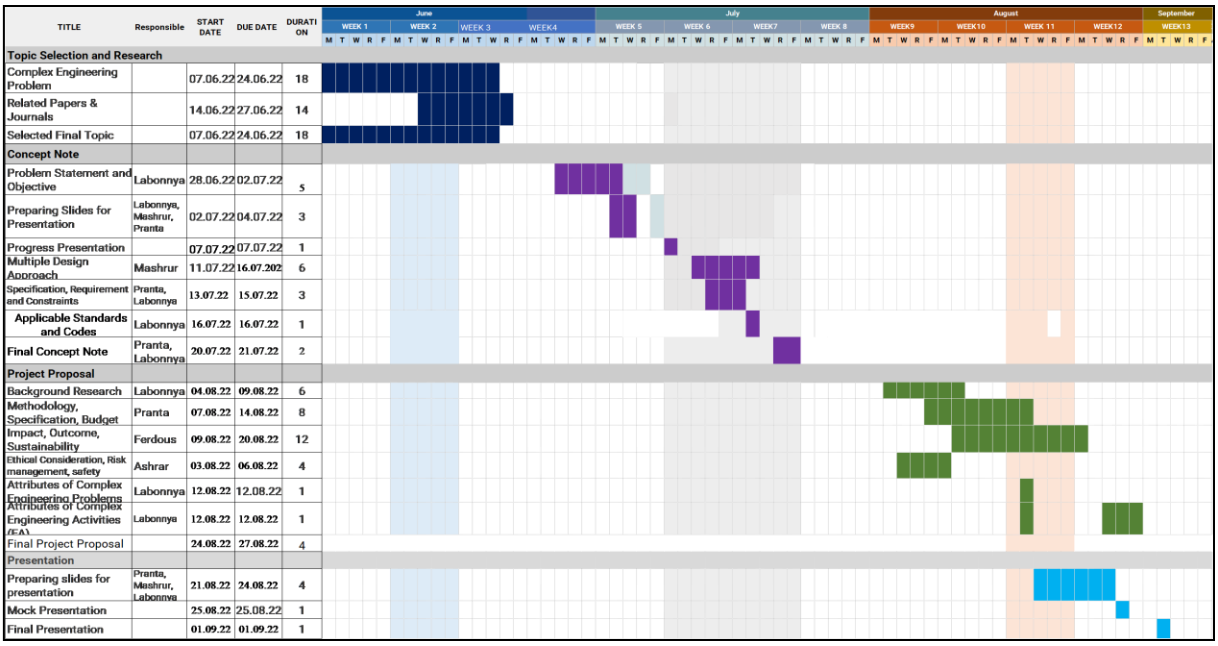


Figure 44: Project Plan of EEE 400P

Table 24: Project Plan of EEE400P

Task	Start Date	End Date	Duration (Days)
Topic Selection & Research	07.06.2022	24.06.2022	18
Find Complex Engineering Problem	07.06.2022	24.06.2022	18
Related Papers & Journals	14.06.2022	27.06.2022	14
Selected Final Topic	07.06.2022	24.06.2022	18
Concept Note	28.06.2022	20.07.2022	23
Tentative Problem Statement and Objective	28.06.2022	02.07.2022	5

Preparing Slides for Progress Presentation	02.07.2022	04.07.2022	3
Progress Presentation	07.07.2022	07.07.2022	1
Multiple Design Approach	11.07.2022	16.07.2022	6
Specification, Requirement and Constraints	13.07.2022	15.07.2022	3
Applicable Standards and Codes	16.07.2022	16.07.2022	1
Final Concept note	20.07.2022	21.07.2022	2
Project Proposal	04.07.2022	24.07.2022	20
Background Research	04.08.2022	09.08.2022	6
Methodology, Specification, Budget	07.08.2022	14.08.2022	8
Impact, Outcome, Sustainability	09.08.2022	20.08.2022	12
Ethical Consideration, Risk management, safety	03.08.2022	06.08.2022	4
Attributes of Complex Engineering Problems (EP)	12.08.2022	12.08.2022	1
Attributes of Complex Engineering Activities (EA)	12.08.2022	12.08.2022	1
Final Project Proposal	24.08.2022	27.08.2022	4
Preparing slides for presentation	21.08.2022	24.08.2022	4
Mock Presentation	25.08.2022	25.08.2022	1
Final Presentation	01.09.2022	01.09.2022	1

EEE 400D

Figure 45: Project Plan of EEE 400D

Table 25: Project Plan of EEE400D

Task	Start Date	End Date	Duration (Days)
Optimal solution	2.10.22	16.10.22	15
Analyzing solution	5.10.22	17.10.22	13
Error detection	12.10.22	20.10.22	9
Debugging	14.10.22	22.10.22	9
Analyzing mechanisms	18.10.22	29.10.22	12
Software Simulation	3.11.22	15.11.22	13
Debugging Simulation	16.11.22	26.11.22	11
Preparing Slides	27.11.22	30.11.22	4
Progress Presentation	31.11.22	3.12.22	4
Report Writing	4.12.22	11.12.22	8
Report Correction	14.12.22	16.12.22	3
Final Presentation Slide	17.12.22	21.12.22	5
Final Presentation	23.12.22	25.12.22	3

EEE 400C

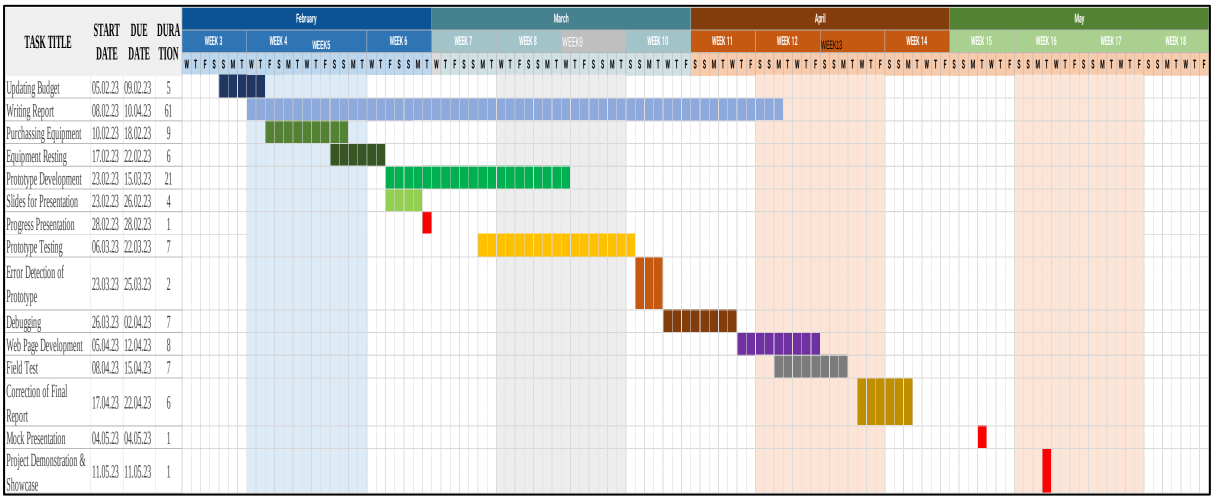


Figure 46: Project Plan of EEE 400C

Table 26: Project Plan of EEE 400C

Task	Start Date	End Date	Duration (Days)
Updating Budget	05.02.23	09.02.23	5
Writing Report	08.02.23	10.04.23	61
Purchasing Equipment	10.02.23	18.02.23	9
Equipment Testing	17.02.23	22.02.23	6
Prototype Development	23.02.23	15.03.23	21
Preparing Slide for Progress Presentation	23.02.23	26.02.23	4
Progress Presentation	28.02.23	28.02.23	1
Prototype Testing	16.03.23	22.03.23	7
Error Detection of Prototype	23.03.23	25.03.23	2
Debugging	26.03.23	02.04.23	7
Web Page Development	05.04.23	12.04.23	8
Field Test	09.04.23	15.04.23	7
Correction on Final Report	17.04.23	22.04.23	6
Mock Presentation	04.05.23	04.05.23	1
Project Demonstration and Showcase	11.05.23	11.05.23	1

7.3 Evaluate project progress

When our proposed proposal got accepted then we immediately started working on the project proposal writing. We divided our tasks almost equally among our team members and everyone knew what one had to do. Everyone was assigned a specific task to complete in the specific timeline and then moved on to the big task and then we divided the task among our group members (figure 4). We had 2 online meetings among group members and one faculty meeting every week apart from what we had worked on at the university. Whoever faced any problems and had any confusion regarding the task completion, managed to solve them in our group meeting first then we checked our solution with ATC (Academic Technical Committee) members. We had a few presentations about the progress we made at the university and to the ATC members as well. This process was almost similar in all P (proposal Writing), D (Design Report), and C(Completion) stages. We had a few presentations about the progress we made to the university and to the ATC members as well.

In the D (Design Report) stage we simulated our 3 proposed designs among which we have found the optimal design to full fill our functional and non-functional requirements at an optimal level. For this, we had to upgrade our computer system for the data set training purposes. some modern IT tools that we used were very tricky to use for new users like us. Figure-5 may explain our D (Design Report) stage clearly.

During the semester break, we ordered the components of our selected optimal design. In the final C(Completion) stage, we focus on establishing a prototype for our design that can perform our project goal. When we got all the components, we tested those in our university lab. Figure 6 will explain the timeline we have followed to complete our prototype and report writing. In the meantime, we have to take lots of drone photos of tomato leaves from the fields. We visited the Sher-e-Bangla Agricultural University vegetable field for that reason.

Prototype development was a memorable experience for us. We were thrilled, cautious, and skeptical at the same time. Frame assembling was easy with the help of proper assembling tools. We paid special attention to connecting all colored coated wires to signal pins while connecting ESC (Electronic Speed Controller) to the flight controller or receiver to the flight controller. PDB (power distribution board) soldering needs to be firmed unless we expect a crash during the flight due to a loose connection. ESC should be placed under the quadcopter arm to avoid propeller hit. While installing the flight controller in the center we checked the forward arrow indication with respect to the upper board. Receiver to the flight controller connected channel-wise. Flight controller setup calibration consists of doing factory setup, selecting drone frame type, selecting motors number, and propellers direction. Calibration needs to be done by placing the drone in an even place. Going to the receiver test command in the flight controller we set all parameter values to 0 using the trim key in the radio transmitter while it is on.

7.4 Conclusion

Project management is a vital part for engineers for making ideas come to working mode from scratch. It is a tool that keeps engineers on track and makes life easy. A well-planned project management includes all the necessary details it needs to be found out for a greater success rate.

Chapter 8: Economical Analysis. [CO12]

8.1 Introduction

Economic analysis is a very important part of any project to evaluate how the project will make its way in the long run. Understanding the economic environment it has and researching for the cost effectiveness and changes in the broader economy will effect this business. All these information will ensure how feasible and accessible the project will be.

8.2 Economic Analysis

The design method used for the project can be improved upon through better resource allocation and optimization of supply chain. An economic analysis of the existing UAV/drone products in the market with our product may help solve such issues to find market gaps and/or opportunities.

Two main sets can be found according to wing types (a)rotary (b)fixed wings. The main shortcoming of commercial drone is their lower payload capacity. The payload capacity of the rotor drones is dependent on the number of rotors. To solve this issue manufacturers, increase the rotors from 4 to 6 and up to 8 reduce the gap. The maximum capacity of such drones are approximately 20 kilograms. Since we do not require anywhere near this level of payload 4 rotors are enough for all our onboard sensors and capacity is sufficient. Increase in rotor number also improves the safety since more rotors can make up for any in flight failure. These are some cases we may need to consider when building alternative prototypes depending on the market demand but as it stands our model is the most economically optimized for the intended purpose.

Another variation of this is the fixed wing drone which although have longer range and higher speeds are quite troublesome due to its maneuverability, cost, and regulations. As such the rotor design chosen by us is the most practical in terms of cost and technicality.

Here is an economic analysis of the available drone manufacturers in comparison with our model:

Table 27: Economic Analysis of the available drone manufacturers in comparison with the prototype model

Type	UAV	Payload (kg)	Endurance (min)	Dimension(m)	Retail (USD)	Retail (Taka)
4 rotors	Parrot AR/2.0	-	12	0.52 × 0.51	USD 179.99	BDT 19,191.00
	Parrot Anafi	-	25	224 × 67 × 65	USD 699.99	BDT 74,481.50
	Phantom 3 Pro	0.3	30	0.35	USD 999.00	BDT 106,295.00
	Phantom 4 Pro	0.3	30	0.35	USD 1,349.00	BDT 143,536.57
	DJI inspire 1	0.2	21	0.29 × 0.28 × 0.11	USD 2,900.00	BDT 208,566.38
	DJI inspire 2	0.2	21	0.29 × 0.28 × 0.12	USD 3,999.00	BDT 425,502.40
	MD4-100/1000	1.2	45	1.03	USD 18,900.00	BDT 2,011,001.58
Fixed wing	Gatewing X100	0.2	15	1 × 0.6 × 0.1	USD 6,950.00	BDT 739,495.29
	Zangão UAV	1.1	60	1.95	USD 11,135.00	BDT 1,184,788.50
	eBee SQ/Plus	0.3	59	1.1	USD 13,577.00	BDT 1,444,622.67
	Tuffwing Mapper	2	40	1.2 × 0.6 × 0.2	USD 2,500.00	BDT 266,005.50
4 rotors	Our model	1.551	13.5	0.5 × 0.5 × 0.34	USD 514.64	BDT 55,056.00

Explanation:

UAVs come in various shapes and sizes, with different capabilities, and are designed for different purposes. To provide insight into the range of UAVs available on the market, that have compiled a table of information on various types of UAVs, including their payload capacity, endurance, dimensions, and retail prices in both US dollars (USD) and Bangladeshi taka (BDT). The UAVs are categorized based on their type: 4 rotors or fixed-wing. The data is sourced from various manufacturers and online retailers. It is important to note that the information provided in the table is accurate as of the time of compilation, but may be subject to change.

