SMART AGRICULTURE MANAGEMENT SYSTEM FOR RICE DISEASE DETECTION AND FERTILIZER SELECTION

By

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

Department of Electrical and Electronic Engineering
Brac University
November 2022

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Department of Electrical and Electronic Engineering
Brac University
November 2022

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.

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Approval

The Final Year Design Project (FYDP) titled "SMART AGRICULTURE MANAGEMENT SYSTEM FOR RICE DISEASE DETECTION AND FERTILIZER SELECTION" submitted by

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of Summer,2022 has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Bachelor of Science in Electrical and Electronic Engineering on 1st September of 2022.

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Ethics Statement

We declare that this project on " SMART AGRICULTURE MANAGEMENT SYSTEM FOR RICE DISEASE DETECTION AND FERTILIZER SELECTION" satisfies the graduation project requirements and that there was no occurrence of duplication in its development. We completed the entire project on our own, with the help of our supervisors and the EEE department, and furthermore the information we collected from sources are cited properly.

Abstract/ Executive Summary

Bangladesh has the ninth-highest population density in the world. Despite significant advancements to meet the expanding food-demand, the nation still relies heavily on agriculture, with unpredictable crop yields and insufficient infrastructure for farming as a result of many sectors adhering to outdated human-centric agricultural practices. A more sustainable agricultural-production could result from the use of smart-farming. Unmanned aerial vehicles (UAVs), a widely used smart-farming technology, are revolutionizing traditional farming methods. Knowing the capabilities of various systems enables the appropriate choice to be made in advance of a particular task, and each task necessitates the appropriate choice of the flight system. In this project, a UAV collected and uploaded images and soil-data from a paddy-field, including NPK, moisture, temperature, and humidity. On this dataset, we conducted an analysis to determine the field's fertility and give fertilizer recommendations. To identify rice diseases like brown spot, we also employed ResNet152V2 model, a deep learning image-based disease detection system. we have used our dataset (images taken with the UAV camera) for training and testing and we have used Google Colab for coding. Although the algorithm was fairly precise, the UAV model was quite unstable and the dataset was relatively tiny, necessitating a significant amount of work in this area in the future.

Keywords: UAV; Fertilizer; Rice-Disease; ResNet152V2; Disease-Detection; Brown-Spot;

Dedication

First and foremost, we are always be grateful to Almighty Allah, for whom we have finished our project without any major interruption. We would also like to thank our parents for their ongoing and enthusiastic support. We are getting close to finishing our graduation with their kind encouragement and prayers.

Acknowledgement

We would like to acknowledge and give our deepest appreciation to Abu S.M. Mohsin, the Chairman of our Academic Technical Committee and Taiyeb Hasan Sakib, member of our Academic Technical Committee for their constant support and insightful counsel throughout this endeavor, without these we could not have completed our Final Year Design Project. Whenever we needed guidance, they were beside us to assist. Their feedback always kept us in the right track and their support and supervision enabled us to improve from each mistake. As we progressed through the project, we not only learned about the project itself but also about professionalism, ethics and morals. The gratitude we have for them is beyond words.

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List of Acronyms

CAD	Computer Aided Design
CNN	Convolutional Neural Network
DAP	Di-ammonium phosphate
DL	Deep Learning
GDP	Gross Domestic Product
GPS	Global Positioning System
IoT	Internet of Things
IP	Internet Protocol
ML	Machine Learning
MoP	Muriate of potash
NPK	Nitrogen, Phosphorus, and Potassium
TCP	Transmission Control Protocol
UAGV	Unmanned Aerial Ground Vehicle
UAV	Unmanned Aerial Vehicle
UGV	Unmanned Ground Vehicle

Glossary

Autonomous	a single or a group of networks which are administrated by the same entity
Cloud server	a centralized server resource that is accessed on demand by numerou s users across a network—typically the Internet
Data set	a combination of linked pieces of information that can be processed as a whole by a computer yet is composed of distinct components
Image Processing	a technique where some operations are applied to the input image after that some relevant and useful information are extracted as a result of output
Machine learning	a branch of artificial intelligence where the ability of a machine to emulate intelligent human behavior is widely defined
Payload	bearing capacity of a set of transmission data unit
Precision Agriculture	management technique that collects, processes, and examines individual data and combine it with other data to enable management decisions based on anticipated variations; it is also known as 'smart farming'
Sensor	a device that stores and responses physical attributes
Unmanned vehicle	a vehicle which does not need any human controller on board

Chapter 1

Introduction [CO1, CO2, CO10]

1.1 Introduction

Smart farming is the incorporation of modern information and communication technology into agriculture and it has a real potential to produce more productive and sustainable agricultural production. Smart farming is a more precise and resource-efficient approach. On the other hand, precision agriculture is an interconnected technology that includes a decision support system for whole farm management intending to optimize returns on input by the widespread use of Global Positioning System (GPS) and aerial images that can measure variables like crop growth, moisture level, or fertilizer level. In our country, the maximum time of the year crop growth is not monitored properly. As a result, farmers could not choose the right fertilizer or decide what to grow or when to grow, so they had to bear huge losses. Also, they have no proper idea of crop diseases. Plant diseases have an impact on smallholder farmers whose livelihoods depend on these healthy crops, in addition to posing a threat to global food security. Lastly, because of the changing soil structure due to different weather conditions, our farmers are not well aware of which crop would be optimally suited for growing in that particular soil. Smart farming can be used to solve such problems because a lot of different systems can be developed by using microcontrollers and wireless sensor networks to monitor and predict the soil conditions for irrigating the field.

1.1.1 Problem Statement

Thanks to technological advancements, agriculture has evolved since humans adopted an agrarian lifestyle. As a result, crop varieties and yields have increased. Agriculture, on the other hand, is at a historic crossroads as humanity grapples with the effects of climate change and the societal challenges that comes with it. The world's population has already exceeded 8 billion people and is expected to exceed 9 billion by 2050. By 2050, the global food supply will need to be increased by 70%. Bangladesh is the world's ninth most densely populated country, with 164.7 million people living on a land area of only 148.5km^2 (1278 people per square km). Despite significant progress in agriculture to meet the growing needs of Bangladesh's massive population, the country remains an agricultural country with unpredictable crop yields and inadequate farming infrastructure, due to the fact that many of its sectors still stick to age old human-centric agricultural practices. This human-intensive agricultural process not only increase human labor, production costs, and error-prone procedures, but it also wastes valuable resources such as water, energy, and fertilizer and ultimately creates food security issues. As a result, modernization and technology-intensive smart farming techniques are an unavoidable requirement for achieving long-term growth in food production while maintaining high resource efficiency. Thanks to recent advances in a number of crucial technologies, agriculture is on the verge of another revolution that could alter not just crop variety and production, but also climatological and societal effects.

Precision Agriculture, often known as Smart farming, is the application of current information and communication technology to agriculture, and it has the potential to increase agricultural productivity and sustainability. It is among the most promising technologies on this track, because our mission is to optimize and improve the processes in the agricultural segments in question and Smart Farming has the potential to succeed that mission.

1.1.2 Background Study

We examined and studied the current state of Bangladesh's agriculture industry in order to have a better understanding of the problem, and we discovered that virtually little has been done to digitalize this sector. When it comes to the application of technology in agriculture, we fall far behind the developed countries. Agriculture, including all of its sub-sectors (e.g., crops cultivation, fishing, animals, and forestry), is Bangladesh's largest employer. According to 2008 data, this industry employs 48% of the workforce and generates around 21% of total GDP. The gap between output (production/GDP contribution) and cumulative investment (e.g., labor, energy, and others) is one of the lowest in the world in the sector of agriculture.

One of Bangladesh's major issues is high energy usage for crop production with poor yields. Energy intensity, which is inversely related to GDP, is used to calculate the economic return on energy consumed by a sector. With the implementation of efficient cutting-edge technology, the energy intensity gradually decreases, assuring effective energy utilization through planning and execution [1][2]. Bangladesh has made significant progress in adopting technology to boost agricultural production during the last two decades, but it still lags behind in reducing energy intensity [3]. This is primarily due to the use of older and inadequate technology in many agricultural areas, such as irrigation. The development of Bangladesh would be unsustainable if agricultural energy intensity continues to rise.

Inorganic fertilizers (e.g., urea, MoP, and TSP) were first introduced in Bangladesh in the mid-twentieth century. By overlooking the side effects, the usage of inorganic fertilizer is growing day by day with the increase in cropping intensity. As a result, nutrient imbalance has been dramatically expanded in soil-plant systems [4]. For example, nitrogen imbalance accounts for roughly 75% of the fertilizer usage in the soil. It also affected surface water, spread infections, and had a negative impact on aquatic life, animals, and people. As a result, roughly 60% of arable land suffers from an organic content deficiency, which is far below the essential level of 1.5 percent [5]. Farmers continue to use inorganic fertilizers due to a lack of knowledge about the appropriate use of inorganic and organic fertilizers. As a result, agricultural production has stagnated or declined for the past two decades, despite the fact that fertilizer consumption has expanded nearly three-fold [6].

Plant disease diagnosis and treatment, as well as timely and effective pest control, are crucial for increased productivity. As a result, rapid climatic change has occurred. Global warming, in particular, has increased the incidence of illnesses and pests. Each year, around 4-14% of Bangladesh's rice yield is lost due to the use of various insect pests. Due to the high temperatures and humidity in Bangladesh, brown spot disease is mostly seen on rice leaves. This disease mostly affects crops between the seedling and milky stages, which is the most crucial period. As a result, it causes a loss in both quality and quantity [7]. However, the technology for identifying and treating this kind of disease is severely poor [6].

The papers contain useful studies into Bangladeshi agriculture practices in order to determine the necessity for automation via a Precision Agriculture or Smart Farming system. According to existing agricultural research in Bangladesh, high energy intensity, misapplication of natural resources (e.g., irrigation water, minerals), excessive use of inorganic fertilizers, and an absence of domain-specific knowledge and technology support the reduction of agricultural production. In addition, the proper implementation of a precision agriculture or smart farming system using linked technologies is cited as a feasible solution to all of the agricultural challenges stated [8]. Therefore, from these papers, it is easily understandable why research on a comprehensive model of a precision agriculture or smart farming system is justified in today's Bangladesh.

1.1.3 Literature Gap

In Bangladesh, most of the work done on this issue is theoretical, and not much has been achieved practically. So, all the research and inventions never reach the people who actually use them: the farmers and government officials. Therefore, we must provide farmers with a technology-intensive coordinated distributed system in order to assure fast, reliable, and authentic utilization of knowledge and resources for increasing agricultural productivity. However, a system of this scale requires wirelessly interconnecting heterogeneous components and a high-performance cloud service to conduct the algorithm. Precision Agriculture, or Smart Farming, is an 'information-intensive' field that would not be possible without massive developments in networking and computing capacity. However, in Bangladesh, one of the major challenges to achieve such developments in these fields, is the lack of datasets. The areas that need to be developed further, are the area of sensing and mapping systems that can offer linked data on crop, soil, and environmental aspects in order to better estimate agricultural output and detect diseases.

1.1.4 Relevance to Current and Future Industry

People are less interested in farming and agriculture these days. Despite the fact that agriculture continues to be Bangladesh's most important source of employment, accounting for 14.2% of GDP in 2017 and employing 42.7 percent of the workforce. Even in the early years of the millennium, this figure was close to 80% to 85%. People are living rural regions in pursuit of new employment possibilities, yet our food needs are expanding in tandem with our population. As a result, we are moving toward automated farming and agricultural system. According to the paper, "Internet of Things (IoT) and Agricultural Unmanned Aerial Vehicles (UAVs) in Smart Farming: A Comprehensive Review," the Internet of Things (IoT) and Unmanned Aerial Vehicles (UAVs) are two popular farming technologies that are bringing in a new era of precision agriculture by transforming conventional farming practices. These technologies have the potential to not only solve the problem of limited manpower but also boost crop yield. Irrigation, fertilization, pesticide use, weed management, plant growth monitoring, crop disease management, and field-level phenotyping are some of the applications of UAV technology in smart agriculture. The development of unmanned aerial vehicles with autonomous flight control, as well as lightweight and powerful hyperspectral snapshot cameras capable of calculating biomass development and fertilization status of crops, has paved the way for advanced farm management guidance. These two essential technologies have transformed traditional agricultural techniques into a new level of intelligence in precision agriculture in recent years. The agriculture sector is now gaining traction, since digitalization has significant potential to benefit both farmers and consumers [9]. These technological improvements are necessary for the technological revolution that will result in major changes in agricultural operations [10].

Precision Agriculture or Smart Farming, is crop management concepts that can help arable agriculture meet many of the increasing environmental, economic, market, and public challenges. Most agricultural businesses will have adopted the concept on a whole-farm basis by the end of the decade. As a result, creating a UAV based system is well-suited to our time.

1.2 Objectives, Requirements, Specification and Constraints

1.2.1. Objectives

The goal of our project is to monitor rice crops from an area of approximately 10,000 square meters, so we have chosen Purbachal China Town, Dhaka. Mainly, we have developed a UAV system according to the size of the field which can capture images of the crops. With the help of image processing, we have extracted the data for crop disease detection.

In our project, one of our goals is to choose the fertilizer based on the data gathered by the sensors. And as we are also capturing images, we can further monitor the deficiency based on the symptoms. The fertilizer will be chosen independently based on nitrogen deficiency symptoms such as small and pale leaves, yellowing, and color distinction of leaves; deficiency of potassium symptoms such as growth reduction and crooked or distorted grain; and phosphorus deficiency symptoms such as weak stems and roots, low yields, and so on [11]. After detecting the deficiency, we can select the required fertilizers that are needed for rice crops, such as urea, di-ammonium phosphate (DAP), and muriate of potash (MoP). Next, we will be able to determine what the crops require based on whether the growth is adequate or not or whether they need any additional efforts to improve production.

Another goal of our project is to detect rice crop diseases such as brown spot, which is common in South-East Asia due to the climate. To detect brown spot disease, we have used Deep Learning or Machine Learning methods using Google Colab and ResNet152 V2. After acquiring images in our system, this algorithm can help us detect whether the crop leaf is healthy or has a brown spot.

By knowing the condition of the soil and detecting diseases like brown spots, it is easier to monitor and do analysis of crop growth.

1.2.2 Functional, Non-functional Requirements and Specifications

Table 1: Specification: System & Component Level

	System Level	Component Level
Functional	UAV System (Depending on the area that we want to monitor – 10,000 square meters)	• LiPo Battery 2200mAh 11.1V 3S • DJI 2212 920kv Brushless Motor 1CW & 1CCW (4x) • DJI Phantom 3 9450 Self-tightening Propellers • 30A RC Brushless Motor Electric Speed Controller (4x)" • KK2.1.5 flight controller • Frame F450
	Image Processing System	• Cloud server (Google Drive) • Google Colab
	Hardware Systems for Image Capture	• ESP32 Camera (Arduino IDE) • ESP8266
	Soil Moisture & Mineral Data Collection System	• NPK Sensor • Soil Temperature Sensor • Air Temperature and Humidity Sensor
	Algorithm Development for Prediction and Disease Detection	• Keras ResNet152 V2
Non-functional	Spraying and Seeding System	• Servo Motor • Water Pump

Component Details

Table 2: Component Details

Components	Details	Purpose
Li-Po Battery 2200mAh 11.1V 3S	Maximum Output Voltage: 11.1V Charging Capacity: 2200mAh Cell Type: Lithium polymer Configurations: 3S Discharge Rate: 25C Maximum Burst Rate: 90C Output Wire Length: 0.1m Temperature Range for operation: -20°C to 60°C	Power Supply to the prototype

DJI 2212 920kv Brushless Motor 1CW & 1CCW	Voltage Rating: 920kv Shaft size: 0.8cm Weight: 0.056kg (with Propeller Adapter) Standard Current flow: 15A-25A Maximum Current flow: 30A Dimension: 7 x 5 x 1.25 in Maximum Power: 370W Maximum Thrust: 1200g	Powerful and durable motor for generate enough thrust to counteract the weight
DJI Phantom 3 9450 Self-tightening Propellers	Dimensions 9.4 x 1.25 x 0.39 inches Item Weight 1.28 ounces	To provide lift for the aircraft by spinning
30A RC Brushless Motor Electronic Speed Controller	Package Dimensions 7 x 4 x 0.05 inches Weight 23g	To adjust and control the speed of the UAV's electric motors
KK2.1.5 Flight Controller	Size: 50.5mm x 50.5mm x 12mm Weight: 21 grams (Inc Piezo buzzer) IC: Atmega644 PA Gyro/Acc: 6050MPU InvenSense Inc. Input Voltage: 4.8-6.0V AVR interface: standard 6 pin. Signal from Receiver: 1520us (5 channels) Signal to ESC: 1520us	To control the motion and detect movement of the UAV, as well as user commands
Frame F450	Item part number TL-26096 Item Weight 290 g	To carry & protect the delicate electrical components from harm
DHT22 Digital Temperature Humidity Sensor Module	Temperature Range: -40 to 80℃ Temperature Accuracy: ±0.5% Humidity Range: 0 to 100RH Humidity Accuracy: ±2%	It helps us to measure the Environment temperature and humidity.
ESP8266 NodeMCU V3 Development Board with CH340	Power input: 4.5V ~ 9V (10VMAX), USB-powered Transfer rate: 110-460800bps Support UART / GPIO data communication interface Support Smart Link Smart Networking Working temperature: -40°C ~ + 125°C Drive Type: Dual high-power H-bridge Flash size: 4MByte Lowest cost WI-FI	To be used as a microcomputer for DL & transmit data to cloud servers.
ESP32- Cam with Camera Module OVA2640	Sensor: OVA2640 Resolution: 2MP, 1600*1200 Lens Size: ¼”	Provide a way to get images from different angles of the crops.

NPK Sensor	Measurement range: 0-199 mg/KG Measurement accuracy: +-2%F. s Resolution: 1mg/KG (mg/L) Response time (T90, s): less than 10 Operating temperature: 5 to 45°C Working humidity: 5 to 95% (relative humidity), no condensation Baud rate: 2400/4800/9600 Communication port: RS485 Power supply: 5V-24v DC Sensor line length: 1.2 meters	It assists in determining the soil's fertility, allowing for an assessment of the soil's state by detecting the amount of phosphorus, nitrogen and potassium.
Capacitive Soil Moisture Sensor	Working voltage: 3.3 ~ 5.5V DC Output voltage: 0 ~ 3.0V DC Interface: PH2.54-3P Size: 10*2.3cm/3.9*0.9in Weight: Approx.11g/0.4oz	For Soil moisture data collection
Waterproof DS18B20 Digital Thermal Probe	Power Supply: 3.0V ~ 5.5V Resolution: 9 ~ 12 adjustable Temperature range: -55°C - +125°C.	For Soil temperature collection
Power Bank	5000 mAh - 160g	To supply power in ESP8266 & ESP32 cam.
ResNet152V2	ResNet-152 V2 is a 152-layer deep convolutional neural network, ResNet has substantially improved the performance of neural networks due to the large number of layers. We can load a pre-trained version of the network from the ImageNet database that has been trained on over a million photos and can categorize images into 1000 object categories. It has 60.4 million parameters. It has the highest Top-1 and Top-5 accuracy among the ResNet models.	For Identifying the pre-trained value.

[12][13]

1.2.3 Technical and Non-technical Consideration and Constraint in Design Process

Technical Consideration

- Have to consider the stability.
- Using a better-quality camera
- Availability of the components
- A good internet connection
- Huge quantity of data sets.

Non-technical Consideration

- Having an experienced pilot.

- Legal permission.
- Getting permission from the land-owner.
- Financial issues.
- Undesirable weather conditions.

Constraints in the Design Process

- **Prototype:** We have used an ESP32 camera and an ESP8266 processor unit. For this reason, we are not able to get accurate clear images for disease detection and could not see live streams or run any algorithms for diseases detection or fertilizer selection on board. Moreover, we have faced another constraint for using the KK2.1.5 flight controller and so have met some difficulties in making the device stable.
- **Economical:** Initially our budget was fifteen thousand takas altogether but we were not capable of completing the project within this amount. Because we could not find any alternative, we increased it to 20,000 Taka and borrowed NPK sensor instead of purchasing it.
- **Availability:** We met some barriers on the availability of the products due to COVID-19 crisis. So, we had to revise the components frequently.

1.2.4 Applicable Compliance, Standard, and Codes

To develop this project, we have to maintain some IEEE Standards:

Table 3: Applicable Standards and Codes

Device/ Technology	Standard Code	Standard Name	Standard Details
Wi-Fi Module	IEEE 802.11n-2011	IEEE Standard for Information technology– Telecommunications and information exchange between systems Local and metropolitan area networks-- Specific requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications	The IEEE 802.11n standard was first established to provide a high degree of performance for the time. This standard was created with the aim of providing much better performance and keeping up with the continually increasing speeds like Ethernet type technology
Cloud Server	IEEE 2301-2020	IEEE Guide for Cloud Portability and Interoperability Profiles (CPIP)	Standards-based decisions in application interfaces, portability interfaces, management interfaces, portability interfaces, file formats and operation conventions are advised for cloud computing ecosystem participants (e.g., cloud vendors, service providers and users). These are divided into numerous logical profiles that are organized to

			distinct cloud roles.
Image Processing	IEEE 610.4-1990	IEEE Standard Glossary of Image Processing and Pattern Recognition Terminology.	Image processing and pattern recognition are defined by this glossary that are currently in use. For such concepts, standard definitions have been created.
UAV (Drone)	IEEE 1936.1-2021	IEEE Approved Draft Standard for Drone Applications Framework	This standard establishes a framework for drone application support. It gives the details of drone application and scenarios as well as the essential application execution environments. The flight platform, flight control system, ground control station, payload, control link and data link, takeoff and landing system are needed for general requirements of drone application. Airworthiness, airspace, air traffic requirements, qualification of operators, qualification of personnel, insurance, and confidentiality are among the drone safety and management demands. The general operation procedure are like the operation results include data classification, data collection and processing, data record and analysis and data reference format, which are all stated in the operation record and report.
	IEEE 1937.1-2020	IEEE Standard Interface Requirements and Performance Characteristics of Payload Devices in Drones	The requirements for general interfaces and performance characteristics of payload devices in drones are addressed. The drone payload interfaces can be categorized by three categories: mechanical interface, electrical interface, and data interface. The payload is attached to the drone using a mechanical interface. An electromechanical device that connects electrical terminations is known as an electrical interface which includes the power supply interface and the two-way communication interface. The communication protocol is referred to as the data interface. The drone payload interface's requirements and performance characteristics are defined in terms of high temperatures, humidity, water, dust, vibration/shock, mold, salt deposits, and so on. Standard UAV payloads, interface requirements, and unique payload performance parameters are depicted.

	IEEE 1939.1-2021	IEEE Standard for a Framework for Structuring Low-Altitude Airspace for Unmanned Aerial Vehicle (UAV) Operations	Standards-based options like application interfaces, portability interfaces, management interfaces, interoperability interfaces, file formats and operating conventions are advised for cloud computing ecosystem participants such as cloud vendors, service providers and mostly for users. These options are divided into some logical profiles that organize to distinct cloud roles.

1.3 Systematic Overview/Summary of the Proposed Project

As we have already mentioned, the selection of fertilizers and the system for disease detection are now manual processes. If we want to automate this process, we must concentrate on making it efficient, usable, and maintainable. In this project, we have to focus on some separate parts.

Unmanned Aerial Vehicle

Primarily, an unmanned aerial vehicle is needed to fly around the field to collect all the images and data. It will work as a carrier for the data and image collection units.

Data Collection from Sensors

The primary goal of this subsystem is to collect data from the field using suitable sensors, such as soil moisture, soil temperature, day temperature and humidity, and NPK level. The ESP8266 microcontroller is used to acquire and transmit this sensor data.

Image Capturing Using a Camera

The main goal of this subsystem is to use the camera to capture field images. We require precise and close-up photos of the crop for disease detection. The use of an ESP32-Cam allows the collection and transmission of these photos.

Storing Data and Images on a Cloud Server

At this point, the ESP8266 and ESP32 use a Wi-Fi module to transmit the sensor data and photos to the cloud server (Google Drive). As a result, the user can utilize a mobile application to view all the data on the cloud server.

Autonomous Fertilizer Selection

In this portion, we will compare the acquired NPK data with the standard NPK value of soil provided by the Bangladeshi Ministry of Agriculture. Following the comparison, the mobile application will automatically suggest which type of fertilization is needed in that field.

Disease Detection Using Deep Learning

Finally, in this phase, we will use the ESP32-Cam images, which have already been stored on the Google Drive. The remaining portion will be processed by ResNet-152 V2, a 152-layer deep convolutional neural network. Because ResNet has so many layers, neural networks now perform significantly better. The ImageNet database contains a pre-trained version of the network that can categorize photos into more than a thousand item categories and has been trained on more than a million images. This will enable us to identify the rice leaves' condition.

1.4 Conclusion

For the nations of Southeast Asia, which includes Bangladesh, smart farming is a new chapter. If properly executed, it has a very high success rate. People with a direct or indirect connection to agriculture will profit. Due to the loss, they experience and the risk they must take to continue making a living from this industry, many people are abandoning it every year. By offering ways to get nourishing food and protect crops from severe harm, our initiative can potentially assist to lessen this issue and establish a healthier farming community.

Chapter 2

Project Design Approach [CO5, CO6]

2.1 Introduction

The goal of our project is to monitor crops from an area so we have chosen Purbachal China Town, Dhaka and we are focusing on rice. We have multiplicity in designing because we intend to build a prototype to fulfill our tentative objectives. Here we find three probable designs for the problem's solution. These are the Unmanned Aerial Vehicle (UAV) model, the Unmanned Ground Vehicle (UGV) or Rover model and Hybrid UAV-UGV model.

2.2 Identify Multiple Design Approach

Design 01: Using Unmanned Aerial Vehicle (UAV) Model or Drone Model
Design 02: Using Unmanned Ground Vehicle (UGV) Model or Rover Model
Design 03: Using Unmanned Aerial Ground Vehicle (UAGV) Model or Hybrid Model

2.3 Describe Multiple Design Approach

Design 01: Using Unmanned Aerial Vehicle (UAV) Model or Drone Model

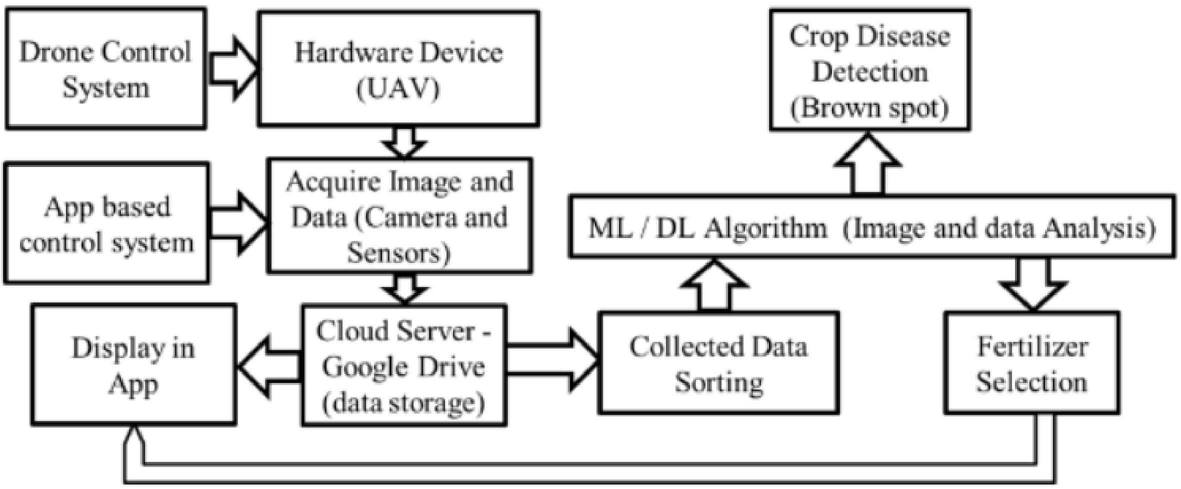


Fig.1: Block Diagram of UAV

In the UAV model, a drone is incorporated to capture images and collect data from the field and it is the heart of our proposed project. These images are shown on the screen of our app Blynk. These data are automatically stored in a cloud server (Google Drive). After that, it is used to analyze and process the data using a Machine Learning/Deep learning Algorithm. By using those data, we can detect the disease. From analyzing those images and the values of the sensors, anonymously fertilizer selection will be shown. By these, we can say that we will be able to reach our aim.