Essentially, for the other UAV models:

Parrot AR/2.0:
- Source website: https://productz.com/en/parrot-ar-drone-2-0/p/bVaW
- Citation: [26]

Parrot Anafi:
- Source website:
- Citation: [27]

DJI Phantom 3 Pro:
- Source website: https://productz.com/en/parrot-ar-drone-2-0/p/bVaW
- Citation: [28]

DJI Phantom 4 Pro:
- Source website: https://productz.com/en/parrot-ar-drone-2-0/p/bVaW
- Citation: [29]

DJI Inspire 1:
- Source website: https://productz.com/en/parrot-ar-drone-2-0/p/bVaW
- Citation: [30]

DJI Inspire 2:
- Source website: https://productz.com/en/parrot-ar-drone-2-0/p/bVaW
- Citation: [31]

Microdrones MD4-100/1000:
- Source website: https://productz.com/en/parrot-ar-drone-2-0/p/bVaW
- Citation: [32]

Gatewing X100:
- Source website: https://productz.com/en/parrot-ar-drone-2-0/p/bVaW
- Citation: [33]

Zangão UAV:
- Source website: https://productz.com/en/parrot-ar-drone-2-0/p/bVaW
- Citation: [34]

eBee SQ/Plus:
- Source website: https://productz.com/en/parrot-ar-drone-2-0/p/bVaW
- Citation: [35]

Tuffwing Mapper 2:
- Source website: https://productz.com/en/parrot-ar-drone-2-0/p/bVaW
- Citation: [36]

Considering the current market places, the prices, specifications and dimensions, the drone we have built is superior in terms of the intended purpose of serving as a agricultural data collection UAV for small land holder farmers. We can even proceed to optimize the UAV cost by streamlining supply chain and managing wholesale material and component sourcing. This would decrease the costing down significantly. Moreover, sourcing of components directly from manufacturers instead of retail will reduce cost. Thus, the product will be more economically viable for a larger demographic which is essential for scaling precision farming in Bangladesh.

8.3 Cost Benefit Analysis

1. Cost determination

Cost can be determined by A. Direct cost B. Indirect cost C. Intangible cost D. Opportunity cost.

A. Direct costs are currently the budget for the drone. The budget values are given below:

Table 28: Budget of Design Approach 3

Components	Quantity	Link/Location	Price(TK)
Pixhawk PX4 2.4.8 Flight Controller	1	https://store.roboticsbd.com/quadcopter/735-pixhawk-px4-248-flight-controller-robotics-bangladesh.html	12000
Ublox NEO-M8N GPS Module With Compass	1	https://radiogearbd.com/product/ublox-neo-m8n-gps-module-with-compass/	1900
Black GPS Folding Antenna Mount Holder Metal Carbon	1	https://store.roboticsbd.com/quadcopter_bd/239-black-gps-folding-antenna-mount-holder-metal-carbon.html	420
4pcs HSKRC BLHeli_S 2-4S 30A ESC	4	https://radiogearbd.com/product/4pcs-hskrc-blheli_s-2-4s-30a-esc/	4370
Original DJI 2312A 800KV BLDC Motor CW CCW	4	https://radiogearbd.com/product/original-dji-2312a-800kv-bldc-motor-cw-ccw-pair-recondition/	3200
S500 Glass Fiber Quadcopter Frame 480mm - Integrated PCB Version	1	https://store.roboticsbd.com/chassis-frames/953-s500-glass-fiber-quadcopter-frame-robotics-bangladesh.html	2150
1045 Self-locking Propeller 2 CW 2 CCW	4	https://radiogearbd.com/product/9450-9x4-5-self-locking-9-5-inch-propeller-cw-ccw-pair/	420

Radiolink AT9S Pro 10/12 Channels 2.4GHz RC Transmitter and Receiver Mode 2	1	https://store.roboticsbd.com/radio-systems/403-radiolink-at9s-pro-1012-channels-24ghz-rc-transmitter-and-receiver-mode-2-robotics-bangladesh.html	17500
APM 2.6 Pixhawk Power Module V1.0	1	https://store.roboticsbd.com/quadcopter/381-apm-26-pixhawk-power-module-v10-robotics-bangladesh.html	999
2200mAh 3S 25C Tiger Lipo Battery for Remote Control for Multi-copter	1	Green ElectronicsBD Address: Shop 16, 62 Rabeya Elias Market, Patuatuli, Dhaka 1100	1950
Skydroid Mini OTG Receiver 5.8G 150CH Mini FPV Receiver	1	https://radiogearbd.com/product/skydroid-mini-otg-receiver-5-8g-150ch-mini-fpv-receiver/	2199
Original Caddx Turbo EOS2 1200TVL CMOS FPV Camera	1	https://radiogearbd.com/product/caddx-turbo-eos2-1200tvl-cmos-fpv-camera/	3100
B3 Pro Lipo Balance Charger	1	https://store.roboticsbd.com/quadcopter_bd/212-build-power-b3-lipo-battery-charger-robotics-bangladesh.html	499
APM Shock Vibration Absorber	1	https://www.rcshopbd.com/product/flight-controller-shock-absorber-for-apm-pixhawk/	350
APM /Pixhawk Radio Telemetry Kit 433Mhz 100mW	1	https://store.roboticsbd.com/wireless-datatelemetry/237-apm-3dr-radio-telemetry-kit-433mhz-100mw-robotics-bangladesh.html	3999
Total			55056 Taka

B. Indirect costs are quite limited such as permission to fly drone for regulation purpose which may involve a fee, hiring of drone operator if needed or parts/components swapping which are extremely rare circumstances.

C. No such intangible costs are applicable.

D. Opportunity costs involve other alternative means such as large drone, use of satellites or balloons. These alternatives pose no threat to our model due to the intended purpose of the small holder farmland with limited resources for data collection.

Risk involved can be determined by A. Regulation, B. Competition, C. Environmental Impact

A. Regulation body regarding drone (i.e., Civil Aviation Authority) has already laid out plan for the agriculture drone use. This is highly unlikely to change hence the risks involved are low. Incentives regarding precision farming is gaining support from Governments around the world. Although Bangladesh doesn't have a clear position or incentive the issue at the moment but the clairvoyance to carry ahead is well known. Thus, the future for regulation is very positive. The size of the farm, the schooling level of the farmer, the accessibility of enabling facilities, and the supply of labour can all affect the incentives for implementing different components. The advantages of farming technologies are still largely unknown because of how quickly they are changing. Due to ongoing technological advancements, it is reasonable to anticipate a decline in capital and learning expenses as well as a rise in the benefits of implementation over time. Therefore, it is probable that over time, incentives to embrace these technologies will increase.

B. Competition regarding the drone operation is quite evident in the previous sections because our model is sufficient in the field of work to the established companies.

C. Environmental issues regarding the UAV are limited to sound pollution which is quite common for drones of this type. Since the drone will survey the field, complaint regarding the humming noise will be limited due to the scarcity of populace in open crop fields. There is also the possibility for propeller design innovation work if need be.

2. Benefit Determination

Benefits of the project can be determined by A. Revenue increase B. Intangible benefits.

A. Revenue increase using precision agriculture is widely known to be factual. The major impact of this is caused by data and remote sensing capabilities that our project has included. Farmers can lessen the ambiguity surrounding choices pertaining to farm management as well as the variability and risks involved with farming output activities by giving timely and accurate disease data. For instance, yield trackers can assist farmers in identifying fields where it might be advantageous to alter practices as well as subfield zones where it might not be advantageous to grow crops. The project may influence running expenses, overhead expenses, and changes in income, which may have an impact on agricultural finances. Because our project requires the acquisition of tools, installation fees, and the time and effort required to learn how to use and keep them, adoption may raise capital and overhead costs. In addition, our project has a lower cost basis than labor expenses and less ability to affect overhead costs. If use is stopped, these expenses are typically not recovered. Comparing these technologies to other types of capital machinery like trucks and land, they are also much more specialized. Another choice is to outsource our project needs to a specialized service provider, but this comes at a price. These elements raise the financial dangers associated with implementing digital technologies. For producers, it may not be difficult to finance our project despite the startup expenses and the possibility of a low rate of return. Although such return rate is highly unlikely to happen if continued use of the drone is ensured. An example of this can be seen in the "smart agriculture competition" to produce strawberries that was held in May 2020 by China Agricultural University and Pinduoduo, the country's biggest agri-tech platform. Up until November, four teams of experts and three conventional teams of best growers were at work. The traditional teams got off to a strong start with an advantage thanks to intergenerational skills, knowledge, and experience. But as they started using IoT devices, data analysis, and automated gardens, the experts started to catch up. Compared to the conventional teams' meagre 2.32kg, they generated an average of 6.86kg of strawberries over the course of six months. In order to create an intelligent decision-making process, the scientists examined past farming data and strawberry pictures and merged them with models of water, nutrients, and greenhouse temperature. They combined smart farming and precision agriculture to regulate moisture, nutrients, temperature, and humidity, resulting in a significantly higher output.

B. The desire for labour will likely be impacted by the adoption of these technologies, but the impacts will vary depending on whether the labour is compensated or unpaid, expert or unskilled. Depending on how much our project is demanded the specialised information management and field operation skills but reduce labour hours, spending on highly trained labour may rise while that on menial and unpaid labour may fall. This is an intrinsic intangible benefit which is clearly viable for the farmer. Our project will improve morale for farmland workers and improve menial labour work.

8.4 Evaluate economic and financial aspects

The project is drone/UAV based which is extremely valuable towards small farmland holders. Although GNSS is primarily done for large farmlands in advanced economies where skilled labour commit to big data, artificial intelligence and advanced precision farming, the developing or underdeveloped countries with its vast share of small farmland holders can benefit from our project. Since GNSS technologies are inefficient at small and uneven farmland levels our project is a perfect fit for the problem solution. According to the data the average farmland size has been decreasing every decade due to rapid urbanization, forest clearing, making way for renewable solar energy systems and public works. Moreover development of modern agricultural technologies has made farmers dependent on less land for the same yield as before. In context of Bangladesh the average farmer has a land size of 0.3-0.6 hectares this past 2 decades. This trend is on average declining, and experts estimate more Asian countries will face declining average farm sizes due to climate change and other causes.

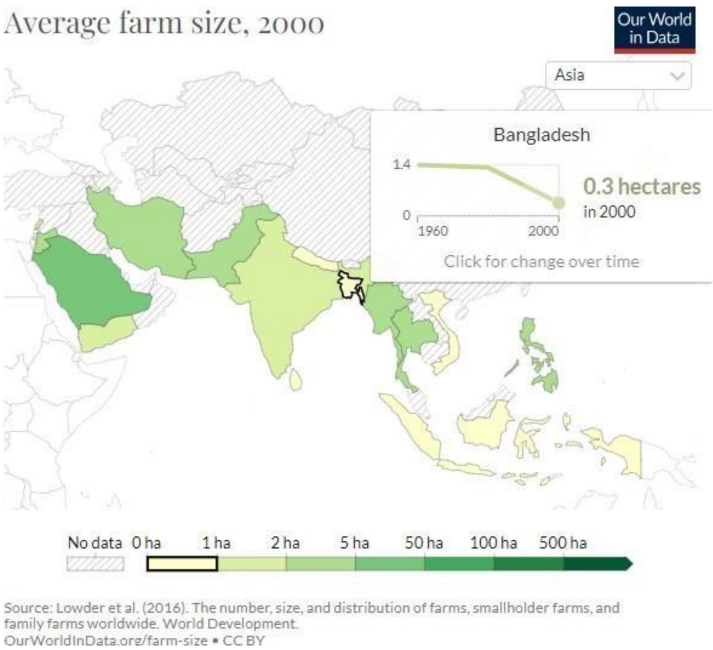


Figure 47: Average Farm Size

This is especially troublesome due to the fact that 1/3rd of the worlds produce is produced by smallholder farms. But no precision farming technologies are widely in use for them. Especially in Asia and Africa where the majority of smallholder farms are existing and will continue to exist as the average farm size continues to dwindle.