Design 02: Using Unmanned Ground Vehicle (UGV) Model or Rover Model

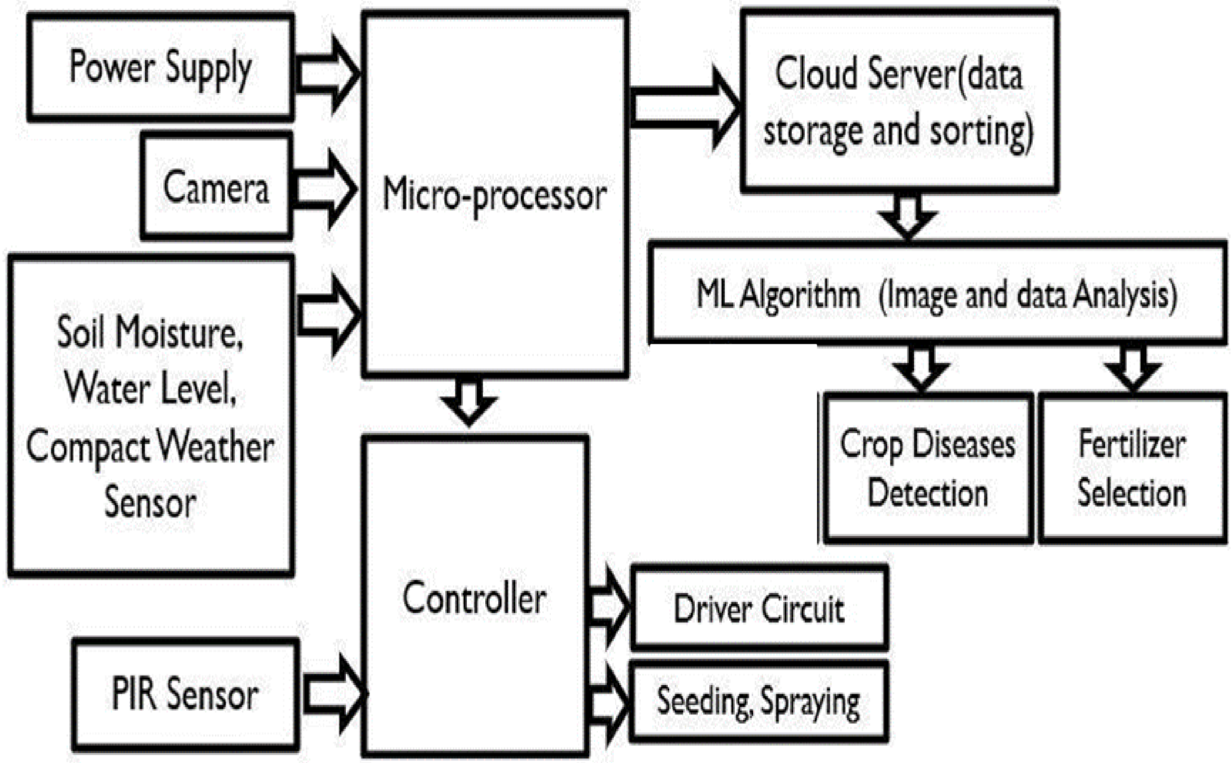


Fig. 2: Block Diagram of UGV

The basic function of the UGV model is similar to the UAV model. However, a rover is used to capture images and collect soil data such as soil moisture, soil temperature, water level, and so on by driving it around the field. The data from the rover is sent to a cloud server, where they are saved and sorted. A machine learning-based algorithm is implemented for disease detection and fertilizer selection. We may add some other feathers to the UGV model, such as seeding, water level indicating and spraying insecticide or fungicide etc. This model's image capture process will be more accurate, but it will take a long time compared to the UAV model.

Design 03: Using Unmanned Aerial Ground Vehicle (UAGV) Model or Hybrid Model

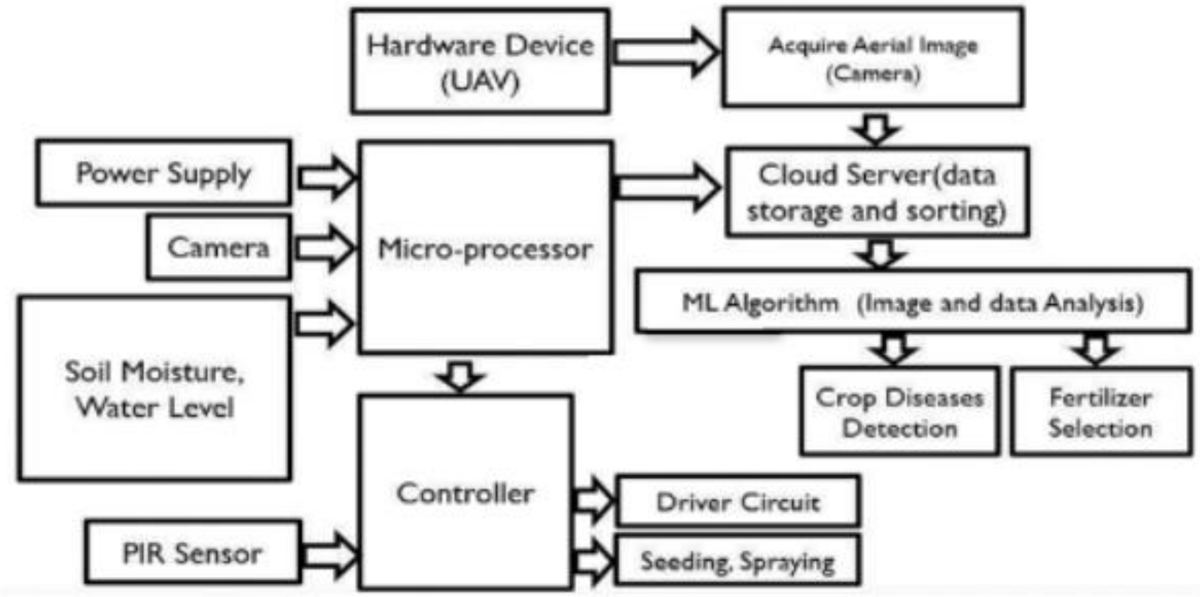


Fig. 3: Block Diagram of Hybrid Model

In the UAV-UGV Hybrid model, the drone is incorporated to capture images of the field and send them to a cloud server, where they are saved and sorted there. A machine learning-based algorithm is used to detect disease and select fertilizer. A rover will be used to capture close images and collect soil data such as soil moisture, water level, water moisture and so on by driving it around the field. The data from the rover is sent to the same cloud server. Some other features can also be added to this model, such as seeding, water level indicating, spraying insecticide or fungicide, etc. using the rover. This model's image capture process will be not only more accurate but also faster but implementing it for us is a huge challenge since it is still under theoretical research.

2.4 Analysis of Multiple Design Approach

Here we have done the comparative analysis between our multiple design approaches that is shown in the table below:

Table 4: UAV vs. UGV vs. UAGV

Basis	UAV	UGV	Hybrid UAGV
Motion Speed	High speed	Low speed	Medium speed as both model is used for different purposes
Image Capturing Speed	Faster	Slower	Medium speed as both model is used for different purposes

Observation and Range of Detection	Large scope of observation, medium detection range	Small field of view, short detection range	Large scope of observation and detection range
Communication Range and Ability	Due to their higher altitude, UAV communication links are less obstructed by obstructions. Excellent communication capability	Limited communication range due to line of sight, obstacles, etc. Weak communication ability	Communication is harder as coordination is needed between UAV and UGV
Image Capturing Ability	Can capture images from different directions	90-degree vision	Can capture images from different directions
Accuracy	Low observation accuracy	Precise observation	Precise observation
Problematic Characteristics	Have trouble standing in a static position when there are strong winds.	Can damage crops on the way	Dealing with info from two different platforms is very hard
Working Duration	Because of the limitation of carried energies, UAVs are restricted by the short flying time	Can work for much longer period as power source can be added easily	Can work for much longer period as power source can be added easily
Technical Complexity	High	High	Very High
Control	Harder	Easier	Very Hard
Sustainability	High	High	High
User Comfortability and Level of Interaction	Lower	Higher	Lowest
Cost-Effectiveness Analysis	Higher	Lower	Lowest

As can be observed from the table above, both image capture and motion speed are faster in UAVs than in IUGVs. O m the other hand, since there is some advantages of altitude and communication links for UAV, UGVs face more blocked by the around obstacles. When it comes to image capture, the UGV can capture precise pictures; however, it can't take pictures from diverse angles due to its 90-degree vision. UGVs can damage crops on their route, despite the fact that managing them is easier and user comfort is higher than UAVs. UGVs can work for longer periods of time; however, UAVs are more cost-effective than UGVs. Apart from these, both models have a high level of technological intricacy and sustainability [14] [15] [16].

Our third design approach is the hybrid UAGV model, and it is a well-known fact that the UAGVs are effective at completing a variety of challenging tasks due to the combination of high heterogeneity and complementarity between UAVs and UGVs in speed, functions, dynamics, sensing communication and so forth. It is noticeable that there has not been much research on the coordination of ground and aerial platforms. This combination is still in the theoretical research phase and there are several technical barriers that must be quickly removed to bring related research from theory to practice. The research on UAGVs is more difficult in the sense of previous studies of UAVs or UGVs as that research was focused on one side. When it comes to deal both of the two very distinct platforms, the work has to be done very carefully. [15]

2.5 Conclusion

Multiple design approaches have been chosen in such a way in order to fulfill our objectives that we must require. Here we have chosen three different designs and found out that each one has its own advantages and disadvantages in obtaining our requirements or goals. Lastly, we will choose the most optimal design to pursue our desired objectives to be fulfilled.

Chapter 3

Use of Modern Engineering and IT Tool. [CO9]

3.1 Introduction

An engineer must possess the ability to use the latest engineering tools, techniques, and skills required for engineering practice. Since they produce more effective results, contemporary engineering tools must be used by engineers in order to accomplish projects. Our best method was designed, and in order to validate it, we needed some hardware and software tools. Analyzing both the hardware and the software is necessary to get the full result.

3.2 Select Appropriate Engineering and IT Tools

The below are the software and hardware tools that we have decided to utilize for our design.

1. **Software Tools:**
   - MATLAB- SIMULINK
   - Proteus 8 Professional
   - Arduino Integrated Development Environment (Arduino IDE)
   - Fritzing
   - Blynk
   - Google Colab
   - SolidWorks
2. **Hardware Tools:**
   - NPK Sensor
   - Air Temperature and Humidity Sensor
   - Capacitive Soil Moisture Sensor
   - Soil Temperature Sensor
   - GPS Module
   - Servo Motor
   - ESP8266 Development Board
   - ESP32-cam
   - 3D Printer

3.3 Use of Modern Engineering and IT Tools

MATLAB- SIMULINK

To develop our Simulink model, we used MATLAB-Simulink. For simulating dynamic systems and modelling, Simulink is a graphical editor. For further analysis, algorithms of MATLAB can be assimilated into models and export simulation results as Simulink is combined with MATLAB. This graphical extension to MATLAB comes with a variety of toolboxes. The toolboxes are function libraries made with the MATLAB technical computing environment. We utilized the UAV toolbox because design, simulation, testing and deployment tools and reference applications for Unmanned Aerial Vehicle (UAV) and drone applications are included in the UAV toolbox [17].

Proteus 8 Professional

Proteus 8 professional was used to simulate our UGV model and image processing system. This software can be used to create schematics, code, and simulate the schematics, allowing us to replicate our work, debug easily and complete the assignment more efficiently. We picked Proteus not only because it has a huge variety of components based on the real environment, but it also has the greatest real-time display effects. Proteus supports several common single-chip models and generic peripheral models. Its dynamic simulation is based on frames and animation; thus, the visual effects are excellent which fulfills our requirements [17].

Arduino Integrated Development Environment (Arduino IDE)

We have used Arduino IDE to write code to control our microcontroller. In Arduino Integrated Development Environment (IDE), a text editor for writing code, a toolbar with buttons for common functions, a text console, a message area and a number of menus are all inclusive. Arduino IDE is also known as Arduino Software.

Fritzing

Fritzing is an open-source project to develop amateur or hobby CAD software for the design of electrical devices, with the purpose of enabling designers and artists to produce more sturdy circuits from prototypes. Our PCB was designed using this tool.

Blynk

Blynk is an Internet-of-Things platform for iOS or Android smartphones that allows users to remotely operate devices like Arduino, Raspberry Pi, and NodeMCU. To create a graphical interface or human-machine interface (HMI), one can compile and deliver the correct address on the various widgets using this application. It can store data, visualize it, display sensor data, remotely control hardware, and perform a variety of other tasks. The Blynk App enables users to construct amazing project interfaces using a variety of available widgets and all communications between the smartphone and hardware are handled by Blynk Server [21]. By the app we can capture images and also this app can suggest whether one should use more fertilizer or not.

NPK Sensor

For fertilizer selection, we opted to use the NPK sensor. The NPK Soil Sensor can be used to quickly determine the soil's nutrients level. Soil contains Nitrogen, Phosphorus and Potassium, which are all significant elements for crop health. So, understanding soil nutrient concentrations can help us figure out if the soil is nutritionally insufficient or rich. In order to assess how much more nutrient content should be given to the soil to increase crop fertility, the concentrations of N (Nitrogen), P (Phosphorus), and K (Potassium) in the soil must be measured. The NPK sensor can be buried in the soil for a long period of time and it does not require any chemical reagents. Because of its high measurement accuracy, quick response time, and interchangeability, it can be used with ESP8266. It features a high-quality probe with rust and electrolysis resistance to assure long term functioning. It can be employed in a variety of soil conditions and it can identify alkaline soil, acid soil, substrate dirt, seedling bed soil, and coconut bran soil, making it the perfect choice for our fertilizer selection purpose [18].

Air Temperature and Humidity Sensor

Among the most often employed environmental sensors are those for temperature and humidity. Occasionally, hygrometers are used to refer to humidity sensors. The actual air humidity state at any given position or location is provided by these devices. The DHT22 is a basic digital temperature and humidity sensor. Without the requirement for analog input ports, it measures the humidity and temperature of the air around it using a thermistor and a capacitive humidity sensor, and it outputs a digital signal on the data pin. DH22 has a temperature range of -40 to 80°C, temperature accuracy of 0.5 percent, and humidity range of 0 to 100 percent RH, humidity accuracy of 2 percent [19].

Capacitive Soil Moisture Sensor

The water content of the soil is measured by soil moisture sensors, which can also be used to calculate the quantity of water that has been retained in the soil layer. Soil moisture sensors do not directly detect soil water since the direct gravimetric measurement of free-soil moisture necessities the removal, drying, and weighing of a sample. Instead, they track changes in some other soil characteristics that are linked to water content, like electrical resistance, the dielectric constant, or neutron interaction, and use those measurements as a stand-in for moisture content [20].