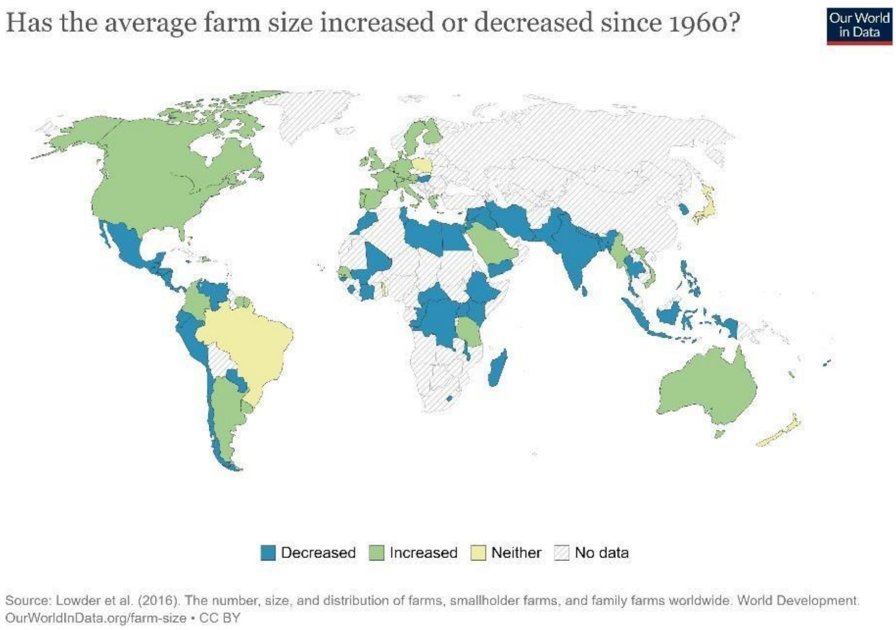


Figure 48: Changing in the Farm Size

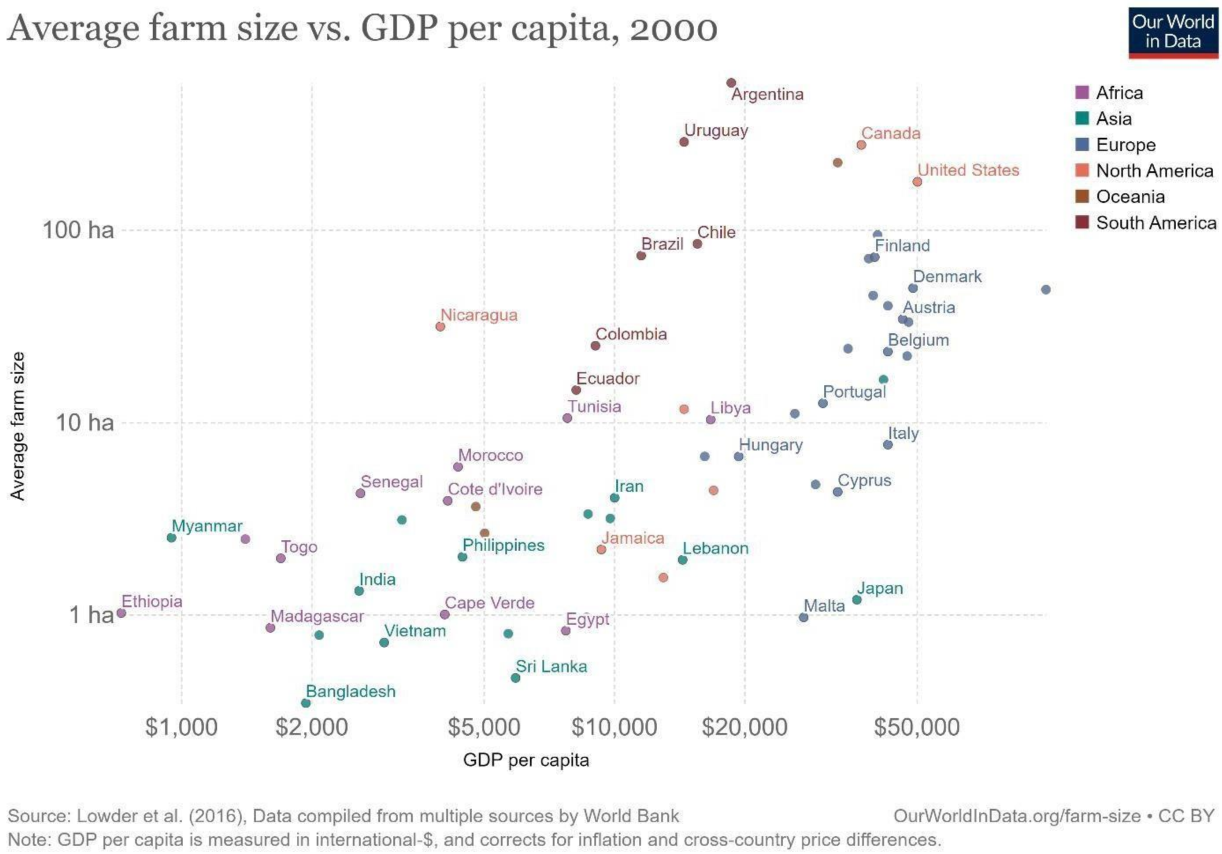


Figure 49: Average Farm Size vs GDP per Capita

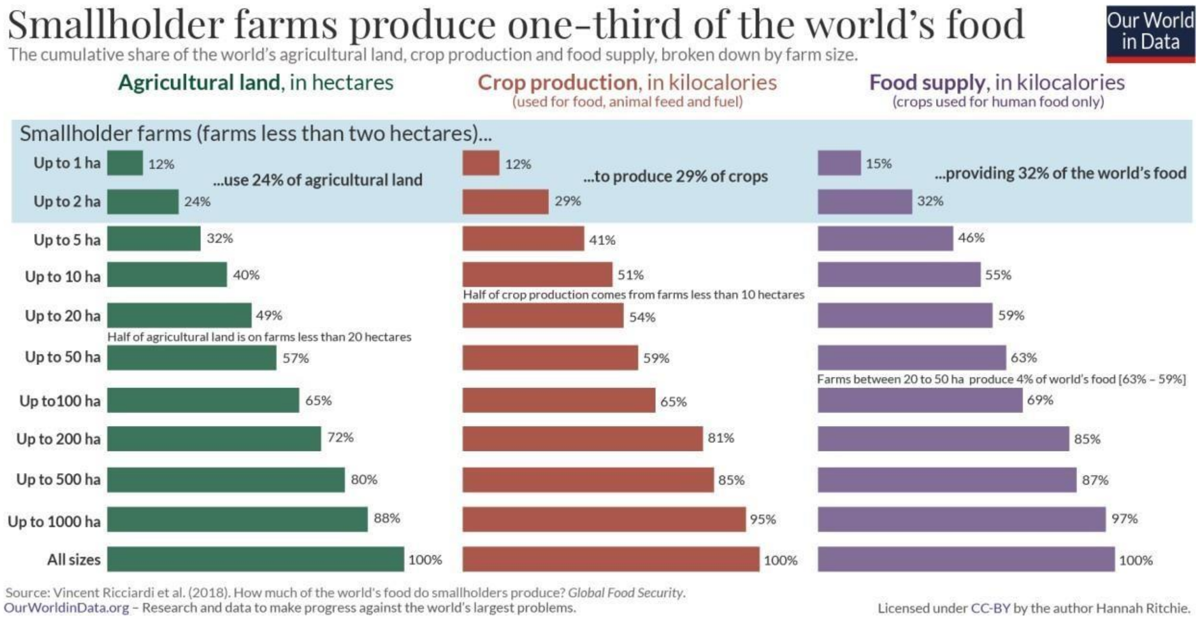


Figure 50: Smallholder Farms Production

Therefore, it is of utmost importance that countries start giving incentive to local farmers the technology for precision agriculture as soon as possible. The economic viability of our project is beyond comprehension in both Bangladesh and abroad. Although advanced countries with larger agricultural land is more suited to GNSS and tracking technologies for more spatial data, the small farmland holders in developing countries with limited resources and capped skilled labourers and technicians can make great use of our project.

8.5Conclusion

This project's measure of success contains manufacturability of electronic components, image processing accuracy, impact and sustainability. Proper analysis of economic aspects will increase the sustainability. there is always room for more research and finding of dots and dashes of project growth and certainly coming up with adequate research on economic analysis will value more.

Chapter 9: Ethics and Professional Responsibilities CO13, CO2

9.1 Introduction

To establish any sort of project, a researcher must consider every ethical issue involved with the project. Though the research is for the betterment of the people, society, economy, and country but we can't hamper any creature or can't break any rules. Ethical policies are for ensuring the legality of the research.

9.2 Identify ethical issues and professional responsibilities

The ethical issues we are going to consider throughout the project are given below:

- **Privacy Policies:** Our project is all about capturing images of crops by using drone. Taking picture may disturb people's privacy. This problem can be dealt with Consequentialism view which says that the action is morally required as the best outcome is provided by it [19]. As our project is for the improvement of agriculture, providing healthy people to the people; consequentialism can be applied here. Moreover, we will provide some banners to let people around that area know that the area is under drone coverage.
- **Noise Concern:** Drones are instructed to be operated in low altitude. The noise of drones can disturb wildlife as well as local people. It is one of the reasons for which drones are banned for some areas. Firstly, agricultural areas are usually not overpopulated. We will provide some consent papers to the people to let them know about the issue. Additionally, we will adjust the propeller as much as possible to reduce noise.
- **Bird's Injury:** Birds can be injured by the moving blades of drone. We are not going to fly our drone in that height where birds will feel any sort of disturbance or attack. We need to fly the drone in a lower height to obtain our project objectives as well. So, birds' safety will be properly ensured.
- **Permission of the authority:** We will seek permission from the air traffic control authority before flying the drone. The authorizations should be submitted before at least 45 days to the Civil Aviation Authority of Bangladesh [18].

Project professional responsibilities entail the obligations and duties that project managers and team members have in ensuring that a project is successful. Project professional responsibilities, encompass a wide range of tasks and duties that are necessary for project managers and team members to perform in order to guarantee the successful completion of a project. These responsibilities may involve creating project plans, establishing timelines and budgets, overseeing resources, engaging with stakeholders, monitoring progress, and implementing necessary changes to ensure that project objectives are met. Moreover, project professionals are accountable for ensuring that the project is finished within the defined scope, quality, and time constraints. This necessitates a high degree of expertise, leadership capabilities, and efficient communication, as well as the ability to manage and inspire a diverse team of individuals towards a shared goal. Ultimately, carrying out project professional responsibilities effectively is crucial to delivering successful projects and achieving desired outcomes.

Such responsibilities may vary depending on the role of the individual in the project team, but generally include:

- **Developing and managing project plans:** This involves setting project goals, identifying tasks, assigning responsibilities, and creating timelines and budgets.
- **Communicating with stakeholders:** Project professionals must communicate regularly with stakeholders such as clients, team members, and vendors to provide updates on project progress, address concerns, and resolve issues.
- **Managing project resources:** This involves managing resources such as people, materials, and equipment to ensure they are used efficiently and effectively.
- **Monitoring project progress:** Project professionals must monitor project progress regularly to identify any issues or delays and take corrective action as needed.
- **Managing project risks:** Project professionals must identify and assess project risks and develop plans to mitigate or manage them.
- **Ensuring project quality:** Project professionals must ensure that the project is completed to the required quality standards.
- **Managing project teams:** Project professionals must manage project teams by providing guidance, direction, and motivation to ensure that team members are working effectively and efficiently.
- **Managing project stakeholders:** Project professionals must manage project stakeholders by ensuring that their needs and expectations are met and that they are kept informed about project progress.
- **Ensuring project compliance:** Project professionals must ensure that the project complies with any legal or regulatory requirements.
- **Closing out the project:** Project professionals must close out the project by documenting the results, conducting a final review, and ensuring that all project deliverables have been completed and accepted.

9.3 Apply ethical issues and professional responsibilities

9.3.1 Ethical Issues

Safety measures

The most important and critical safety issues and mitigation measures are pointed out below. These measures are vital for the wellbeing of the operator, drone and its surrounding area and component wellbeing.

Electronic speed controller (ESC): The ESC must be capable of handling the amps needed for the motor to run smoothly, this must be backed by an appropriate battery. If the battery is unable to provide the specified voltage the motors will be damaged or will not work. This is a huge issue since our quadcopter will fall out of the sky and damage itself. ESCs receive acceleration data from the flight controller, it uses on board MCUs and requires firmware to control the hardware. Failure in this will result in flight acceleration errors.

Flight Controller: The flight controller is the brain of the drone. It takes the inputs from the GPS module, compass, obstacle avoidance sensors, remote controller and process the data for the ESCs to control the motors. There is no alternative to a faulty flight controller and must be replaced.

Telemetry kit: The telemetry kit gathers data and its surroundings to send back to the operator/ground station. Moreover, the telemetry data allows us to track the UAV in real time and information about the RPM of the rotors and the voltage level of the batteries. Drone telemetry data is transmitted by radio signals. Since the common frequencies of a telemetry kits are 433 MHz,915 MHz and newer ones are 2.4 GHz. Although the links are separate, it may pose security issues since it can be taken over with the same frequencies with malicious intent. In the event of the drone being taken over, it can be configured to detect multiple frequencies and drop to the ground

Arduino/Raspberry(microcontroller): The microcontroller is relevant to the model by storing the algorithms/instructions by which the model is programmed to function. This component is irreplaceable when hacked or damaged.