Soil Temperature Sensor

Numerous soil and soil ecosystem functions are impacted by temperature. Photosynthesis, respiration, soil water potential, soil translocation, and microbiological activity are all impacted by soil temperature. Designs for soil temperature sensors using thermistors, thermocouple wires, and averaging thermocouples are available. Some units of measurement, for example, °C, °F, and °K, can be converted from the electrical signals sent from the sensors to our data loggers.

One-wire programmable temperature sensors like the DS18B20 are frequently used to monitor temperature in challenging situations like soil. Installing the sensors is simple because it’s enclosure is sturdy and has the option to be waterproof. It can measure a wide range of temperatures, from -55° to +125°, with an acceptable precision of 5°C. It is a wonderful way for taking several temperature measurements without using a lot of digital pins of microcontroller’s because each sensor has a unique address and only requires one MCU channel to transport data.

GPS Module

The Global Positioning System (GPS) is a satellite-based system that calculates and measures its position on Earth using ground stations and satellites. A GPS module is typically a small board on which the GPS sensor and other parts are attached. In addition to the GPS module, a GPS receiver also has a data display and other parts, like a memory for storing data, GPS modules contain a small processor and antennas that are used to automatically receive data from satellites via appropriate RF frequencies. The data it receives after then will come from a variety of sources, including timestamps from all observable satellites. If the antenna of the module can identify more than four satellites, it can precisely compute its location and time. Our GPS Module is connected to the ESP8266 control board.

Servo Motor

A rotary actuator or linear actuator that provides for precise control of angular or linear position, velocity, and acceleration is known as a servo motor. It is made consisting of a suitable motor connected to a position feedback sensor. A self-contained electrical device, servo motors are a component of closed-loop control systems and rotate machine parts with high precision and efficiency. An analog or digital electrical signal is applied to the motor to control the amount of movement which corresponds to the ultimate commanded position of the shaft. A gear system-based motor housing has the circuit incorporated right into it. This motor’s output shaft has the ability to move at an angle, location, and speed that a typical motor cannot. A conventional motor is used by the servo motor, and it is connected to a sensor to provide position feedback. We have used the servo motor to control the position of the camera.

ESP8266 Development Board

The ESP8266 is a low-cast Wi-Fi microchip that has microcontroller and TCP/IP networking software capabilities built in. This tiny gadget enables microcontroller to join Wi-Fi networks and establish straightforward TCP/IP connections. The module's extremely cheap price and the fact that there were few external components on it hinted that its final volume pricing would be very low. The ESP32 family of gadgets has replaced these microcontroller chips.

ESP32-cam

The ESP32 family of system on chip microcontrollers features integrated Wi-Fi and dual-mode Bluetooth and is inexpensive and low power. It is an ESP-32 based, low power requirement, compact camera module. It comes with an inbuilt TF card slot and an OV2640 camera. Numerous clever IoT applications, including wireless video monitoring, Wi-Fi picture upload, QR identification, and others, can make use of the ESP32-CAM. The lens on this camera has a diameter of 1/4" and has a resolution of 5MP at 1600 x 1200.

3D Printer

Computer-aided design, or CAD, is a technique known as 3D printing that builds items layer by layer. In today’s manufacturing and automotive industries, 3D printers are regularly utilized to create tools and parts. Compared to conventional production techniques, 3D printing makes it possible to create complicated shapes with less material. We used SolidWorks to design our payload and use 3D printer to build the payload.

Google Colab

Google Colaboratory, also known as Colab, is a web-based IDE for Google Research's Python product that was published in 2017. Colab is a fantastic platform for data scientists to utilize to execute Machine Learning and Deep Learning projects by using cloud storage. Colab is basically a free Jupyter notebook environment running in the cloud and that cloud part differentiates it from Jupyter. On the other hand, Colab does not requires a significant setup, and the notebooks create can be maintained collaboratively by the team members using the same way that people edit documents in Google Docs. The most significant advantage is that Colab supports the most popular machine learning libraries which can be easily loaded into one’s notebook. As we all know Google Colab is a great choice but sadly it has its own limitations too like- Closed Environment, no Live-Editing, limited Space & Time etc. [22].

SolidWorks

For generating mechatronic systems, we apply SolidWorks from the starting to end. Project management, planning, visual creation, modeling, feasibility assessment, and prototyping are the primary application of the software. Following that, the program is applied to design and build mechanical, electrical, and software components. Besides, cloud services, analytics, supervision, device management, and the data automation can also be done by this software. Utilizing templates and CAD library, the 3D CAD design is simple but sophisticated. It also helps speed up the process via automation and design reuse. Designers may test their designs with SOLIDWORKS Simulation to quickly and precisely spot any faults. With the help of extremely accurate data, the designer will be able to make adjustments to the design before an actual prototype is made [23][24].

3.4 Conclusion

To conclude, the whole point of engineering is to find solutions to issues that are practical. We have familiarized ourselves with all the tools, techniques, and skills that are essential for process engineering practices. Even though the hardware and software tools we chose have their own restrictions, we are able to use them to their fullest potential.

Chapter 4

Optimization of Multiple Design and Finding the Optimal Solution. [CO7]

4.1 Introduction

To make it easier for us to select the best design solution from the many available options, we have set certain rating criteria. The rating takes into account the performance of the objective task, cost effectiveness, usability, manufacturability, and maintainability. On the other hand, in order to optimize the various designs covered in the preceding chapter, we also kept in mind the use of modern engineering tools. To see the potential final designs, we first constructed simulation models for each design method. In addition to the hardware models, we have also taken into account a variety of approaches for the disease detection aspect.

4.2 Optimization of Multiple Design Approach

Here, we are going to discuss some important factors which are needed for our project. To fulfill our objectives, we need to collect soil data, our images have to be clear and fine, we have to keep in mind the limitation of budget, manufacturability, usability maintainability, speed, control, accuracy and so on. Before optimizing the design, it is obvious to run some test cases in software which will help to decide the best model for our proposed project. Below are the simulation models for our design approaches.

4.2.1 Multiple Design Solutions for Hardware and CNN Models

Model 01: <u>Unmanned Aerial Vehicle (UAV)</u>

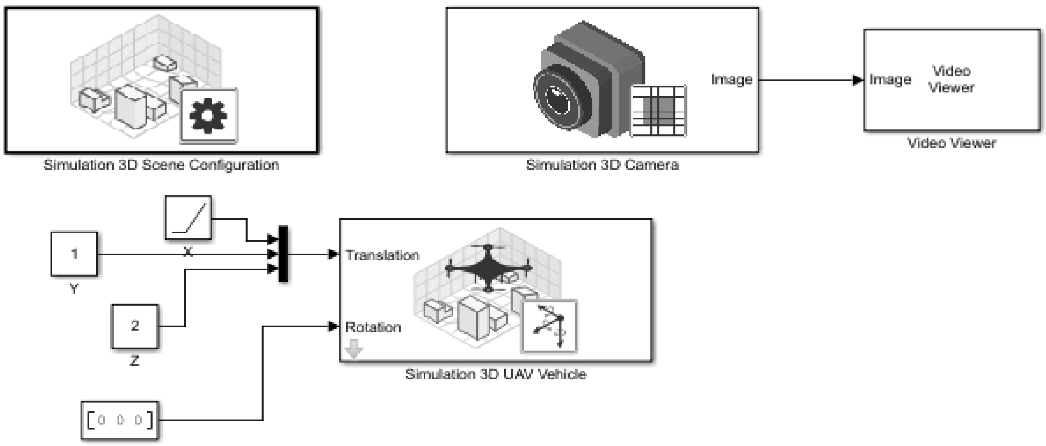


Fig. 4: Simulation Model of UAV

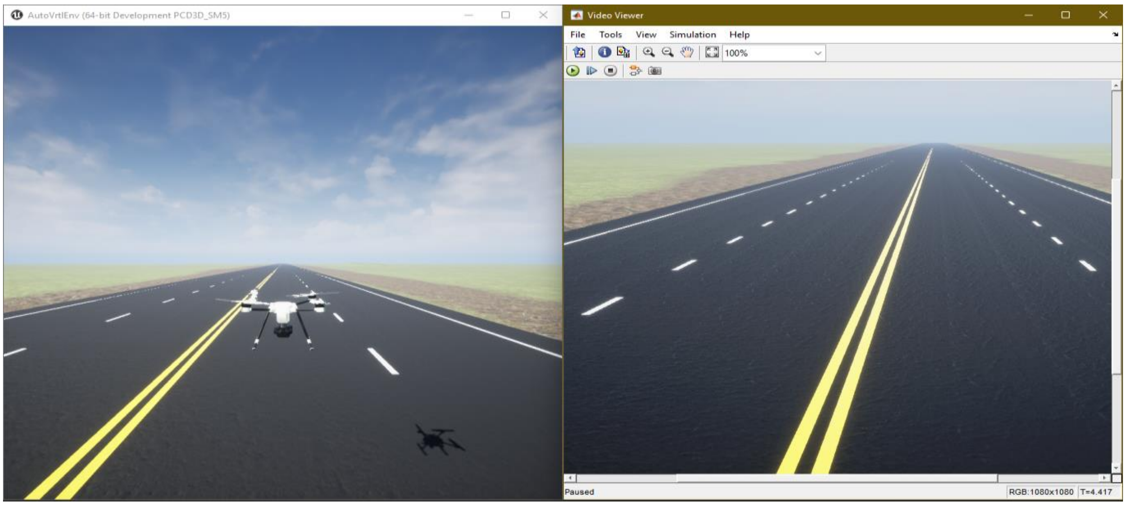


Fig. 5: Simulation Result of UAV Model

Our UAV model has been created in MATLAB to simulate. It is basically a 3D simulation of an UAV vehicle. In this model we gave some inputs like ramp inputs and certain constants as translation and rotational inputs which are mostly given for the moving control of UAV. In the simulation 3D camera, we put a set of relative translation and rotation, mainly the angle of observation from which we need our required data. Also, the given Simulation 3D scene configuration setting was a challenge for us because MATLAB has some built-in configuration so we could not change the environment as we wanted to take data from a crop field.
After simulation we can see the results in another window (Fig.5) from the unreal engine viewer, we can see our UAV is moving forward and the video viewer gives us a view of camera data. So, we have got our result that UAV has a larger scope of observation than UGV.

Model 02: Unmanned Ground Vehicle (UGV)

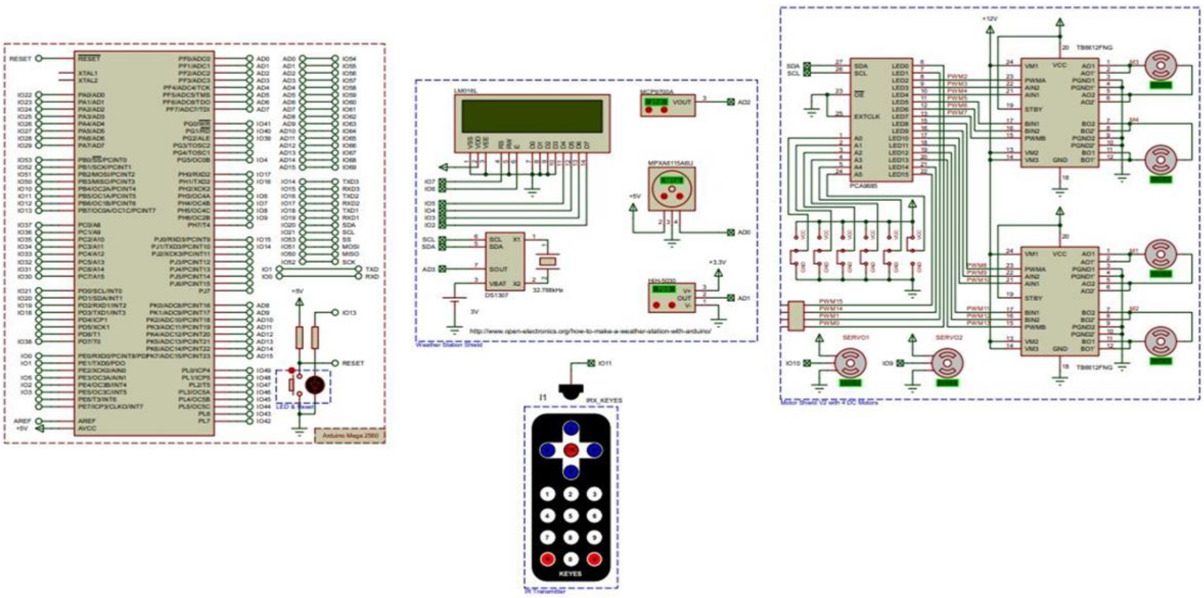


Fig. 6: Simulation Model of UGV

In Proteus, we designed our UGV design. Because the Proteus library for the Raspberry Pi does not include all of the essential sensors, we chose an Arduino mega as our microcontroller. Pressure, temperature, and humidity sensors are all part of the sensor system. However, because the NPK sensor is not included in the Proteus library, it is absent. We have a driving unit consisting of a motor controller, a DC motor, and a servo motor that gives us a sense of how the rover moves and how fast it moves. Finally, there is a remote control for operating the rover and an LCD display for viewing sensor data. We were unable to successfully simulate this model due to a lack of necessary libraries.

Model 03: Unmanned Aerial Ground Vehicle (UAGV)

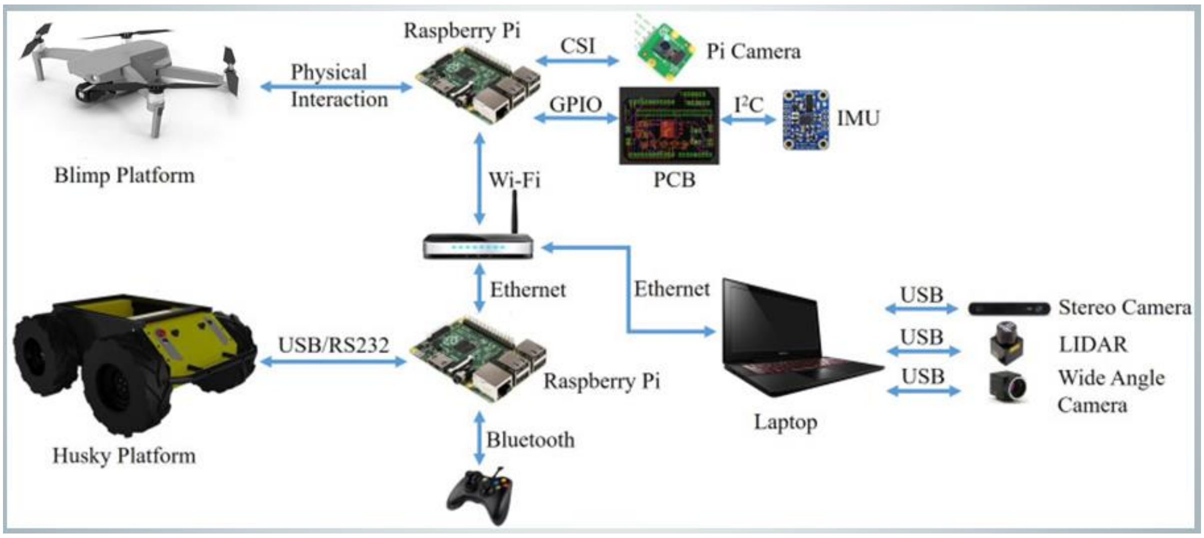


Fig. 7: Design of UAGV

As we previously indicated, research on cooperative control of aerial and ground systems is uncommon. We can see that the entire procedure is fairly complicated. The procedure became more difficult due to the necessity to deal with data from two entirely separate platforms while also effectively coordinating the actions of two systems. Existing studies are still in the theoretical research stage; thus, we could not present a realistic simulation of this model.

Payload Design in Fritzing:

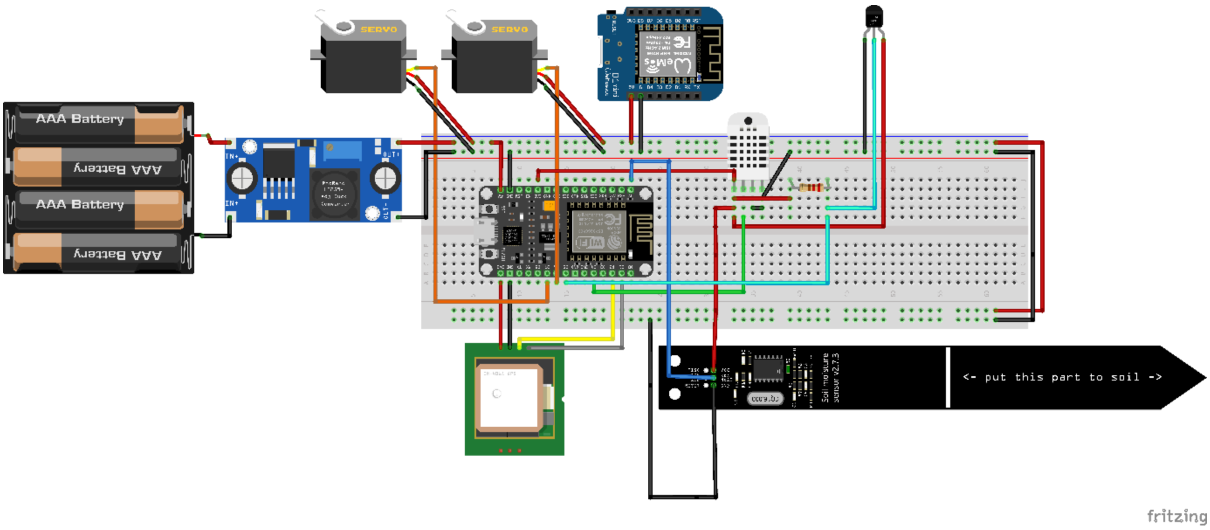


Fig. 8: Image Capturing and Data Collection Unit

Then, in Fritzing, we have developed image and data processing unit. There is soil temperature, soil moisture, day temperature, day moisture sensors in the breadboard which will collect the data. Then, there is also an ESP-32 camera attached which will capture images and for the processor unit, we are using ESP-8266 where every data will be stored and processed. From these stored data, we will continue the selection of fertilizer through Blynk app and the disease detection part through ResNet152V2 which are explained later.

Keras Models for Disease Detection

ResNet50, ResNet152V2, and InceptionV3 are the three models we have taken into consideration for disease diagnosis. These are all CNNs, or Convolutional Neural Networks. A Convolutional Neural Network (CNN) is a form of artificial neural network that is specifically made to process pixel input and is used in image recognition and processing.

4.2.2 Optimization of the Design

Choosing the Camera Device:

Capturing images for disease detection is one of our prototype's main objectives. For a comprehensive analysis, we require high-quality photos. For our final solution we have decided to use an ESP-32 camera and it has 2MP, 1600*1200 resolution. Even though there are so many better-quality cameras than ESP-32, the reason behind choosing this is, those are either expensive for us or they are unavailable in market.

Disease Detection:

For autonomous disease identification, we require a model that will give the most accurate result. We have gotten the best result with the ResNet152 V2 CNN model with the activation method ‘Sigmoid’ and with an epoch of 10 and batch of 16.

Cost Efficiency:

The unmanned aerial vehicle is the least expensive of the three versions in terms of price, costing between twenty to sixty thousand takas. Moreover, we have decided to use the ESP8266 Development Board which is cheaper in price and also used cheap sensors to keep the price in an affordable range.

4.3 Identify Optimal Design Approach

4.3.1 Identifying the Optimal Hardware Model

We have had some discussion on theoretical ideas, simulations and test cases among our multiple designs. After that, we have chosen design 1, which is the design using unmanned aerial vehicles, as our optimal design based on the below mentioned criterion.

Simulation Result Analysis:

We were unable to compare the models using our simulation models because the UGV and the hybrid models were either too complicated or the software lacked some of the components we needed to finish the simulation. Because the UAV model was the only one, we could simulate properly, we may conclude that it is the one that actually operates. Moreover, this simulation design is capable of fulfilling our objectives: disease detection, fertilizer selection and growth monitoring of crops.

Image Quality:

Capturing images for disease detection is one of our prototype's main objectives. For a comprehensive analysis, we require high-quality photos. Unmanned aerial vehicles are able to capture images from various angles and are faster. This model is capable of capturing high-quality photos for crop growth monitor and disease detection. The unmanned ground vehicle can record high-quality photos for disease identification, but it only has a 90-degree field of vision, limiting its ability to estimate agricultural yields. The hybrid unmanned aerial ground vehicle, on the other hand, can capture great image quality for these two missions [25][26].

Disease Detection:

For autonomous disease identification, we require closer and clear images of the crop. The unmanned ground vehicle and the hybrid unmanned aerial ground vehicle are both capable of capturing high-quality photos for disease detection as they are moving on the ground but they can damage crops of thin leaves. Generally, the unmanned aerial vehicle flies at a higher altitude. To acquire high-quality photos for disease detection, we need to bring them closer to the ground which needs an expert pilot.

Cost Efficiency:

The unmanned aerial vehicle is the least expensive of the three versions in terms of price, costing between twenty to sixty thousand Taka. On the other hand, unmanned ground vehicles cost between sixty and seventy thousand Taka. Because of the sophisticated design and component requirements, the hybrid unmanned aerial and ground vehicle cost more than one lakh seventy thousand taka. When it comes to task completion, the unmanned aerial vehicle can complete all of our requirements in a short amount of money and time, which is why we can say it is the most cost-effective option.

Motion Speed and Control:

Controlling the device and speed are principal points. For capturing images and collecting data fast, the device must have to be higher in speed; on the other hand, it has to be stable. If it can take good pictures but takes a lot of time, it will be totally useless. Unmanned aerial vehicles are higher in speed and moderate to control if there is an expert. To be mentioned, we are preparing this project for not the general people. We expect that, this prototype will be available in every village or union, and an expert will be there to fly it. Unmanned ground vehicles are much lower in speed but easier to control. Hybrid model is medium in speed since both models are used, but very hard to control for the user. It is basically not user-friendly.

Manufacturability, Usability and Maintainability:

As previously said, the unmanned aerial vehicle requires fewer components than the other two versions, making the prototype cheaper and easier to manufacture. Despite its complexity, it can also be a good answer if we focus on other criteria and gain expertise in controlling unmanned aerial vehicles. On the other hand, the hybrid unmanned aerial ground vehicle has the capability to fulfill the needed duties, but its system design is complex and its components are expensive. Stakeholders face a significant problem in maintaining and controlling this prototype [27].

Soil Data Collection:

In order to work on the autonomous fertilizer selection, our prototype must collect various important and valuable data from the soil, such as, soil moisture, soil temperature, humidity, Nitrogen, Potassium and Phosphorus deficit.

We have used a soil moisture and temperature sensor, an NPK sensor for this task. The NPK sensor has three independent pins that must be pushed into the soil with force. The sensor collects all the necessary data and stores it in a memory device. The sensor operates properly in unmanned ground vehicles, and hybrid unmanned aerial ground vehicles [18]. Still in unmanned aerial vehicle, we are using it by manually putting it into the soil, so that we can fulfill a feature like selecting the fertilizer autonomously.

We can state this after careful analysis of all theoretical and simulation comparisons. Among the three designs, the unmanned aerial vehicle model is the most promising and optimal for us, as it matches our required needs and specifications, as well as our objectives, while retaining cost efficiency, maintenance, and usability because others are so costly and not budget-friendly. But there are some limitations. Due to budget issue and unavailability, we could not manage good processor, so our prototype is not that much stable to take clear pictures for disease detection from near the leaves. Rather, we are manually holding the UAV and taking clear pictures from the ESP-32 camera which is adjusted in UAV as it stays stable in higher altitude. Again, we are forcefully putting the sensors in the soil to have data since sensors attaching in the UAV cannot easily go inside to the soil and take data.

4.3.2 Identifying the Optimal CNN Models:

InceptionV3 has 48 layers, ResNet152 has 152 layers, and ResNet50 has 50 layers. Processing is divided by scale in Inception before being merged and repeated. ResNet has a more straightforward, single-scale processing unit with connections for data pass-through. ResNet generates 2,048 features per image compared to 1,536 for Inception. ResNet introduces the skip connection (also known as shortcut connection) to seamlessly fit the input from on layer to the next. The ResNet152V2 is the most accurate of the three models in terms of Top-1 and Top-5 accuracy as well as number of parameters, as shown in the table below. [28]

Table 5: Comparison between CNN Models

Model	Size (MB)	Top-1 Accuracy	Top-5 Accuracy	Parameters	Depth	Time (ms) per inference step (CPU)	Time (ms) per inference step (GPU)
ResNet50	98	74.9%	92.1%	25.6M	107	58.2	4.6
ResNet152V2	232	78.0%	94.2%	60.4M	307	107.5	6.6
InceptionV3	92	77.9%	93.7%	23.9M	189	42.2	6.9

Also, while performing experiments on these models, we have gotten the best result with ResNet152V2.

4.4 Performance Evaluation of Developed Solution

We chose some criteria on which to judge the effectiveness of our generated solution. These criteria allow us to compare the performance of our various designs. UAVs can take very good and high-quality photos that would be used for disease detection, however, UGVs and UAGVs cannot be used for properly capturing images for disease detection, according to simulation results. Also, the availability of components for UAVs is pretty much higher rather than the components of UGVs and UAGVs. Besides, UAVs can be a cost-effective solution as components used in UGVs and UAGVs are not available in our region. Moreover, in our project controlling the device is a big part of accomplishing our objective so in that case, UAVs can be user friendly than UGVs and UAGVs. As an outcome, we concluded that

UAVs will be a better fit for our project since, unlike UGVs, they can be utilized for both crop yield prediction and disease detection, and they will be much easier to manage than hybrid UAGVs.

4.5 Conclusion

To sum up, our design 1 is the best system which can work properly if we can consider time and budget. We have figured out all the necessary points which are needed to make the system. We have clearly shown all the good sides as well as all the drawbacks later in the report. We have also shown the alternatives of the drawbacks which are really needed to complete our task in chapter 10. After all the discussions, we can say, our design 1 will be viable to fly smoothly and can capture images from a higher altitude.

Chapter 5

Completion of Final Design and Validation. [CO8]

5.1 Introduction

In our project, we had two tasks: the hardware implementation of the UAV and the analysis of the data that was acquired. Prior to working on our image dataset, we created and implemented our hardware prototype. We attempted to follow a methodical and logical process at every stage of this project in order to achieve our goal, and we encountered several issues that were resolved in the same logical way.

5.2 Completion of Final Design

5.2.1 Hardware Implementation

Before developing the payload for our hardware prototype, we constructed the UAV body. To estimate the relevant measurements, such as how much weight our device would need to carry, etc., we first acquired all the components we would need. After that, we assembled the components. The images below display the various parts of the UAV.

UAV Payload

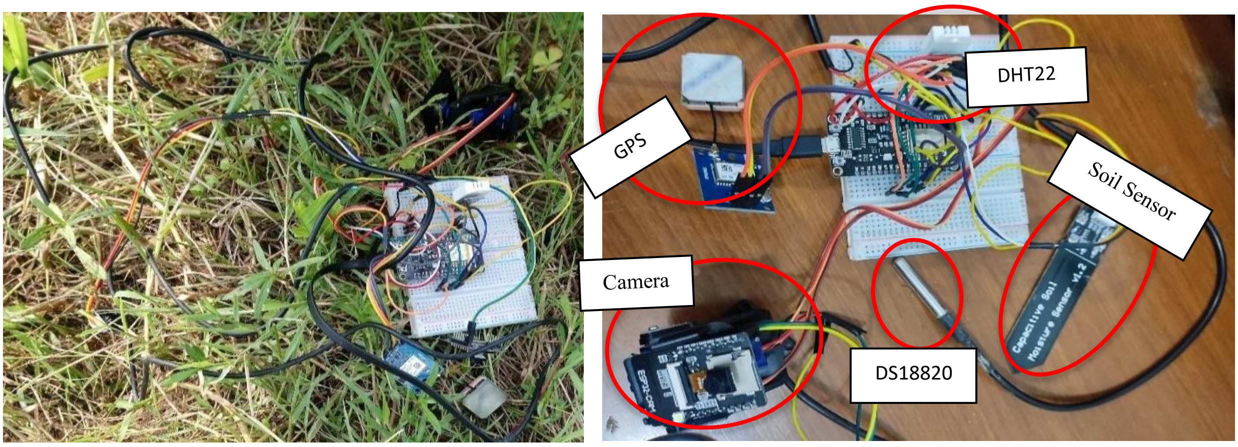


Fig 9: Breadboard model of Image & Data Collection Unit and test run of the model

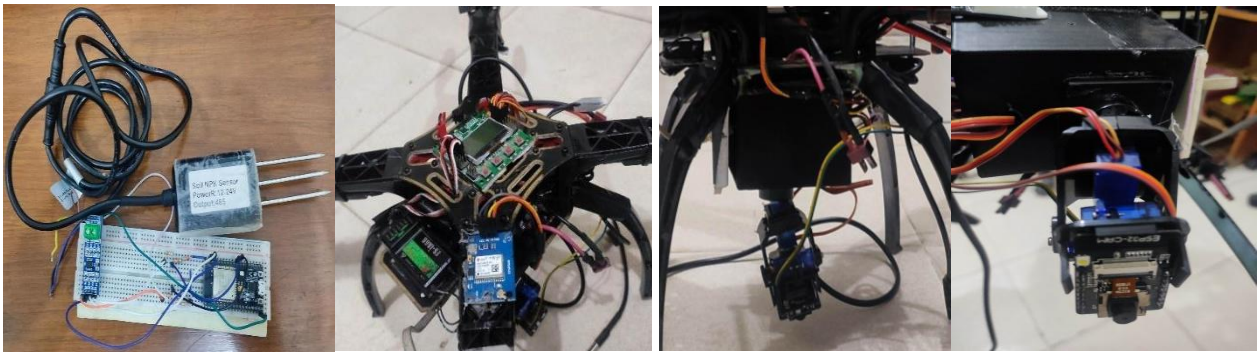


Fig. 10: NPK Sensor, Flight Controller, Image and Data Collection Unit and Camera Module

UAV Body

Fig. 11: UAV from Different Angles

The problem with our UAV was that, it was not fully capable of capturing images from a close range. Whenever we took our UAV closer to the field, it created a strong wave of air because of the propellers and the pictures were either blurry or not clear enough for further image processing. Also, the propellers of the UAV were cutting the leaves, which were damaging the crops. Below, we have a few pictures taken by the UAV.