Camera: Troubleshoot model camera in case of errors. In case of the camera component being faulty there is no other choice but to find replacements.

Signal interference & GPS: GPS is very precise and reliable under optimal circumstances. Obstructions such as trees, buildings, clouds etc. can negatively impact the reception. In adverse conditions such as thunderstorms, rainfall GPS can detect the differences up to 1 kilometer. Although the receiver can incrementally correct the location, in unfavorable conditions the system can still have incorrect position. Hence longer flight times can be hazardous. The model can be configured to return home from the GPS positioning. But the best course of action during such conditions is to turn off all the motor and let the model gently drop at a matted surface such as grass or earth. Signal interference can affect GPS signal reception Thus, it can be hazardous.

Storage battery: Modern LiPo (Lithium polymer) batteries are highly volatile due to their huge amount of energy. If the model crashes, or is short circuited then there is an immediate threat of fire. This fire must not be attempted to be extinguished by water. The best resource extinguishing the flames would be a fire extinguisher or a fire blanket.

Ultrasonic Module Distance Measuring Transducer Sensor: Errors and risks pertaining to this module commonly refers to dead zone, which is an area directly in front of the transducer face where the sensor is unable to reliably take measurements. This occurs due to the phenomenon known as ringing. This happens when the transducer continues vibrating after the excitation pulse. In order for the transducer to get the return echo the energy must be dissipated. Hence the target location must be identified in order to avoid dead zone errors.

Teleoperation & unfavorable conditions: Remote controlling UGV (unmanned ground vehicle) or land-based rovers is a difficult task requiring significant training, experience and practice. When the conditions are more uncertain, equipment requires more supervision for weak perceptual and decision-making capabilities. The amount of supervision required for safe operation is immense and should be handled with care.

Software: Software errors will lead to invalid data/information about the crops and may lead to disastrous results if followed without rectifying. This is one of the most crucial errors and risk management checks of our system.

9.3.2 Applying Professional Responsibilities

1. **Developing and Managing Project Plans** for a Quadcopter Drone Crop Monitoring System would involve the following tasks:
   - **Defining project goals and objectives:**
     The first step would be to clearly define the goals and objectives of the project, which may include developing a quadcopter drone crop monitoring system that can accurately detect crop health and provide farmers with actionable insights.
   - **Identifying project tasks and dependencies:**
     Once the project goals and objectives have been defined, the project team would need to identify the tasks that need to be completed in order to achieve those goals. They would also need to identify any dependencies between tasks, such as tasks that cannot be started until others are completed.
   - **Developing a project schedule:**
     Based on the tasks and dependencies identified, the project team would need to develop a project schedule that outlines the timeline for completing each task and the overall project timeline.
   - **Allocating resources:**
     The project team would need to determine the resources required for the project, including personnel, equipment, and materials. They would also need to allocate those resources effectively to ensure that the project stays on schedule and within budget.
   - **Creating a budget:**
     The project team would need to develop a budget for the project that takes into account the resources required and any other costs associated with the project, such as travel expenses.
   - **Defining project milestones:**
     The project team would need to identify key milestones that mark the completion of major project deliverables. These milestones can be used to track progress and ensure that the project stays on schedule.
   - **Establishing project communication and reporting protocols:**
     The project team would need to establish protocols for communication and reporting throughout the project to ensure that all team members are kept informed about project progress and any issues that arise.

- **Monitoring and controlling project progress:**
  The project team would need to monitor project progress regularly to ensure that the project stays on schedule and within budget. They would also need to take corrective action if any issues arise that could impact the project timeline or budget.
- **Managing project risks:**
  The project team would need to identify and manage project risks, such as equipment failures or weather conditions that could impact the project timeline or budget.
- **Closing out the project:**
  Once the project is complete, the project team would need to conduct a final review to ensure that all project deliverables have been completed and accepted. They would also need to document the results of the project and ensure that all project materials are properly stored and archived.

2. **Communicating with stakeholders** for a Quadcopter Drone Crop Monitoring System would involve the following tasks:

- **Identifying stakeholders:**
  The project team would need to identify all stakeholders involved in the project, including farmers, agricultural consultants, and any regulatory bodies or government agencies that may be involved.
- **Determining stakeholder needs and expectations:**
  The project team would need to determine the needs and expectations of each stakeholder, such as the specific crop types that need to be monitored and the frequency and format of reporting.
- **Establishing communication channels:**
  The project team would need to establish communication channels that allow for regular communication with stakeholders, such as email, phone, or in-person meetings.
- **Developing a communication plan:**
  Based on stakeholder needs and expectations, the project team would need to develop a communication plan that outlines the frequency and format of communication, as well as the specific information that will be shared with each stakeholder.
- **Providing regular updates:**
  The project team would need to provide regular updates to stakeholders on project progress, including any issues or delays that may impact the project timeline or budget.
- **Addressing stakeholder concerns:**
  The project team would need to address any concerns or questions that stakeholders may have about the project, including issues related to privacy or data security.
- **Managing stakeholder feedback:**
  The project team would need to manage stakeholder feedback and incorporate it into project planning as appropriate.
- **Ensuring stakeholder satisfaction:**
  The project team would need to ensure that stakeholders are satisfied with the project outcomes and that their needs and expectations have been met.
- **Conducting stakeholder reviews:**

The project team may conduct stakeholder reviews at various stages of the project to ensure that the project is meeting stakeholder needs and expectations.

- **Closing out stakeholder communications:**
  Once the project is complete, the project team would need to close out stakeholder communications and ensure that all stakeholders have received the necessary information and documentation regarding the project outcomes

3. **Managing project resources** for a Quadcopter Drone Crop Monitoring would involve the following steps:
   - **Identify resources:**
     The project team should identify the resources required to complete the project, such as human resources, equipment, software, and materials.
   - **Determine resource availability:**
     The project team should determine the availability of each resource and develop a plan to acquire any missing resources.
   - **Allocate resources:**
     The project team should allocate resources based on the project plan and timeline, ensuring that resources are used efficiently and effectively.
   - **Monitor resource usage:**
     The project team should monitor resource usage to ensure that resources are being used effectively and efficiently, and make any necessary adjustments to resource allocation as needed.
   - **Manage resource constraints:**
     The project team should manage any resource constraints or conflicts, such as competing demands for the same resource or limited availability of a critical resource.
   - **Maintain resource inventory:**
     The project team should maintain an inventory of resources, including equipment and materials, to ensure that they are available when needed.
   - **Develop contingency plans:**
     The project team should develop contingency plans for any unexpected changes or issues that may affect resource availability, such as equipment failure or a delay in resource delivery.

By effectively managing project resources, the project team can ensure that the project is completed on time, within budget, and with the required quality standards.

4. **<u>Monitoring project progress</u>** for a Quadcopter Drone Crop Monitoring System would involve the following steps:
   - **Establish project milestones:**
     The project team should establish project milestones to track progress and identify critical points in the project timeline.
   - **Define project tasks:**
     The project team should define the specific tasks required to achieve each milestone, including dependencies between tasks and deadlines.
   - **Track task completion:**
     The project team should track task completion to ensure that tasks are completed on time and identify any potential delays or issues.
   - **Monitor resource usage:**
     The project team should monitor resource usage to ensure that resources are being used efficiently and effectively, and make any necessary adjustments to resource allocation as needed.
   - **Monitor project risks:**
     The project team should monitor project risks and develop contingency plans to address any unexpected issues or delays.
   - **Hold regular project status meetings:**
     The project team should hold regular project status meetings to review progress, discuss any issues or concerns, and make any necessary adjustments to the project plan.
   - **Update project documentation:**
     The project team should update project documentation, including project plans, schedules, and risk management plans, to ensure that they accurately reflect project progress.
   - **Use project management software:**
     The project team can use project management software to track progress and automate project monitoring tasks, such as task tracking and resource allocation.

By monitoring project progress, the project team can identify potential issues and take proactive measures to address them, ensuring that the project is completed on time, within budget, and with the required quality standards.

5. **<u>Managing project risks</u>** for a Quadcopter Drone Crop Monitoring System using Machine Learning with Image Processing would involve the following steps:

   - **Identify project risks:**
     The project team should identify potential risks that could impact the project, such as equipment failure, weather conditions, or changes in regulations.
   - **Assess risk probability and impact:**
     The project team should assess the probability and potential impact of each identified risk to determine which risks require the most attention.

- **Develop risk mitigation plans:**
  The project team should develop risk mitigation plans to address the identified risks, including strategies for avoiding, transferring, or mitigating each risk.
- **Assign risk management responsibilities:**
  The project team should assign responsibilities for managing each risk to specific team members, who will be responsible for monitoring the risk and implementing mitigation strategies.
- **Monitor and review risks:**
  The project team should monitor and review risks regularly to ensure that mitigation strategies are effective and to identify any new risks that may arise.
- **Develop contingency plans:**
  The project team should develop contingency plans for any unexpected risks that may arise, including plans for managing equipment failure or responding to unexpected weather events.
- **Communicate risks to stakeholders:**
  The project team should communicate risks and mitigation strategies to stakeholders to ensure that they are aware of potential risks and are supportive of mitigation efforts.

By effectively managing project risks, the project team can reduce the likelihood of unexpected issues and delays, ensure that project resources are used efficiently, and improve overall project outcomes.

6. **Ensuring project quality** for a Quadcopter Drone Crop Monitoring System using Machine Learning with Image Processing would involve the following steps:

- **Define quality standards:**
  The project team should define the quality standards for the project, including requirements for equipment, software, and data analysis.
- **Develop quality assurance plans:**
  The project team should develop quality assurance plans to ensure that all project deliverables meet the defined quality standards.
- **Conduct quality checks:**
  The project team should conduct regular quality checks on project deliverables, including equipment, software, and data analysis, to ensure that they meet the defined quality standards.
- **Use quality control techniques:**
  The project team should use quality control techniques, such as statistical process control, to identify and address any quality issues that arise during the project.
- **Incorporate feedback:**
  The project team should incorporate feedback from stakeholders, including farmers, agricultural experts, and end-users, to improve project outcomes and ensure that the final product meets their needs.

- **Train project team members:**
  The project team should ensure that all team members are properly trained and have the necessary skills to meet the defined quality standards.
- **Use appropriate technology:**
  The project team should use appropriate technology, such as sensors and drones, to collect and analyze data to meet the defined quality standards.

By ensuring project quality, the project team can ensure that the final product meets the needs of stakeholders, operates as intended, and provides reliable data and insights for agricultural decision-making.

7. **Managing Project Teams** for a Quadcopter Drone Crop Monitoring System would involve the following steps:

- **Define team roles and responsibilities:**
  The project manager should define clear roles and responsibilities for each team member, including project leads, technical specialists, and support staff.
- **Establish communication channels:**
  The project manager should establish clear communication channels among team members, including regular team meetings, status updates, and progress reports.
- **Foster collaboration:**
  The project manager should foster collaboration among team members to encourage open communication, knowledge sharing, and problem-solving.
- **Provide training and development opportunities:**
  The project manager should provide training and development opportunities to team members to improve their skills and increase their contributions to the project.
- **Monitor team performance:**
  The project manager should monitor team performance to ensure that each team member is meeting their defined roles and responsibilities, and to identify any issues or challenges that may arise.
- **Address conflicts and challenges:**
  The project manager should proactively address conflicts and challenges that arise within the team, including any issues related to communication, performance, or work quality.
- **Recognize and reward team members:**
  The project manager should recognize and reward team members for their contributions to the project, including their achievements and successes.

By effectively managing project teams, the project manager can ensure that team members are working effectively and efficiently to meet project objectives, and that team members are motivated, engaged, and supported throughout the project.

8. **Managing project stakeholders** for a Quadcopter Drone Crop Monitoring System using Machine Learning with Image Processing would involve the following steps:

   - **Identify stakeholders:**
     The project manager should identify all stakeholders involved in the project, including farmers, agricultural experts, government officials, and end-users.
   - **Prioritize stakeholders:**
     The project manager should prioritize stakeholders based on their level of influence and interest in the project, and their potential impact on project outcomes.
   - **Develop stakeholder engagement plan:**
     The project manager should develop a stakeholder engagement plan that outlines the communication channels, frequency of updates, and methods of engagement for each stakeholder group.
   - **Communicate regularly:**
     The project manager should communicate regularly with stakeholders to provide updates on project progress, address any concerns or questions, and gather feedback.
   - **Manage expectations:**
     The project manager should manage stakeholder expectations by setting realistic goals and timelines, and by being transparent about any challenges or delays that may arise.
   - **Address stakeholder concerns:**
     The project manager should proactively address stakeholder concerns or issues, and work to find solutions that meet the needs of all stakeholders involved.
   - **Monitor stakeholder satisfaction:**
     The project manager should monitor stakeholder satisfaction throughout the project, and make adjustments to the stakeholder engagement plan as needed to ensure that stakeholders remain engaged and satisfied.