We have captured images using the UAV, but as it can be clearly seen from the below pictures that, using these images are not really suitable for our dataset because for disease detection we need very precise images.

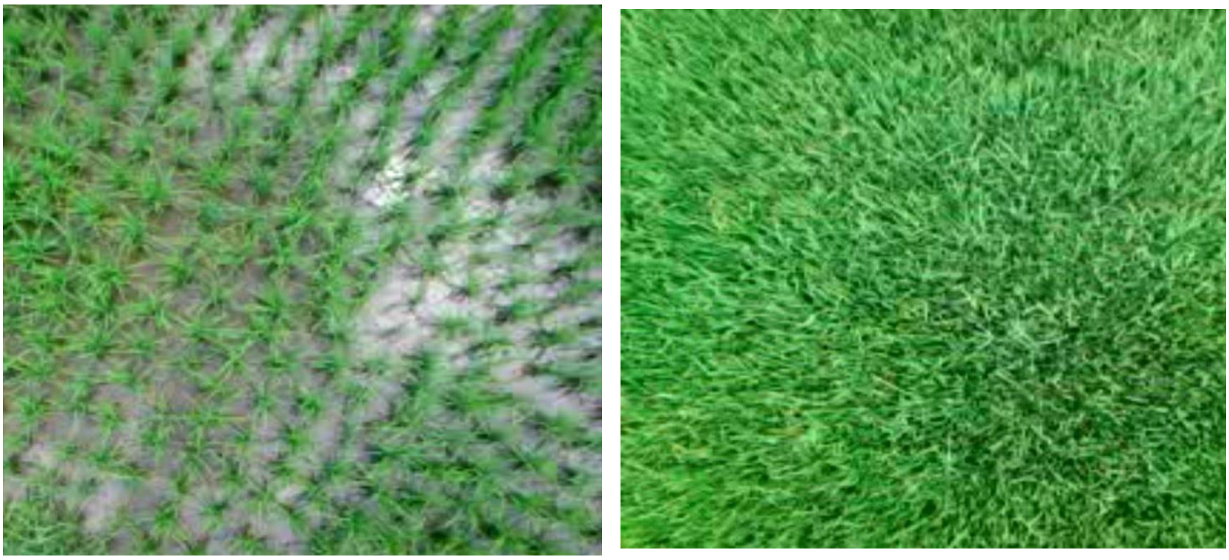


Fig. 12: Images Captured by the UAV while Flying

So, we have decided to take pictures using our UAV camera when the UAV was not flying, which are basically the images that we would have gotten if our UAV could go near the field. Below are the pictures that we have used in our dataset. We have collected images from May to August in different days, so we have images of crops in different stages of life cycle.

Fig. 13: Images Captured Manually by the UAV Camera

5.2.2 Analysis of Collected Data

In 7 days (July 27, August 5, 13, 17, 20, 24, and 29), we collected a total of 205 samples using the sensors in Purbachal China Town (Latitude-23.87° and Longitude- 90.51°). On those days, we have collected 15, 15, 30, 35, 20, 45 and 45 samples, respectively. (All the collected data are attached in the appendix section)
In the following part we will see the sensor output vs. sample graph.

NPK Sensor:

NPK stands for nitrogen, phosphorus, and potassium; therefore, the sensor will tell us the NPK data for our soil sample. The three straight lines (yellow, green and sky-blue) in this sample represent the standard range for nitrogen-163 mg/Kg, phosphorus-59 mg/Kg, and potassium-69 mg/Kg in milligrams per kilogram. which indicates the standard deviation's mean value. The levels of fertilizer in those samples are indicated by the other three lines. Here, the nitrogen level is represented by the blue line, the phosphorus level by the orange line, and the potassium level by the ash-colored line.
This demonstrates, the nitrogen level was initially within the normal range, but the phosphorus and potassium levels were excessive. As a result, our prototype advised avoid applying fertilizer that is enriched with phosphate and potassium, and after a few days, we discovered that the level of these two nutrients had decreased. Additionally, it advised farmers to use fertilizer as soon as the level dropped.

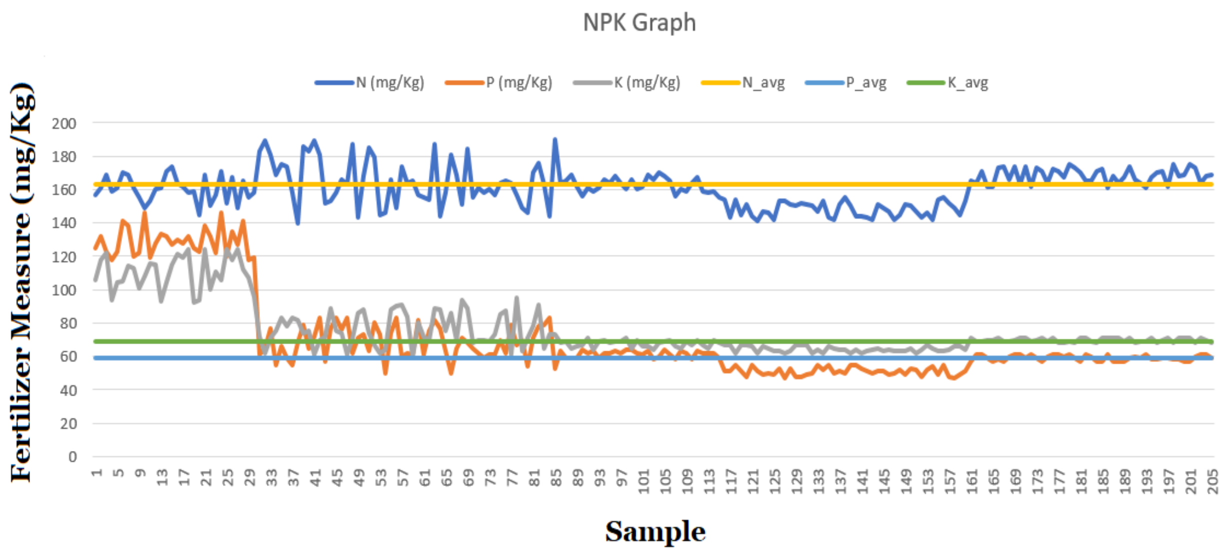


Fig. 14: Graph for NPK Sensor

Temperature Sensor:

The graph shows that the majority of the sample's temperature ranges between 34°C and 38°C. The growth of yield is significantly influenced by temperature.

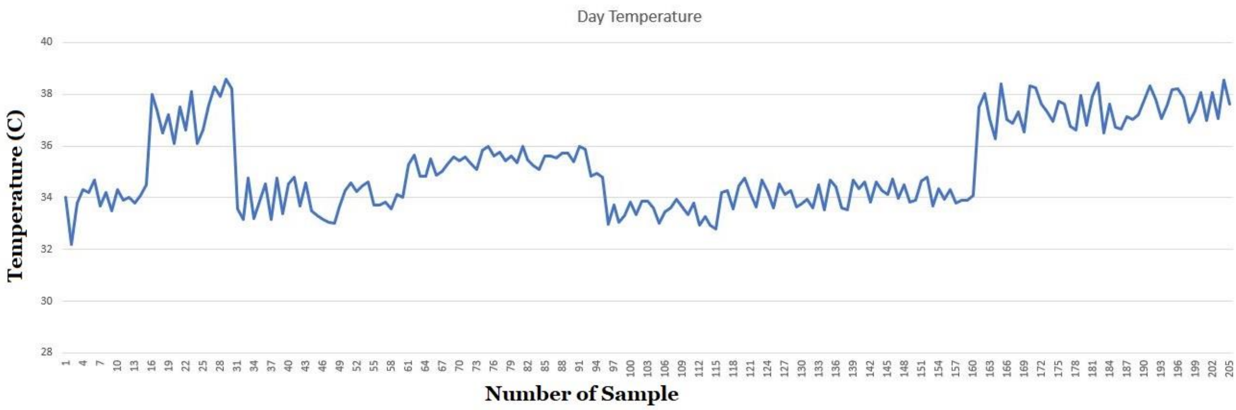


Fig. 15: Graph for Day Temperature

Soil Moisture Sensor:

The graph indicates that the soil sample's moisture content was mostly between 97% and 100%. The yield will decrease if the soil's upper surface is not sufficiently moistened.

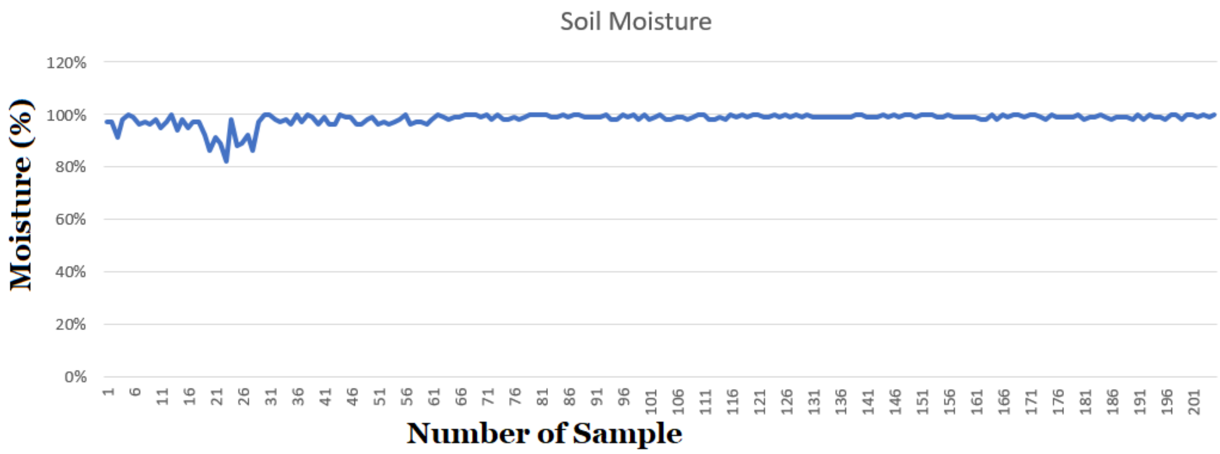


Fig. 16: Graph for Soil Moisture Sensor

Soil Temperature Sensor:

The graph shows that the temperature range of the soil sample was primarily between 31°C and 33°C. The rice plant needs more water if the soil's top surface temperature rises.

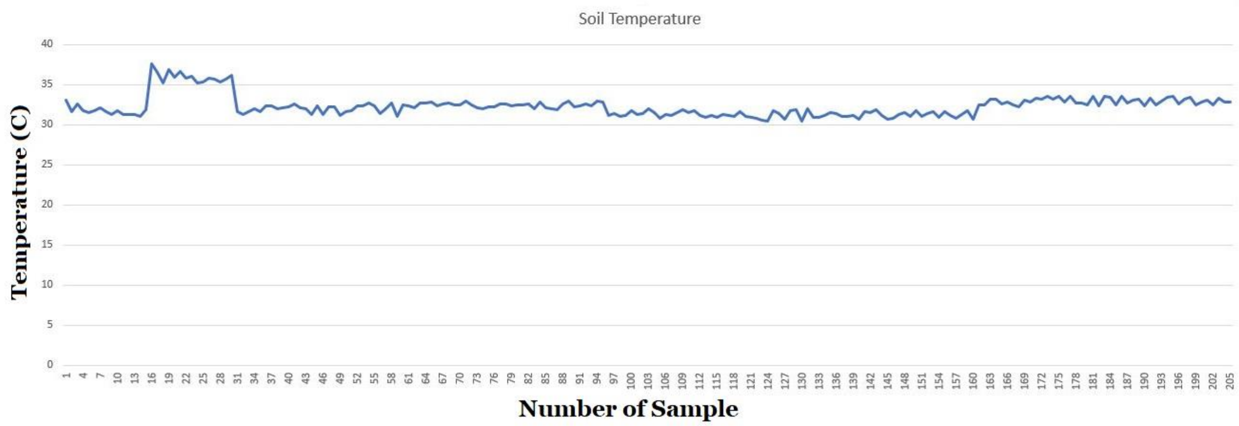


Fig. 17: Graph for Soil Temperature Sensor

These are all the sensors output in graphs.

Fly-time Calculation:

When the UAV fly with is full load, the full system consumes an amount of current which is denoted as I_{cons} . For our system Maximum draw of current is I_{cons}: 9.45A

The Battery Capacity is C: 2200mAh for our system

So, The Maximum Fly time $t_{fly} = \frac{C}{1000} \cdot \frac{1}{I_{cons}} \cdot 60 = \frac{2200}{1000} \cdot \frac{1}{9.45} \cdot 60 = 13.96\, min \approx 14\, min$

Fig 18: UAV Test Run

5.2.3 Algorithm Analysis

Disease Detection

For disease detection, we have used ResNet152V2 model and our dataset (images taken with the UAV camera) for training and testing and we have used Google Colab for coding.

Methodology

Import the libraries

- Open Google Colab and create a new notebook for coding
- Import Drive, keras and tensorflow
- Import ConfigProto and InteractiveSeesion and set values
- Import necessary libraries: ResNet152V2, Preprocess Input, Image Data Generator, image, np, glob and matplot etc.

Preparing the dataset

- Resize the image to 224*224 resolution
- Import ResNet152V2 library and ImageNet
- Don't train the existing weights
- Set activation function Softmax and create model object
- Show the structure of the model

Fitting the model to attributes

- Set the loss function, metrics and optimizer
- Use Image Data Generator to import images and use data augmentation
- Set the training set and testing set, set the target size as the image size, batch size and class mode. Then fit and run the model with a set epoch

Plotting and loading model

- Plot the train loss vs validation loss and train accuracy vs validation accuracy
- Import load model and save it as a h5 file
- Apply the model on test set and show the array
- Import numpy, image and load model

Uploading image and validating it

- Upload the image file and reshape and process it.
- Predict the image data and show it as an array
- Identify the leaf's condition
- Show the result

Setting Values for Parameters

We have utilized data augmentation as our dataset is relatively small. In order to enhance the performance and generalizability of the model, image data augmentation is employed to increase the training dataset. By using random (but accurate) changes like scaling, flipping, rotating, cropping, padding etc. data augmentation increases the diversity of the training set. It strengthens the model and improves performance while assisting in addressing problems like overfitting and data shortages. Using the Keras preprocessing layers, we can augment the data. This is offered in the class ImageDataGenerator of tf.keras.preprocessing.image. We have used trial-and-error methods and set the values for data augmentation.

For our algorithm, we must now set two critical hyper-parameters: batch size and epochs. The number of training samples used in a single iteration is referred to as the "batch size" in machine learning. On the other hand, an epoch means training the neural network with all of the training data for a single cycle. Every piece of information is used exactly once during an epoch. A pass consists of a forward pass and a backward pass combined and each epoch consists of one or more batches in which we train the neural network using a portion of the dataset.

We must keep in mind when choosing the batch size that models with larger batch size are more likely to overfit, which results in generalization gaps that are wider than those produced by models with smaller batch sizes that can successfully function over untested examples. To fully utilize the processing capabilities of the GPUs, the number of batch sizes should be a power of 2. Normally, it is advised to test lower batch sizes initially in order to find the ideal batch size (usually 32 or 64). There are two primary uses for smaller batch sizes: smaller batch sizes have a regularizing impact and a smaller generalization error because they are noisy. Furthermore, it is simpler to fit a batch's worth of training data in memory with smaller batch sizes.

We choose the batch size and the epoch numbers for our algorithm using the trial-and-error method to avoid overfitting. A model that has been overtrained on the specifics of the training data is said to be overfit (when the model learns the noise in the dataset). On new, untested data, an overfit model will not perform well. So, we experimented with batch sizes of 16, 32, 64 and 128 and found that the batch size of 64 produced the best result. All of the other situations produced inconsistent findings, with large fluctuations in our loss values.

For better understanding, we have provided samples of the graphs here. It is clear from the graphs how much better the 64-batch size performs than the other values. The graph of 64-batch size displays a nearly steady rise in accuracy and a steady fall in loss, in contrast to other graphs that show oscillations in both accuracy and loss and hence cannot prove the linearity of the trend.

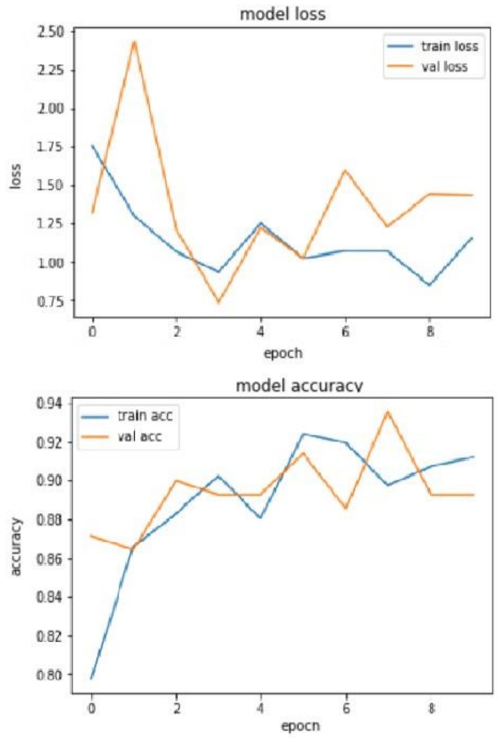


Fig. 19: Batch Size: 16, Training Accuracy: 91.22%, Validation Accuracy: 89.29%.

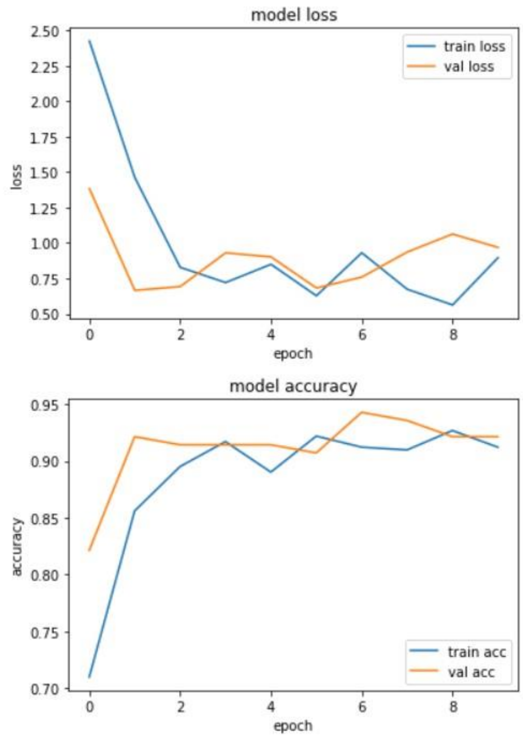


Fig. 20: Batch Size: 32, Training Accuracy: 91.22%, Validation Accuracy: 92.14%.

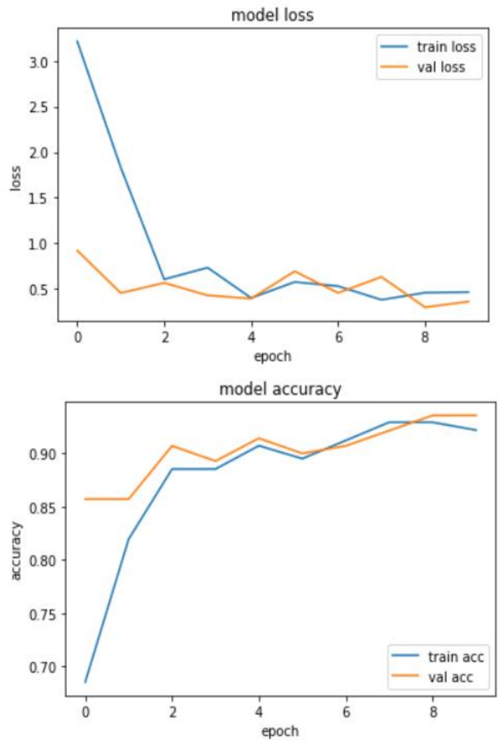


Fig. 21: Batch Size: 64, Training Accuracy: 92.20%, Validation Accuracy: 93.57%.

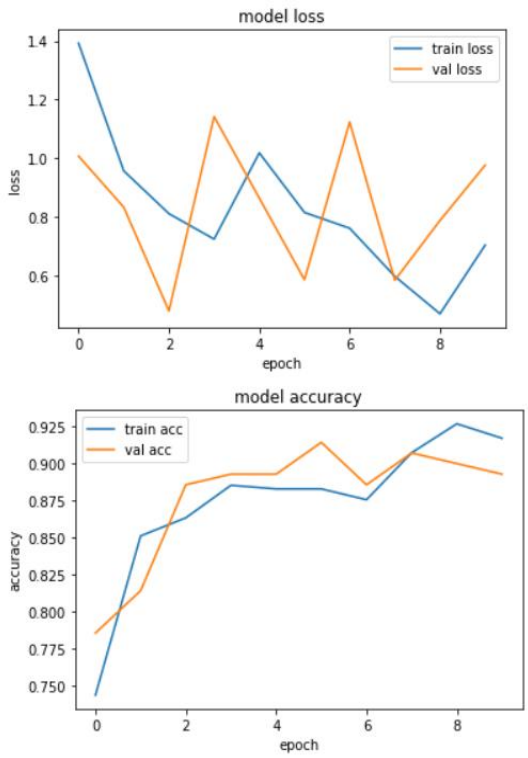


Fig. 22: Batch Size: 128, Training Accuracy: 91.71%, Validation Accuracy: 89.29%.

When setting the value for epoch, we need to consider the fact that too many epochs may cause the training dataset to get overfitted, while too few may cause the model to become underfit. Early stopping is a technique that lets us provide an arbitrary large number of training epochs and end training when the model's performance on the validation dataset stops advancing.

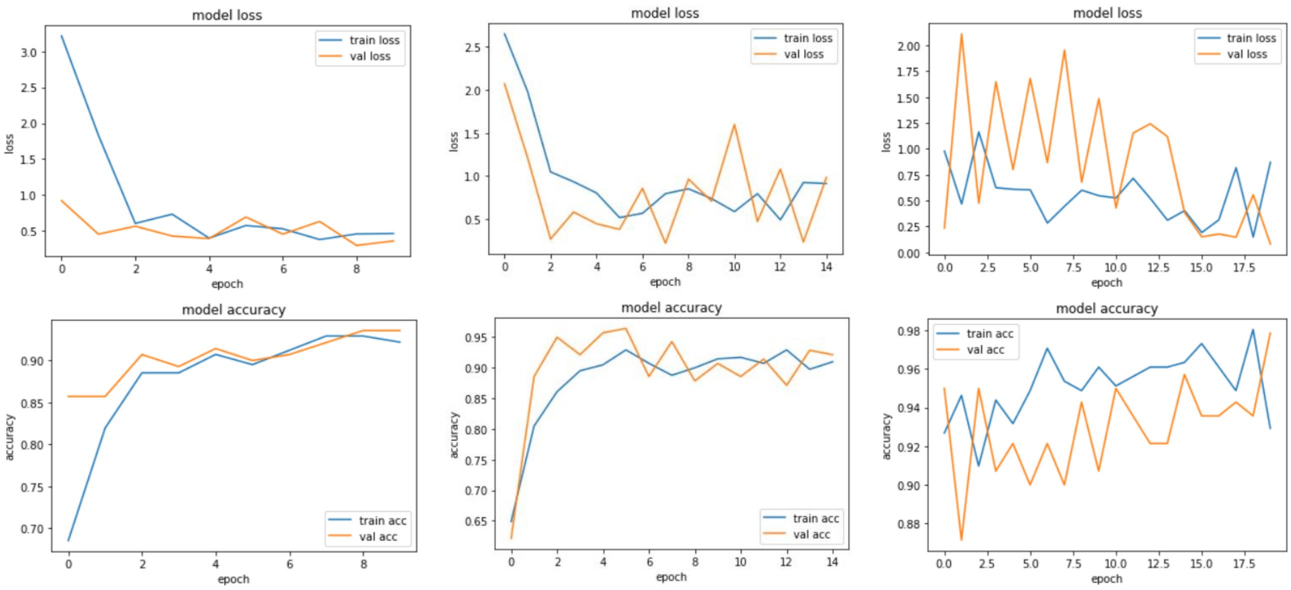


Fig. 23: Epoch 10, Epoch 15 and Epoch 20

We have experimented with epochs of 10, 15, 20 etc. Setting the number to 15 or 20 caused the accuracy and loss to fluctuate which indicates overfitting. The best result was obtained when 10 epochs were employed and we have seen that the last few epochs provide a stable result for accuracy and loss values which is enough to understand the trend of the dataset.

Therefore, we have chosen 64 as our batch size and 10 as our epoch number, as these values gave us the best results. Below we have shown the final training accuracy and validation accuracy as well as the training loss and validation loss after we have run the model.

```
[1023] # Fit the model
       # Run the cell

       r = model.fit_generator(
         training_set,
         validation_data=test_set,
         epochs=10,
         steps_per_epoch=len(training_set),
         validation_steps=len(test_set)
       )

       /usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:9: UserWarning: `Model.fit_generator` is deprecated and will be remove
         if __name__ == '__main__':
       Epoch 1/10
       7/7 [==============================] - 21s 2s/step - loss: 3.2139 - accuracy: 0.6854 - val_loss: 0.9209 - val_accuracy: 0.8571
       Epoch 2/10
       7/7 [==============================] - 9s 1s/step - loss: 1.8326 - accuracy: 0.8195 - val_loss: 0.4553 - val_accuracy: 0.8571
       Epoch 3/10
       7/7 [==============================] - 9s 1s/step - loss: 0.6055 - accuracy: 0.8854 - val_loss: 0.5662 - val_accuracy: 0.9071
       Epoch 4/10
       7/7 [==============================] - 9s 1s/step - loss: 0.7333 - accuracy: 0.8854 - val_loss: 0.4292 - val_accuracy: 0.8929
       Epoch 5/10
       7/7 [==============================] - 10s 1s/step - loss: 0.4004 - accuracy: 0.9073 - val_loss: 0.3940 - val_accuracy: 0.9143
       Epoch 6/10
       7/7 [==============================] - 9s 1s/step - loss: 0.5757 - accuracy: 0.8951 - val_loss: 0.6936 - val_accuracy: 0.9000
       Epoch 7/10
       7/7 [==============================] - 9s 1s/step - loss: 0.5304 - accuracy: 0.9122 - val_loss: 0.4562 - val_accuracy: 0.9071
       Epoch 8/10
       7/7 [==============================] - 9s 1s/step - loss: 0.3808 - accuracy: 0.9293 - val_loss: 0.6318 - val_accuracy: 0.9214
       Epoch 9/10
       7/7 [==============================] - 10s 1s/step - loss: 0.4586 - accuracy: 0.9293 - val_loss: 0.2988 - val_accuracy: 0.9357
       Epoch 10/10
       7/7 [==============================] - 9s 1s/step - loss: 0.4654 - accuracy: 0.9220 - val_loss: 0.3609 - val_accuracy: 0.9357
```