By effectively managing project stakeholders, the project manager can ensure that all stakeholders are engaged and informed throughout the project, and that their needs and concerns are addressed in a timely and effective manner. This can help to build trust and support among stakeholders, and increase the likelihood of project success.

9. **Ensuring project compliance** for a Quadcopter Drone Crop Monitoring System would involve the following steps:

   - **Identify relevant regulations and standards:**
     The project manager should identify all relevant regulations and standards that apply to the project, such as data privacy regulations, aviation regulations, and agricultural standards.

- **Develop a compliance plan:**
  The project manager should develop a compliance plan that outlines the specific regulations and standards that the project must comply with, as well as the processes and procedures that will be used to ensure compliance.
- **Assign responsibilities:**
  The project manager should assign responsibilities for ensuring compliance to specific team members or stakeholders, and ensure that they have the necessary training and resources to perform their duties effectively.
- **Monitor compliance:**
  The project manager should monitor compliance throughout the project to ensure that all regulations and standards are being met, and to identify any potential compliance issues or violations.
- **Address compliance issues:**
  If a compliance issue is identified, the project manager should take immediate action to address the issue, such as modifying project processes or procedures, or working with stakeholders to develop a mitigation plan.
- **Document compliance:**
  The project manager should document all compliance activities, including any compliance issues or violations, and maintain a record of all compliance-related documentation.
- **Conduct regular reviews:**
  The project manager should conduct regular reviews of the compliance plan and associated processes and procedures to ensure that they remain up-to-date and effective.

By effectively ensuring project compliance, the project manager can minimize the risk of regulatory or legal violations, protect the project from reputational harm, and ensure that the project meets all relevant standards and requirements.

10. **Closing out the project** for a Quadcopter Drone Crop Monitoring System would involve the following steps:

- **Verify project completion:**
  The project manager should verify that all project deliverables have been completed and that all project objectives have been met.
- **Obtain stakeholder acceptance:**
  The project manager should obtain formal acceptance from stakeholders that the project has been completed to their satisfaction.
- **Conduct post-project evaluation:**
  The project manager should conduct a post-project evaluation to identify lessons learned, areas for improvement, and best practices to be applied to future projects.
- **Document project results:**
  The project manager should document all project results, including project deliverables, final budget, and project completion report.

- **Close out contracts:**
  The project manager should close out all project contracts, including contracts with vendors and suppliers.
- **Release project resources:**
  The project manager should release all project resources, including team members, equipment, and materials.

By effectively closing out the project, the project manager can ensure that all project objectives have been met, stakeholders are satisfied, and lessons learned are captured for future projects. Additionally, celebrating project success can help to build morale and motivation among team members, and can provide a sense of accomplishment and pride in a job well done.

9.4 Conclusion

In conclusion, as a project professional responsible for the drone crop monitoring project, you would need to fulfill a range of responsibilities to ensure its success. These responsibilities include planning, risk management, budget management, quality management, team management, stakeholder management, contract management, and upholding ethical and legal standards.

By effectively managing these responsibilities, you can ensure that the project meets its objectives, produces accurate and reliable data, stays within the allocated budget, and is completed on time to the satisfaction of stakeholders. This, in turn, can help to improve crop yields, reduce resource waste, and promote sustainable agriculture practices.

In summary, the successful implementation of the drone crop monitoring project would require a skilled project professional who is capable of managing various aspects of the project, including technology, resources, stakeholders, and budgets. By fulfilling these responsibilities effectively, you can help to ensure the success of the project and contribute to the improvement of the agricultural sector.

Chapter 10: Conclusion and Future Work.

10.1 Project Summary/Conclusion

This project's goal is to contribute to agriculture by using cutting-edge tools and technology. We have attempted to deploy drones to speed up and simplify the monitoring process by utilizing current artificial intelligence techniques such as deep learning. We have carefully considered the advantages and disadvantages of various other designs to demonstrate why the drone is the ideal choice for this project. In order for the farmers to be able to afford the service and take use of it, we made every effort to make the technology affordable and employed the best components. To make this project viable and fruitful, we conducted a ton of research and used a variety of software.

10.2 Future work

Improvements can always be made. The efficiency and power consumption of the drone can both be improved with a variety of tweaks. Also, by gathering more data, we can modify the image processing and machine learning portion and improve its accuracy and responsiveness. The following are some of the changes that can be made:

Drone Improvement: We made a drone which is nearly 1500gm in weight and we are using 800kv BLDC motors which is capable to serve our purpose but to improve it we can use powerful BLDC motor which can generate more thrust and can carry more weight which will allow us to add more advance components and provide us various land and crop monitoring data.

PCB Design: Creating a printed circuit board to integrate every component of the drone we're using so that it can function as a single unit, this will use less energy. Moreover, it will free up space for other components so that more parts can be added to get more data of the crop land. Also, we can add more advance flight controller to fly our drone more efficiently.

Real Time Crop Monitoring with Accuracy improvement: We have developed an algorithm using image data containing 10 classes to detect the disease with accuracy of 95%. We can train the same thing with video data to monitor our crop in real time. Moreover, we have used here 256*256 image dimension with 40 epochs but we can increase it and work with higher resolution images more than 256 pixel to get better accuracy with more powerful machine.

Online Based Crop Monitoring System: More data is required in order to make the prediction accurate and exact. The accuracy of the prediction will increase with the size of the dataset. With a huge dataset, we can improve our trained model and create a subscription-based online prediction platform. Also, we may simplify it so that everyone can comprehend it and also include instructions on the necessary procedures to cure the ailment.

Autonomous Crop Monitoring System: Using of satellite data allows us to go completely automate crop monitoring, but the key limitation is that we cannot quickly obtain a real-time image of the crop. We can utilize GPS-based drone crop monitoring to improve the accuracy and confirm it with satellite data. This is how we can improve crop monitoring overall and obtain information about the health of plant leaves using weather reports and land-based crop preferences.

Object Detection and Avoidance of Quadcopter:

Algorithms: There are several collision avoidance algorithms that can be used to help a quadcopter autonomously avoid collisions. Here are a few examples:

Reactive Collision Avoidance: Reactive collision avoidance algorithms are designed to react to immediate threats and make adjustments to the quadcopter's flight path in real-time. These algorithms typically use a combination of sensors, such as ultrasonic or infrared sensors, to detect obstacles and determine the quadcopter's position and velocity. Based on this information, the algorithm will adjust the quadcopter's flight path to avoid the obstacle. This can include changing the quadcopter's altitude or direction of flight.

Predictive Collision Avoidance: Predictive collision avoidance algorithms use information about the quadcopter's surroundings to predict potential collisions before they occur. These algorithms typically use sensor data to create a 3D map of the quadcopter's environment, and then use this map to predict the motion of nearby obstacles. Based on this prediction, the algorithm will adjust the quadcopter's flight path to avoid the obstacle. This can include changing the quadcopter's altitude or direction of flight.

Artificial Intelligence-based Collision Avoidance: Artificial intelligence (AI)-based collision avoidance algorithms use machine learning techniques to analyze data from sensors and other sources to identify potential collision risks. These algorithms can learn from past experiences to improve their accuracy over time. For example, they can learn to recognize common obstacles in a particular environment and develop strategies for avoiding them.

The Hardware Involved:

The sensors and hardware that support collision avoidance algorithms in a quadcopter may include:

1. Distance Sensors: These sensors can be used to measure the distance between the quadcopter and nearby obstacles, and include ultrasonic and infrared sensors.
2. Vision Sensors: Cameras and other vision sensors can be used to detect obstacles and track their movement.
3. GPS/GNSS: GPS and GNSS systems can be used to track the quadcopter's position and velocity, and predict potential collisions.
4. LiDAR: LiDAR sensors can be used to create detailed 3D maps of the environment and detect obstacles in real-time.
5. IMU: An IMU can be used to measure the quadcopter's orientation and motion, which can help predict potential collisions and adjust the quadcopter's flight path accordingly.
6. Onboard Computer: An onboard computer can be used to process sensor data and run collision avoidance algorithms in real-time.

Overall, the sensors and hardware used to support collision avoidance algorithms in a quadcopter will depend on the specific requirements of the system and the environment in which it operates. A combination of different sensors and hardware may be used to provide a comprehensive approach to collision avoidance.

Four legged Quadpod movement for Quadcopter: A quadpod is a type of quadcopter drone with four legs, which allows it to land and take off from a wider variety of surfaces compared to a traditional quadcopter with landing skids. Here are some ways in which four-legged quadpod movement can be useful for crop monitoring:

1. Stability: The four legs of the quadpod provide greater stability during takeoff and landing, allowing it to maintain a level position on uneven terrain. This can help to prevent damage to the drone and ensure that the camera captures clear images of the crops.

2. Improved Maneuverability: The four-legged design of the quadpod can allow for greater maneuverability and precision movements during flight, which can be helpful when navigating through crops or getting close to specific areas of interest for monitoring.

3. Increased Payload Capacity: The four-legged quadpod design can provide greater payload capacity, allowing for larger and more advanced cameras or sensors to be used for crop monitoring.

4. Versatility: The four-legged quadpod can also provide versatility in the types of crops it can monitor. It can be used for crops that are low to the ground or taller crops that require a higher altitude for monitoring.

Essentially, the four-legged quadpod movement can be a valuable addition to a crop monitoring system, providing greater stability, maneuverability, payload capacity, and versatility for monitoring different types of crops.

Some additional parts and systems that could be used to create a quadpod drone with smart legs that can move in a spider-like way and retract during flight:

1. Leg Mechanism: The leg mechanism is the core component that allows the quadpod drone to move its legs in a spider-like way. It can be made up of multiple joints, each with its own servo motor to control its movement.

2. Control System: The control system is responsible for managing the leg mechanism and coordinating its movement with the drone's other systems. It can be based on a microcontroller or other processing unit, and may incorporate sensors to detect obstacles or other hazards in the drone's path.

3. Retractable Mechanism: The retractable mechanism allows the legs to be folded up and retracted during flight, reducing the drone's overall size and improving its aerodynamics. This mechanism can be integrated into the leg design itself, or it can be a separate component that is activated by a motor or other mechanism.

4. Power Supply: The leg mechanism and control system require their own power supply in order to operate. This can be provided by a dedicated battery or by tapping into the main drone battery.
5. Software: The software that controls the quadpod drone can be customized to take advantage of the leg mechanism's capabilities. For example, it can be programmed to move the legs in a specific pattern to navigate through crops or to avoid obstacles.

Overall, the smart leg mechanism can provide the quadpod drone with greater mobility and flexibility, allowing it to navigate through complex environments and avoid obstacles. The retractable mechanism also improves the drone's overall design and can help to reduce its size and weight during flight.

Automation of Laptop Computer processes: that is usually done so by manual intervention through keyboard and mouse manipulation.

General steps for developing an application that automates file detection and uploading for leaf disease detection.

Here are the steps:

1. **Define the requirements:** Start by identifying the requirements for the application, including the types of files to be detected and uploaded, the website where they will be uploaded, and any other specific needs.
2. **Choose the programming language and framework:** Select a programming language and framework that best suits your needs and requirements. Popular choices for web applications include Python with Flask or Django, Java with Spring or Struts, and Ruby on Rails.
3. **Set up the environment:** Set up the development environment by installing the necessary software and tools, including a code editor, a web server, and any libraries or frameworks required for the chosen programming language.
4. **Write the code:** Develop the application code to detect the files in the specified directory and upload them to the website using the appropriate API or file transfer protocol.
5. **Test the application:** Test the application thoroughly to ensure that it meets all requirements and performs as expected. Debug any issues that arise during testing.
6. **Deploy the application:** Once the application is fully tested and validated, deploy it to the production environment, making it available for use by end-users.
7. **Maintain and update the application:** Regularly maintain and update the application to ensure that it remains secure, stable, and up-to-date with the latest requirements and technologies.

Overall, the development of such an application requires a combination of skills in software development, web development, and data management. It may also require knowledge of machine learning and computer vision algorithms for leaf disease detection.

Chapter 11: Identification of Complex Engineering Problems and Activities.

11.1 Identify the attribute of complex engineering problem(EP)

Attributes of Complex Engineering Problems (EP)

Table 29: Attributes of Complex Engineering Problems

	Attributes	**Put tick (√) as appropriate**
P1	Depth of knowledge required	√
P2	Range of conflicting requirements	
P3	Depth of analysis required	√
P4	Familiarity of issues	√
P5	Extent of applicable codes	√
P6	Extent of stakeholder involvement and needs	√
P7	Interdependence	

11.2 Provide reasoning how the project address selected attribute (EP)

P1_ Depth of knowledge required

The project requires prior knowledge of different field. Among them, the most important one is Machine Learning and Image Processing. Here we need to learn python, CNN, tensor flow, use of Jupyter notebook, process of training a model. Finally, we need to learn the use of layers, augmentation, optimizer:

- **Image Processing:** Spectral Images that are acquired are required to be processed with the use of appropriate image processing techniques, Digital Image Processing (DIP), with the useof a computer. Essentially the various levels of image processing are low level, mid- level and high-level image processing**.**
- **Machining Learning:** Here, it is understood that Machine learning is required since Convoluted Neural Network architectures are necessarily used for the interpretation of the data that has been represented using graphs, charts e.t.c. subsequent to image processing.
- **Power Electronics:**
  For the case of Drone with it being a quadcopter, as a consequence, the motors would essentially be brushless and knowledge of how it functions and how its design is requires power electronics.
- **Control Systems:**
  There are concepts of Control Systems involved, which include the PID controller, Kalman Filter. Hence such aspects are necessary for the understanding of drone function and the working of the drone as it is required for remote sensing of the particular Agricultural Crops with the use of cameras.

P3_ Depth of analysis required

We must analyze a lot to make this project successful. For example, we identified the risks we might face while conducting the project. We had to come up with plans for facing those situations. Also, we had to find out all the protocols, codes, laws related to our project. Moreover, we analyzed a lot in making the project more sustainable and efficient.

P4_ Familiarity of issues

To complete the project, we are learning a lot of new things. Most of the works related to this project are new to us. We are not trained previously to solve this sort of problem.

P5_ Extent of applicable codes

This project requires some international codes and standards to follow. Without following those codes, the system will break rules.

P6_ Extent of stakeholder involvement and needs

Stakeholder involvement is an essential component of any successful project. There are, such to be, as numerous ways effective Stakeholder involvement could be done:

1. Identifying stakeholders: In order for the involvement of stakeholders to be so, in this or any project, the initial step is to identify who they are. Stakeholders can be individuals or groups who are impacted by the project or have a personal or professional interest in its success. By recognizing the stakeholders, project managers can ensure that they are taking their needs and expectations into account.
2. Communication: Stakeholder involvement in a project requires effective communication. Project management involves ensuring that stakeholders are kept up-to-date on the progress ofthe project, any changes that may occur, and any issues that may arise. By maintaining open lines of communication, project managers can help stakeholders feel engaged andinformed throughout the project lifecycle.
3. Stakeholder analysis: Understanding the needs, interests, and expectations of stakeholders is important to ensure that their input is considered in project decision-making. Stakeholder analysis can help identify potential conflicts and areas of agreement.
4. Stakeholder engagement: Engaging stakeholders in project planning and decision-making can help ensure that their perspectives and concerns are considered. This can involve soliciting feedback, involving stakeholders in focus groups or workshops, or forming advisory committees.
5. Conflict resolution: It is common for stakeholders to have competing interests or conflicting views. Project managers should be prepared to address conflicts as they arise and work to find mutually acceptable solutions.
6. Evaluation: Stakeholder involvement should be evaluated periodically to ensure that it is effective and meeting the needs of all stakeholders. This can involve soliciting feedback and making adjustments as needed.

This project includes the involvement of stakeholders. There is involvement of certain few, major stakeholders in this project. The first and the most important one is the farmers who are directlyinvolved with the project.

We went to **Sher-e-Bangla Agriculture University** several times and talked with the farmers who were there, and we got to know about the issues they were facing in farming.

Dr. Abul Hasnat M. Solaiman as one of the most important Stakeholders pertaining to the project. Essentially, he has approved in the flying of the Drone of the design prototype in two separate the Tomato Fields of the for the data acquisition phase, in the campus of Sher-e-Bangla Agricultural University, Dhaka. He has also approved of the System-level as well as the Component-level Specifications of our Prototype Model (See Appendix section).

We Additionally went to BCSIR Science Lab For testing The Maximum Height and Payload of the Quadcopter Drone. Dr. Mohammad Moniruzzaman, Principal Scientific Officer, BCSIR, Dhaka, Bangladesh is also very essential Stakeholder, whose permit allowed for the Testing of Drone in the Certain Ground of Science Lab BCSIR. (See Appendix section).

Secondly, the companies from where we managed all the Equipment to build the prototype for example, we have purchased some equipment from Robotics BD which is a stakeholder of our project.

We can also add some third-party companies who will take our technology and directly communicate with the farmer. We can work with those companies to improve our crop monitoring system and keep updating with newer data to get the best results. For this, we have talked with an agriculturalist, Mr. Andalib from the company ifarmer. Currently they are working on a vast area like Agri finance, Agri machineries, supply chain etc. They also focus on land monitoring, they are using satellite-based land monitoring and using device to detect the moisture level of the land. If we sell our system this will help the farmer to detect the crop disease as well as new method of crop monitoring will be added to the company. Moreover, if we collaborate will them the farmers will get a boost to grow more crops and would be able to take precautions for their crops.

11.3 Identify the attribute of complex engineering activities (EA)

Attributes of Complex Engineering Activities (EA)

Table 30: Attributes of Complex Engineering Activities

	Attributes	Put tick (√) as appropriate
A1	Range of resource	√
A2	Level of interaction	√
A3	Innovation	
A4	Consequences for society and the environment	
A5	Familiarity	√

Note: Project must have some or all of the characteristics from attributes A1 to A5

11.4 Provide reasoning how the project address selected attribute (EA)

A1_ Range of resource

We planned the project on a basis of five research papers. We got different ideas about how this sort of technology is being used worldwide. The we came up with multiple design approaches. We also researched about the cost of the equipment. Finally, we decided the efficient budget for the project.

A2_ Level of interaction

We will be communicating with the stakeholders involved with this project, authorities and local people as well.

A5_ Familiarity

There are many protocols, codes and standards that we will be following to conduct the project. A lot of research has already been done about this technology from which we had taken some ideas about making the technology more efficient, sustainable and upgraded.

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Appendix

Logbook

Group 11

Project Title: Design and Implementation of a Crop Health Monitoring System

	Final Year Design Project (C) Spring 2023		
Student Details	**NAME & ID**	**EMAIL ADDRESS**	**PHONE**
Member 1	Mashrur Kabir (18121034)	mashrur.kabir@g.bracu.ac.bd	01796661755
Member 2	Pranta Roy (16121043)	pranta.roy@g.bracu.ac.bd	01775621092
Member 3	Sheikh Sabikun Naher Labonnya (19321035)	sheikh.sabikun.naher.labonnya@g.bracu.ac.bd	01679189284
Member 4	Ashrar Ibne Hussain (17121051)	ashrar.ibne.hussain@g.bracu.ac.bd	01536174910
Member 5	Md. Ferdous Islam (10110007)	md.ferdous.islam@g.bracu.ac.bd	01742282140
ATC Details:			
ATC 3			
Chair	Prof. Dr. AKM Abdul Malek Azad	a.azad@bracu.ac.bd	01556528695
Member 1	Dr. Touhidur Rahman	touhidur.rahman@bracu.ac.bd	
Member 2	Mohammad Tushar Imran	thushar.imran@bracu.ac.bd	

Date/Time/ Place	Attendee	Summary of Meeting Minutes	Responsible	Comment by ATC
26.01.2023 (FYDP Committee Meeting-1)	**Speaker**: Dr. Abu S. M. Mohsin **Students** 1. Mashrur 2. Labonnya 3. Ferdous **Absent:** 1. Pranta (Pooja leave) 2. Ashrar (Went to hospital due to father's sickness)	1. Introduction of FYDP_C 2. Talked about the deadlines of report submissions and presentations. 3. Mentioned the things we need to focus for progress presentation. 4. Explained the process of final presentation and project showcasing. 5.Explained different CO 6. Discussed about cost analysis of the device 7. Talked about plagiarism 8. Discussion on the process of report writing.		N/A as it was an introductory meeting.
30.01.23 (Group Meeting-1) (Online)	**Students** 1. Mashrur 2. Pranta 3. Labonnya 4. Ashrar 5. Ferdous	1. Collection and discussion of research paper 2. Discussion about the format of report 3. Overview of FYDP class	Task 1: Pranta, Ashrar Task 2: Labonnya Task 3: Ferdous, Labonnya, Mashrur **Task Progress** Task 1: Completed Task 2: Completed Task 3: Completed	

04.02.23 (ATC Meeting- 1)	**Speaker**: 1. Prof. Dr. AKM Abdul Malek Azad **2.** Dr. Touhidur Rahman **Students** 1. Mashrur 2. Pranta 3. Labonnya 4. Ferdous **Absent:** 1. Ashrar (Abroad due to father's sickness)	1. Explained the logbook 2. Discussion about the revised budget 3. Displayed the papers for drone implementation	Task 1: Mashrur Task 2: Mashrur, Pranta Task 3: Pranta **Task Progress** Task 1: Completed Task 2: Completed Task 3: Completed	1. Make corrections on the cover page of the logbook 2. Submit the updated report 3. Add the revised budget updates on the logbook 4. Revise the Gantt chart
07.02.23 (Group Meeting-2) (Online)	**Students** 1. Mashrur 2. Pranta 3. Labonnya 4. Ashrar 5. Ferdous	1. Divided responsibility for writing the report	Task 1: Everyone **Task Progress** Task 1: Completed	
09.02.23 (Group Meeting-3) (Online)	**Students** 1. Mashrur 2. Pranta 3. Labonnya 4. Ashrar 5. Ferdous	1. Prepared a final budget for constructing the prototype 2. Prepared a revised Gantt chart for EEE400C 3. Introduction of Impact Analysis and Project Sustainability and Comparison table of impact 4. Updated the use of Modern Engineering and IT Tool 5. Discussion of Economic analysis	Task 1: Pranta Task 2: Labonnya Task 3: Ferdous Task 4: Pranta Task 5: Everyone **Task Progress** Task 1: Completed Task 2: Completed Task 3: Completed Task 4: Partially Completed Task 5: Completed	

11.02.23 (ATC Meeting- 2)	**Speaker**: 1. Prof. Dr. AKM Abdul Malek Azad 2. Dr. Touhidur Rahman 3. Mohammad Tushar Imran **Students** 1. Mashrur 2. Pranta 3. Labonnya 4. Ashrar 5. Ferdous	1. Discussion about the project report 2. Discussion about the updated gantt chart	Task 1: Everyone Task 2: Everyone **Task Progress** Task 1: Completed Task 2: Completed	1. In pace with the gantt chart 2. Do some corrections of the citations of background research 3. Do corrections on the tables of report. 4. Start writing the abstract of the report 5. More IT TOOLS needs to be added in Chapter 3 6. Start buying components
14.02.23 (Group Meeting-4) (Online)	**Students** 1. Mashrur 2. Pranta 3. Labonnya 4. Ferdous **Absent:** 1.Ashrar (Connectivity issue)	1. Writing abstract 2. Introduction & Conclusion of Chapter-1 3. Evaluated different equipment to be purchased 4. Searched online for components best price	Task 1: Ferdous Task 2: Labonnya Task 3: Pranta Task 4: Mashrur **Task Progress** Task 1: Completed Task 2: Completed Task 3: Completed Task 4: Partially Completed	
16.02.23 (Group Meeting-5) (Online)	**Students** 1. Mashrur 2. Pranta 3. Labonnya 4. Ashrar 5. Ferdous	1. Components Buying and capturing photos and recording videos. 2. Editing the use of Modern Engineering and IT Tool 3. Writing literature gap	Task 1: Mashrur Task 2: Pranta Task 3: Labonnya **Task Progress** Task 1: Completed Task 2: Partially Completed Task 3: Partially Completed	

18.02.23 (ATC Meeting- 3)	**Speaker**: 1. Prof. Dr. AKM Abdul Malek Azad 2. Dr. Touhidur Rahman 3. Mohammad Tushar Imran **Students** 1. Mashrur 2. Pranta 3. Labonnya 4. Ashrar 5. Ferdous	1. Discussion about the incomplete points of the report 2. Discussion about the task distribution of the logbook 3. Discussion on the image processing update 4. Displayed pictures of equipment	Task 1: Everyone Task 2: Everyone Task 3: Pranta Task 4: Mashrur **Task Progress** Task 1: Completed Task 2: Completed Task 3: Completed Task 4: Completed	1. Make corrections in the cover page of the logbook 2. Everybody should have tasks assigned in every discussion. 3. Include the conclusion of chapter 2 4. Use of IT tools chapter should be completed 5. Finish chapter 4 as soon as possible 6. Start writing chapter 8 7. Get ready to demonstrate the image processing part 8. Make corrections on the page numbers of the report 9. In line with Gantt chart
21.02.23 (Group Meeting-6) (Online)	**Students** 1. Mashrur 2. Pranta 3. Labonnya 4. Ashrar 5. Ferdous	1. Completed the Modern Engineering and IT Tools chapter 2. Literature gap Evaluation of sustainability & Introduction of Engineering Project Management 4. Risk Management Analysis and Safety Measures 5. Equipment Testing of Certain Essential parts 6. Completion of Acknowledgment of Report	Task 1: Pranta Task 2: Labonnya Task 3: Ferdous Task 4: Ashrar Task 5: Everyone Task 6: Mashrur, Ferdous **Task Progress** Task 1: Completed Task 2: Partially Completed Task 3: Completed Task 4: Completed Task 5: Completed Task 6: Completed	

23.02.23 (Group Meeting-7) (Physical meeting on thesis lab)	**Students** 1. Mashrur 2. Pranta 3. Labonnya 4. Ashrar 5. Ferdous	1. Worked on equipment testing	Task: Everyone **Task Progress** Task 1: Completed	
27.02.23 (Group Meeting-8) (Physical meeting on thesis lab)	**Students** 1. Mashrur 2. Pranta 3. Labonnya 4. Ashrar 5. Ferdous	1. Prepared Slides for progress presentation 2. Worked on building prototype	Task 1: Ashrar Task 2: Everyone **Task Progress** Task 1: Completed Task 2: Partially Completed	
28.02.23 (Group Meeting-9) (Physical meeting on thesis lab)	**Students** 1. Mashrur 2. Pranta 3. Labonnya 4. Ashrar 5. Ferdous	1. Worked on building prototype	Task 1: Everyone **Task Progress** Task 1: Partially Completed	
28.02.23 (ATC Meeting- 4)	**Speaker**: 1. Prof. Dr. AKM Abdul Malek Azad 2. Dr. Touhidur Rahman 3. Mohammad Tushar Imran **Students** 1. Mashrur 2. Pranta 3. Labonnya 4. Ashrar 5. Ferdous	1. Demonstrated the image processing update 2. Discussion about the issues of the logbook and report 3. Discussed about the equipment testing result	Task 1: Pranta Task 2: Mashrur, Pranta, Labonnya Task 3: Mashrur **Task Progress** Task 1: Completed Task 2: Completed Task 3: Completed	1. Look into the silly mistakes of the logbook. 2. Send videos of equipment testing 3. Start building prototype. 4. Start writing about the image processing part in the report.
01.03.23 (Group Meeting-10) (Physical meeting on thesis lab)	**Students:** 1. Ferdous 2. Pranta 3. Ashrar 4. Mashrur 5. Labonnya	1. Worked on building prototype 2. Rehearsal for progress Presentation (Online)	Task 1: Everyone Task 2: Everyone **Task Progress** Task 1: Partially Completed Task 2: Completed	

02.03.23 (FYDP Committee Meeting -2)	**Speaker**: Dr. Abu S. M. Mohsin **Students** 1. Mashrur 2. Pranta 3. Labonnya 4. Ashrar 5. Ferdous	1. Progress Presentation	Task 1: Everyone **Task Progress** Task 1: Completed	**Feedbacks of Progress Presentation from FYDP Committee** 1. Visit field to capture image data and observe the accuracy of the prediction 2. Questioned about image processing algorithm 3. Asked to Increase flight time
04.03.23 (ATC Meeting-5)	**Speaker**: 1. Prof. Dr. AKM Abdul Malek Azad **2.** Dr. Touhidur Rahman **Students** 1. Mashrur 2. Pranta 3. Labonnya 4. Ashrar 5. Ferdous	1. Displayed pictures of the crops capturedusing drone 2. Discussion about the feedback of FYDP committee from the progress presentation 3. Discussion about the issues of report	Task 1: Mashrur Task 2: Everyone Task 3: Everyone **Task Progress** Task 1: Completed Task 2: Completed Task 3: Completed	2. Start writing chapter 5 3. Add the final budget on the report. 4. Everyone should participate on prototype testing in the thesis lab 5. Leading the gantt chart
15.03.23 (Group Meeting-11) (Online)	**Students** 1. Mashrur 2. Pranta 3. Labonnya 4. Ashrar 5. Ferdous	1. Technical and Non-technical Constraints 2. Relevance to current and future industry 3. Started working on the web page design 4. Evaluate project progress and Conclusion 5. Discussed economic analysis. 6. Introduction and overview of three design approaches	Task 1. Ashrar Task 2. Labonnya Task 3. Pranta Task 4: Ferdous Task 5: Everyone Task 6: Mashrur **Task Progress** Task 1: Completed Task 2: Completed Task 3: Partially Completed Task 4: Completed Task 5: Completed Task 6: Partially Completed	

16.03.23 (Group Meeting-12) (Physical meeting on thesis lab)	**Students** 1. Mashrur 2. Pranta 3. Labonnya 4. Ashrar 5. Ferdous	1. Worked on drone calibration 2. Discussion about the safety measures	Task 1: Everyone Task 2: Everyone **Task Progress** Task 1: Completed Task 2: Completed	
18.03.23 (ATC Meeting-6)	**Speaker**: 1. Prof. Dr. AKM Abdul Malek Azad 2. Dr. Touhidur Rahman 3. Mohammad Tushar Imran **Students** 1. Mashrur 2. Pranta 3. Labonnya 4. Ashrar **Absent:** 1. Ferdous (Went to hospital)	2. Discussion on various issues of the project report 3. Provided update on the physical group meeting on the thesis lab	Task 1: Everyone Task 2: Everyone **Task Progress** Task 1: Completed Task 2: Completed	1. Add feedback of progress presentation in the logbook. 2. Add list of tables and figures 3. Start writing the chapter 5 4. Budget must be added 5. Image processing section should be placed in the appropriate section 6. Review abstract 7. Review the citation 8. Every chapter should be started from a new page 9. Review chapter 3.4 10. Make corrections on the page numbers 11. Start writing the page numbers in the table of content 12. Review the conclusion of the IT Tools section

21.03.23 (Group Meeting-13) (Online)	**Students** 1. Ferdous 2. Pranta 3. Ashrar 4. Mashrur 5. Labonnya	1. Created list of tables and figures 2. Correction of page numbers 3. Placed the image processing part on the appropriate section of the report and reviewed the conclusion of IT Tools 4. Correction in the citations of Background Study 5. Enhanced the accuracy of the training 6. Corrected the Abstract 7. Identification of optimal design approach and performance evaluation of developed solution 8. First two subchapters of Economic Analysis (Introduction and Economic Analysis)	Task 1: Labonnya Task 2,3: Pranta Task 4: Labonnya Task 5: Pranta Task 6,7: Mashrur Task 7: Ferdous, Ashrar **Task Progress** Task 1: Completed Task 2: Completed Task 3: Completed Task 4: Completed Task 5: Completed Task 6: Completed Task 7: Completed Task 8: Completed	

23.03.23 (Group Meeting-14) (Online)	**Students** 1. Mashrur 2. Pranta 3. Labonnya 4. Ashrar 5. Ferdous	1. Introduction of the Optimization of the Multiple Design Approach 2. Worked on developing the webpage for displaying the disease and cure. 3. Chapter 8(Cost benefit analysis, Evaluation of Economic and Financial aspects and Conclusion) 4. Inserted page numbers in the table of content. 5. Completion of Final Design and Validation 6. Conclusion of Ethics and Professional Responsibility	Task 1: Labonnya Task 2: Pranta Task 3: Ferdous, Ashrar Task 4: Labonnya Task 5,6: Mashrur **Task Progress** Task 1: Completed Task 2: Completed Task 3: Completed Task 4: Completed Task 5: Completed Task 6: Completed	
25.03.23 (ATC Meeting-7)	**Speaker**: 1. Prof. Dr. AKM Abdul Malek Azad 2. Mohammad Tushar Imran **Students** 1. Mashrur 2. Pranta 3. Labonnya 4. Ashrar 5. Ferdous	1. Demonstrated the enhanced accuracy. 2. Discussion about the current update of the prototype	Task 1: Pranta Task 2: Everyone **Task Progress** Task 1: Completed Task 2: Completed	1. Send the Report and logbook earlier from the next week 2. Start working on making poster 3. Instructed Mashrur to demonstrate the data taken by drone in the next meeting 4. Add results on the report.

27.03.23 (Group Meeting-15) (Online)	**Students** 1. Mashrur 2. Pranta 3. Labonnya 4. Ashrar 5. Ferdous	1. Revised Ethics and Professional Responsibilities 2. Discussed various aspects of primary and secondary dataset 3. Tested the primary dataset and got the result from the trained model. 4. Discussion about certain limitations of the codes.	Task 1: Mashrur Task 2: Everyone Task 3: Everyone Task 4: Everyone **Task Progress** Task 1: Completed Task 2: Completed Task 3: Completed Task 4: Completed	
30.03.23 (Group Meeting-16) (Physical meeting on thesis lab)	**Students** 1. Mashrur 2. Pranta 3. Labonnya 4. Ferdous **Absent** 1. Ashrar (Sickness)	1. Downloaded CD210x driver package and adjusted Baud rate for mission planner 2. Adjusted camera to prevent glitching and trouble shooted power module 3. Acquired leaf primary dataset and discussion on camera dataset 4. Discussion about the possible lacking of the drone 5 Stated the drawbacks of the Mission Planner autonomous flight mode for the drone. 6. Writing the project summery of the report 7. Adjustment of the page numbers and the chapters 8: Discussion on mission planner software and its significance. 9. Added the predicted result on the report.	Task 1: Mashrur Task 2: Mashrur Task 3: Ferdous, Pranta Task 4: Everyone Task 5: Pranta Task 6: Labonnya Task 7: Labonnya Task 8: Everyone Task 9: Pranta **Task Progress** Task 1: Completed Task 2: Completed Task 3: Completed Task 4: Completed Task 5: Completed Task 6: Completed Task 7: Completed Task 8: Completed Task 9: Completed	

01.04.23 (ATC Meeting-8)	**Speaker**: 1. Prof. Dr. AKM Abdul Malek Azad 2. Dr. Touhidur Rahman 3. Mohammad Tushar Imran **Students** 1. Mashrur 2. Pranta 3. Labonnya 4. Ashrar 5. Ferdous	1. Discussion about the modifications in the report 2. Discussion about various issues of the report 3. Provided update about the prototype	Task 1: Everyone Task 2: Everyone Task 3: Everyone **Task Progress** Task 1: Completed Task 2: Completed Task 3: Completed	1. Complete the list of tables of the report 2. Abstract and acknowledgement needs to be corrected 3. Insert colors on the block diagrams of the design approaches 4. Weight values should carry reference 5. Tables need to be minimized of the chapter 4.4 6. Enhance the chapter of Future Work 7. Make corrections on the alignment of the specifications 8. Revise chapter 5 (check template) 9. Recheck chapter 9.3.2 10. Include Ethics Statement 11. Go for field test by next week
05.04.23 (Group Meeting-17) (Physical meeting on the field)	**Students** • Mashrur • Pranta • Labonnya • Ashrar • Ferdous	1. Tested the flight time of the drone 2. Tested the weight, that the drone can carry 3. Captured images of the tomato leaves.	Task 1: Everyone Task 2: Everyone Task 3: Everyone **Task Progress** Task 1: Completed Task 2: Completed Task 3: Completed	Field location: Sher-e-Bangla Agriculture University

08.04. 23 (ATC Meeting-9)	**Speaker**: 1. Prof. Dr. AKM Abdul Malek Azad 2. Dr. Touhidur Rahman 3. Mohammad Tushar Imran **Students** 1. Mashrur 2. Pranta 3. Labonnya 4. Ferdous **Absent** 1. Ashrar (Network Issue)	1. Discussion about the percentage of plagiarism of the report 2.Discussion about various issues of the report 3. Discussion about the final poster that is going to be prepared	Task 1: Everyone Task 2: Everyone Task 3: Everyone **Task Progress** Task 1: Completed Task 2: Completed Task 3: Completed	1. Start preparing poster 2. Send the poster to ATC by next Friday 3.Check plagiarism of the report and make it upto 20% and send the result to ATC 4. Page 50-51 space correction 5. Provide reference of the images 6. Put the picture of the drone in the report 7. Review page 100 Table (Retail price can be converted in BDT, reference of conversion rate) 8.Check references 9. Add all the codes in the appendix 10. Stakeholders involvement should be specific
13.04.23 (Group Meeting-18) (Online)	**Students** 1. Mashrur 2. Pranta 3. Labonnya 4. Ashrar 5. Ferdous	1. Prepared poster 2. Plagiarism checking 3. Stakeholders point reviewed 4. Included Appendix 5. Retail price converted to BDT 6. Correcting references 7. Fixing GPS module and Repairing GPS antenna	Task 1: Ashrar, Pranta Task 2: Labonnya Task 3: Pranta, Mashrur, Labonnya Task 4: Pranta Task 5: Ferdous, Ashrar, Pranta Task 6: Pranta, Labonnya Task 7: Mashrur **Task Progress** Task 1: Completed Task 2: Completed Task 3: Completed Task 4: Completed Task 5: Completed Task 6: Completed Task 7: Completed	

15.04. 23 (ATC Meeting- 10)	**Speaker**: 1. Prof. Dr. AKM Abdul Malek Azad 2.Dr. Touhidur Rahman **Students** 1. Mashrur 2. Pranta 3. Labonnya 4. Ashrar 5. Ferdous	1. Displayed the poster and extensive discussion about it 2. Discussion about the process of poster presentation 3. Discussion about the guideline of project showcase 4. Discussion about the payload of the drone and the outcome of field test 5. Discussion about the similarity check report	Task 1: Everyone Task 2: Everyone Task 3: Everyone Task 4: Mashrur Task 5: Everyone **Task Progress** Task 1: Completed Task 2: Completed Task 3: Completed Task 4: Completed Task 5: Completed	1. Consult with FYDP committee regarding the landscape orientation of the poster 2. Attach the logbook with the report and add the plagiarism information and send the final report to ATC 3. Send the videos of prediction to the ATC
20.04.23 (Group Meeting- 19) (Online)	**Students** 1. Mashrur 2. Pranta 3. Labonnya 4. Ashrar 5. Ferdous	1. Added a description about a software in Modern IT Tools 2. Revised Technical and Non-Technical Constraints 3. Description of velocity and acceleration 4. Added new points on future work 5. Prepared the poster in a portrait format 6. Proof reading of the whole report 7. Corrected some citation and capitalization issues of chapter 6 8. Re checked the new additions of the report 9. Correction of the new points with proper font 10. Correction on few parts of image processing. 11. Updated the appendix accordingly	Task 1: Mashrur Task 2: Mashrur Task 3: Mashrur Task 4: Mashrur Task 5: Ashrar Task 6: Ferdous, Pranta, Labonnya Task 7: Ferdous Task 8: Labonnya Task 9: Labonnya Task 10: Pranta Task 11: Pranta **Task Progress** Task 1: Completed Task 2: Completed Task 3: Completed Task 4: Completed Task 5: Completed Task 6: Completed Task 7: Completed Task 8: Completed Task 9; Completed Task 10: Completed Task 11: Completed	

27.04.23 (Poster Presentation) (Physical)	**Faculties Present:** 1. Entire FYDP Committee 2. All ATC Panel Group Members **Students** 1. Mashrur 2. Pranta 3. Labonnya 4. Ashrar 5. Ferdous	1. Bought Styrofoam Frame. 2. Setup The Table and Required Poster and Set up the Prototype Before Presentation. 3. Gave A brief Overview Explanation of the Optimal Design. 4. Demonstrated the Functioning Prototype System 5. Answered Queries of Faculties and other individuals, inquiring. 6. Submission of Report pdf Soft Copy (with combined logbook pdf), Presentation Poster pdf Soft Copies and Uploaded of zip folder, all in Google Classroom Before 12:30 am deadline.	Task 1, 2: Mashrur Task 3: Mashrur, Pranta Task 4: Mashrur, Pranta, Ferdous, Ashrar Task 5: Everyone Task 6: Mashrur **Task Progress:** Task 1: Completed Task 2: Completed Task 3: Completed Task 4: Completed Task 5: Completed Task 6: Completed	1.Very Good Presentation Performance (**Dr. Sabuj, Dr. Abu Mohsin, Mr.**) 2.Demonstration of Prototype was Very Good (**Dr. Sabuj**) 3.Suggested Automation of Certain Manual Computer processes, (which was already addressed for Future work) (**Mr. Md. Mahmudul Islam)** 4.Suggested further refining of algorithm of CNN (which was suggested in Future Work) (**Dr Abu Mohsin**)
08.05.23 (Group Meeting-19) (Online)	**Students** 1. Mashrur 2. Pranta 3. Labonnya 4. Ashrar 5. Ferdous	1. Submission of Report pdf, Poster Presentation pdf and Zip File of Other Resources PDF (by 28thMay) to ATC via email thread 2. Submission of Plagiarism Report (by 28th May) to ATC via email thread **3.** Modification of Report pdf in the Chapter 8: 8.2 Economic Analysis: Added **Explanation** section, mentioning **Source** website links and **Citations.**	Task 1,3: Mashrur Task 2: Labonnya **Task Progress:** Task 1: Completed Task 2: Completed Task 3: Completed	

09.05.23 (Group Meeting-19) (Online)	**Students** 1. Mashrur 2. Pranta 3. Labonnya 4. Ashrar 5. Ferdous	1. Added Website Links in References in proper IEEE format in Reference Section (for addition of Explanation section of **8.2 Economic Analysis** of Chapter 8. 2. Added additional information pertaining to Stakeholders' involvement as well as specific location of field where drone was launched and flown for testing of prototype. 3. Modified Chapter 3: Modern IT Tools: sub-chapter 3.2: **Select appropriate engineering IT tools**, Table: 12, and Hardware Part of subchapter 3.3: **Use of Modern Engineering and IT tools** and added additional information on Modern IT Tools on Mission Planner Software and Skydroid Camera module Hardware. 4. Added information on Automation of Computer Processings for Design in Chapter: Future Work and Conclusion 5. Discussed and Checked Modifications 6. Made Booklet 7. Each Group Member Signed with their own Signature on Booklet at appropriate place.	Task 1,2,3,4: Mashrur Task 6,7: Everyone **Task Progress:** Task 1: Completed Task 2: Completed Task 3: Completed Task 4: Completed Task 5: Completed Task 6: Completed Task 7: Completed	

10.05.23	**Students** 1. Mashrur 2. Pranta 3. Labonnya 4. Ashrar 5. Ferdous	1. Signature of Booklet of ATC and FYDP and other bodies taken. 2. Submitted Booklet to EEE Department DCO, ATC panel-3	Task 1,2: Everyone **Task Progress:** Task 1,2: Complete	

Related code/theory

Training the model:

```
import tensorflow as tf

from tensorflow.keras import models, layers
import matplotlib.pyplot as plt

BATCH_SIZE = 32
IMAGE_SIZE = 256
CHANNELS=3
EPOCHS=40

dataset = tf.keras.preprocessing.image_dataset_from_directory(
    "Dataset",
    seed=123,
    shuffle=True,
    image_size=(IMAGE_SIZE,IMAGE_SIZE),
    batch_size=BATCH_SIZE)

for image_batch, labels_batch in dataset.take(1):
    print(image_batch.shape)
    print(labels_batch.numpy())

plt.figure(figsize=(10, 10))
for image_batch, labels_batch in dataset.take(1):
    for i in range(12):
        ax = plt.subplot(3, 4, i + 1)
        plt.imshow(image_batch[i].numpy().astype("uint8"))
        plt.title(class_names[labels_batch[i]])
        plt.axis("off")

len(dataset)
train_size = 0.8
len(dataset)*train_size
train_ds = dataset.take(400)
len(train_ds)
test_ds = dataset.skip(400)
len(test_ds)

val_size=0.1
len(dataset)*val_size

def    get_dataset_partitions_tf(ds,    train_split=0.8,    val_split=0.1,    test_split=0.1,
shuffle=True, shuffle_size=10000):
    assert (train_split + test_split + val_split) == 1

    ds_size = len(ds)

    if shuffle:
        ds = ds.shuffle(shuffle_size, seed=12)

    train_size = int(train_split * ds_size)
    val_size = int(val_split * ds_size)

    train_ds = ds.take(train_size)
    val_ds = ds.skip(train_size).take(val_size)

    test_ds = ds.skip(train_size).skip(val_size)

    return train_ds, val_ds, test_ds


train_ds = train_ds.cache().shuffle(1000).prefetch(buffer_size=tf.data.AUTOTUNE)
val_ds = val_ds.cache().shuffle(1000).prefetch(buffer_size=tf.data.AUTOTUNE)
```

```
test_ds = test_ds.cache().shuffle(1000).prefetch(buffer_size=tf.data.AUTOTUNE)


resize_and_rescale = tf.keras.Sequential([
    layers.experimental.preprocessing.Resizing(IMAGE_SIZE, IMAGE_SIZE),
    layers.experimental.preprocessing.Rescaling(1./255),
])


data_augmentation = tf.keras.Sequential([
    layers.experimental.preprocessing.RandomFlip("horizontal_and_vertical"),
    tf.keras.layers.experimental.preprocessing.RandomZoom(0.2),
    tf.keras.layers.experimental.preprocessing.RandomHeight(0.2),
    tf.keras.layers.experimental.preprocessing.RandomWidth(0.2)
])


input_shape = (BATCH_SIZE, IMAGE_SIZE, IMAGE_SIZE, CHANNELS)
n_classes = 10

model = models.Sequential([
    resize_and_rescale,
    layers.Conv2D(62, kernel_size = (3,3), activation='relu', input_shape=input_shape),
    layers.MaxPooling2D((2, 2)),
    layers.Conv2D(82, kernel_size = (3,3), activation='relu'),
    layers.MaxPooling2D((2, 2)),
    layers.Conv2D(128, kernel_size = (3,3), activation='relu'),
    layers.MaxPooling2D((2, 2)),
    layers.Conv2D(256, (3, 3), activation='relu'),
    layers.MaxPooling2D((2, 2)),
    layers.Conv2D(256, (3, 3), activation='relu'),
    layers.MaxPooling2D((2, 2)),
    layers.Flatten(),
    layers.Dense(80, activation='relu'),
    layers.Dense(n_classes, activation='softmax'),
])

model.build(input_shape=input_shape)

model.compile(
    optimizer='adam',
    loss=tf.keras.losses.SparseCategoricalCrossentropy(from_logits=False),
    metrics=['accuracy']
)


history = model.fit(
    train_ds,
    epochs=EPOCHS,
    batch_size=BATCH_SIZE,
    validation_data=val_ds,
    verbose=1,
)

acc = history.history['accuracy']
val_acc = history.history['val_accuracy']

loss = history.history['loss']
```

```
val_loss = history.history['val_loss']

plt.figure(figsize=(8, 8))
plt.subplot(1, 2, 1)
plt.plot(range(EPOCHS), acc, label='Training Accuracy')
plt.plot(range(EPOCHS), val_acc, label='Validation Accuracy')
plt.legend(loc='lower right')
plt.title('Training and Validation Accuracy')

plt.subplot(1, 2, 2)
plt.plot(range(EPOCHS), loss, label='Training Loss')
plt.plot(range(EPOCHS), val_loss, label='Validation Loss')
plt.legend(loc='upper right')
plt.title('Training and Validation Loss')
plt.show()

import numpy as np
for images_batch, labels_batch in test_ds.take(1):

    first_image = images_batch[0].numpy().astype('uint8')
    first_label = labels_batch[0].numpy()

    print("first image to predict")
    plt.imshow(first_image)
    print("actual label:",class_names[first_label])

    batch_prediction = model.predict(images_batch)
    print("predicted label:",class_names[np.argmax(batch_prediction[0])])

def predict(model, img):
    img_array = tf.keras.preprocessing.image.img_to_array(images[i].numpy())
    img_array = tf.expand_dims(img_array, 0)

    predictions = model.predict(img_array)

    predicted_class = class_names[np.argmax(predictions[0])]
    confidence = round(100 * (np.max(predictions[0])), 2)
    return predicted_class, confidence

model.save("./tomatoes.h5")
```

Prediction of the Disease:

```
import tensorflow as tf
import numpy as np
from tensorflow.keras.preprocessing import image
import cv2

# load the trained model
model = tf.keras.models.load_model('C:/Users/proyr/Desktop/Tomato Trained again
(New)/tomatoes.h5')


# load the image
img = cv2.imread('C:/Users/proyr/Desktop/Tomato Trained again (New)/1e8c2c4d-e787-45ff-87ac-
56484ac8d3d4_GH_HL Leaf 472.JPG')
img = cv2.resize(img, (256, 256))
x = image.img_to_array(img)
x = np.expand_dims(x, axis=0)
x = tf.keras.applications.resnet.preprocess_input(x)

# predict the class probabilities
preds = model.predict(x)

# get the predicted class index1d8bb370-3c10-4806-b2ff-1621e21355ba_RS_HL 9882
class_idx = np.argmax(preds[0])

# get the predicted class name
class_names =
['Tomato_Target_Spot','Tomato_mosaic_virus','Tomato_YellowLeaf_Curl_Virus','Tomato_Bact
erial_spot','Tomato_Early_blight','Tomato_healthy','Tomato_Late_blight','Tomato_Leaf_Mold',
'Tomato_Septoria_leaf_spot','Tomato_Spider_mites_Two_spotted_spider_mite'] # replace with
your class names
class_name = class_names[class_idx]

print('Predicted class:', class_name)
```

Stakeholders

Acknowledgements and Approvals:

Professor Abul Hasnat M. Solaiman, PhD of Sher-e Bangla Agriculture University, has approved and certified that particular prototype design build as a drone crop monitoring system meet the requirements necessary for its function and object. He also states and approves through his vigilant observation that the system level as well as the component level specification of the design have met the necessary standard for it to be used for the purpose of tomato leaf disease detection and progress.

It is he whose permit provided allowance to Fly the Drone In certain Crop Tomato Fields. Crop Field 1 and Crop Field 2.

Likewise, he has Commented to a high regard towards the diligence and cordiality, along with overall resource fullness of Mr. Mashrur Kabir of Group-11 FYDP EEE400C, who (according to him (Dr Solaiman)), without which this would not have been possible.

Dr. Mohammad Moniruzzaman, Principal Scientific Officer, BCSIR, Dhaka, Bangladesh is a stakeholder who has also approved and certified the use of the drone of the prototype, to thus be tested for payload and maximum height in the field grounds of BCSIR, Dhaka

Additionally, he has commented to a high regards towards the diligence and cordiality, as well as the overall resource fullness of Mr. Mashrur Kabir of Group-11 FYDP EEE400C, who (according to him (Dr. Moniruzzaman,)), without which this would not have been possible, on the grounds of BCSIR. He regards highly of the negotiating capability as well as the knowledge and resourcefulness of Mr. Mashrur Kabir of Group-11 FYDP EEE400C.