Fig. 24: Fitting the Model

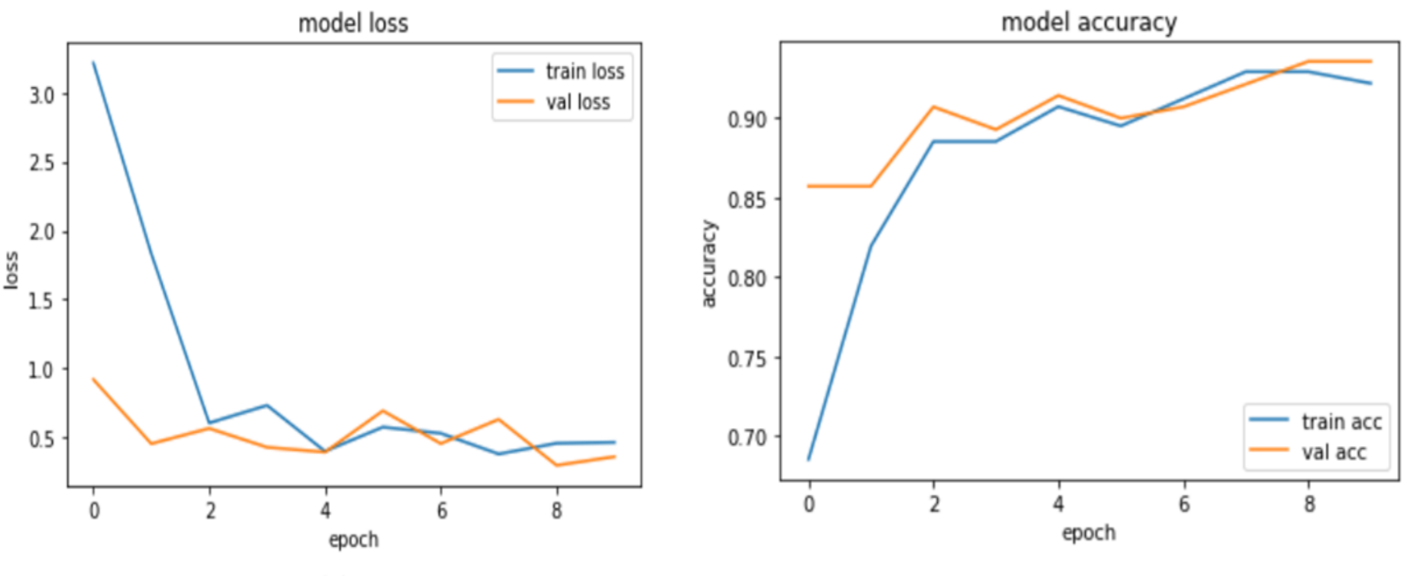


Fig. 25: Plotting the Loss and Accuracy

We have gotten a training accuracy of 92.20% and the validation accuracy is near 93.57% and a training loss of 0.4654 and a validation loss of 0.3609. The graphs show almost a linear decrease in loss and increase in accuracy. But we need to keep in mind that this accuracy is achieved by using our dataset. If we used the images taken by the UAV while it was flying, then the accuracy would not be anywhere near this.

Validation of the Code for Disease Detection

Here are a few cases when we uploaded leaf images and executed our code to check the efficacy of our method. Here are some examples where the model has run successfully and produced accurate response.

Fig. 26: Validation of a Diseased (Brown Spot) Leaf

Fig. 27: Validation of a Healthy Leaf

```
[116] x.shape

      (224, 224, 3)

[117] x=x/255

[118] import numpy as np
      x=np.expand_dims(x,axis=0)
      img_data=preprocess_input(x)
      img_data.shape

      (1, 224, 224, 3)

[119] model.predict(img_data)

      1/1 [==============================] - 0s 36ms/step
      array([[9.99989629e-01, 1.03186485e-05]], dtype=float32)

[120] a=np.argmax(model.predict(img_data), axis=1)

      1/1 [==============================] - 0s 38ms/step

[121] if (a==0):
        print ("The Leaf has Brown Spot.")
      else:
       print ("The Leaf is Healthy.")

      The Leaf has Brown Spot.
```

BS_59.jpg ×

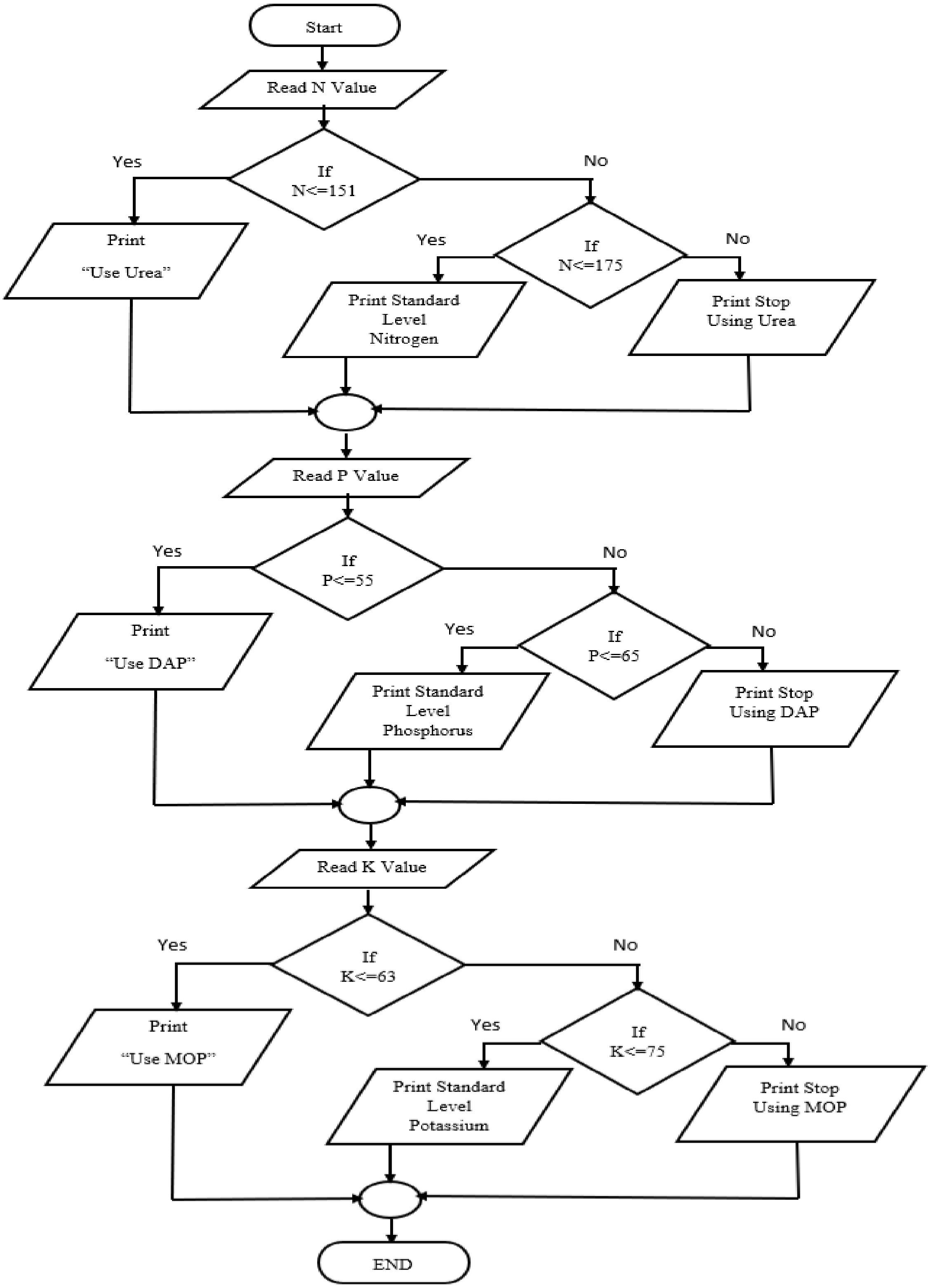
Fig. 28: Validation of Another Diseased (Brown Spot) Leaf

```
[148] x.shape

      (224, 224, 3)

[149] x=x/255

[150] import numpy as np
      x=np.expand_dims(x,axis=0)
      img_data=preprocess_input(x)
      img_data.shape

      (1, 224, 224, 3)

[151] model.predict(img_data)

      1/1 [==============================] - 0s 34ms/step
      array([[0.0061423, 0.9938577]], dtype=float32)

[152] a=np.argmax(model.predict(img_data), axis=1)

      1/1 [==============================] - 0s 35ms/step

[153] if (a==0):
        print ("The Leaf has Brown Spot.")
      else:
       print ("The Leaf is Healthy.")

      The Leaf is Healthy.
```

HL_152.jpg ×

Fig. 29: Validation of Another Healthy Leaf

Flowchart of Fertilizer Selection:



Fertilizer Selection

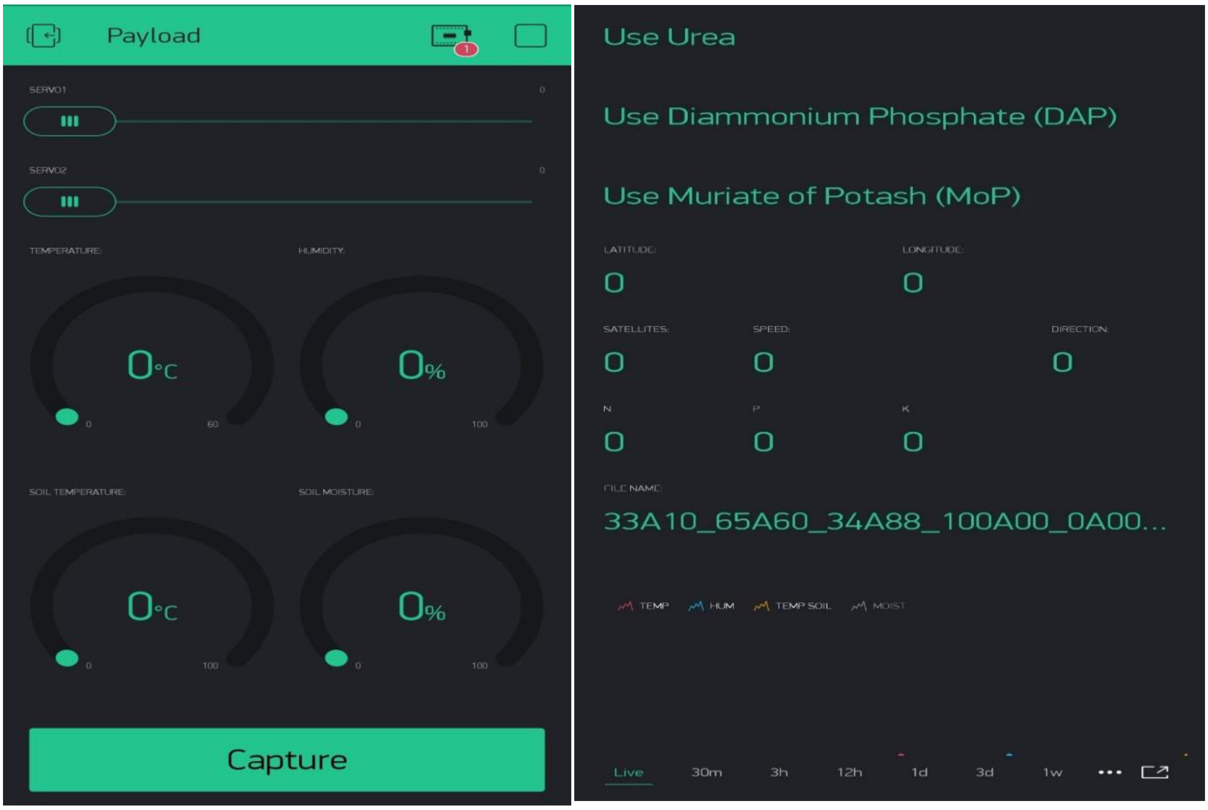


Fig. 30: App Interface

The app's user interface for our prototype appears like this: The purpose of the first two lines is to determine the camera angle. For both the horizontal and vertical camera angles, there are two servo motors. Following that, these four circles will show the soil temperature, soil moisture, day temperature, and humidity. The ESP32 camera is operated by pressing the capture button. After that is the "fertilizer notification box," where it will make fertilizer-related suggestions. Next, it will show the GPS and NPK sensor data. Finally, after reviewing all the sensor and GPS data, our algorithm will assign a name to any captured image following those. Our app's interface also features a graph of the data that has been gathered.

Sample Reading based on the Standard Level

Standard NPK Sensor Value Calculation:

From the Fertilizer manual of Bangladesh Agriculture ministry Fertilizer Recommendation Guide 2018, we found out,

The standard $Nitrogen$ level in 1 shatak field is 1584 $gram/shatak$ which is $\frac{1584*247.11}{1000} = 390\ Kg/hectare$.

The standard $Phosphorus$ level in 1 shatak field is 486 $gram/shatak$which is $\frac{486*247.11}{1000} = 120\ Kg/hectare$.

The standard $Potassium$ level in 1 shatak field is $615\ gram/shatak$ which is $\frac{615*247.11}{1000} = 151\ Kg/hectare$

As we all know, NPK sensor gives output in mg/Kg. So, we have to convert the $Kg/hectare$ value into mg/Kg.

The formula is:

$$Value\ in\ mg/Kg\ = \frac{Value\ in\ kg/hector}{soil\ layer\ thickness \times \frac{Bulk\ Density}{10}}$$

For Bangladesh,

Soil Layer thickness value varies from $18.3cm\ to\ 20.3\ cm$.

Bulk Density value varies from $1.1\ to\ 1.3$.

For Example,

When the Bulk density is 1.1 and the soil layer thickness is 20.3. the sensor output for Nitrogen will be:

$$Sensor\ output\ = \frac{Value\ in\ kg/hector}{soil\ layer\ thickness \times \frac{Bulk\ Density}{10}} = \frac{390}{20.3 \times \frac{1.1}{10}} = 174.65$$
$$\approx 175\ mg/kg$$

When the Bulk density is 1.27 and the soil layer thickness is 20.3. the sensor output for Nitrogen will be:

$$Sensor\ output\ = \frac{Value\ in\ kg/hector}{soil\ layer\ thickness \times \frac{Bulk\ Density}{10}} = \frac{390}{20.3 \times \frac{1.27}{10}} = 151.27$$
$$\approx 151\ mg/kg$$

After doing all the calculation respectively we found out,

Table 6: Soil Mineral Standard

Soil Mineral	**Low (mg/kg)**	**Standard (mg/kg)**	**High (mg/kg)**
N	**<151**	**151-175**	**>175**
P	**<55**	**55-65**	**>65**
K	**<63**	**63-75**	**>75**

[29]

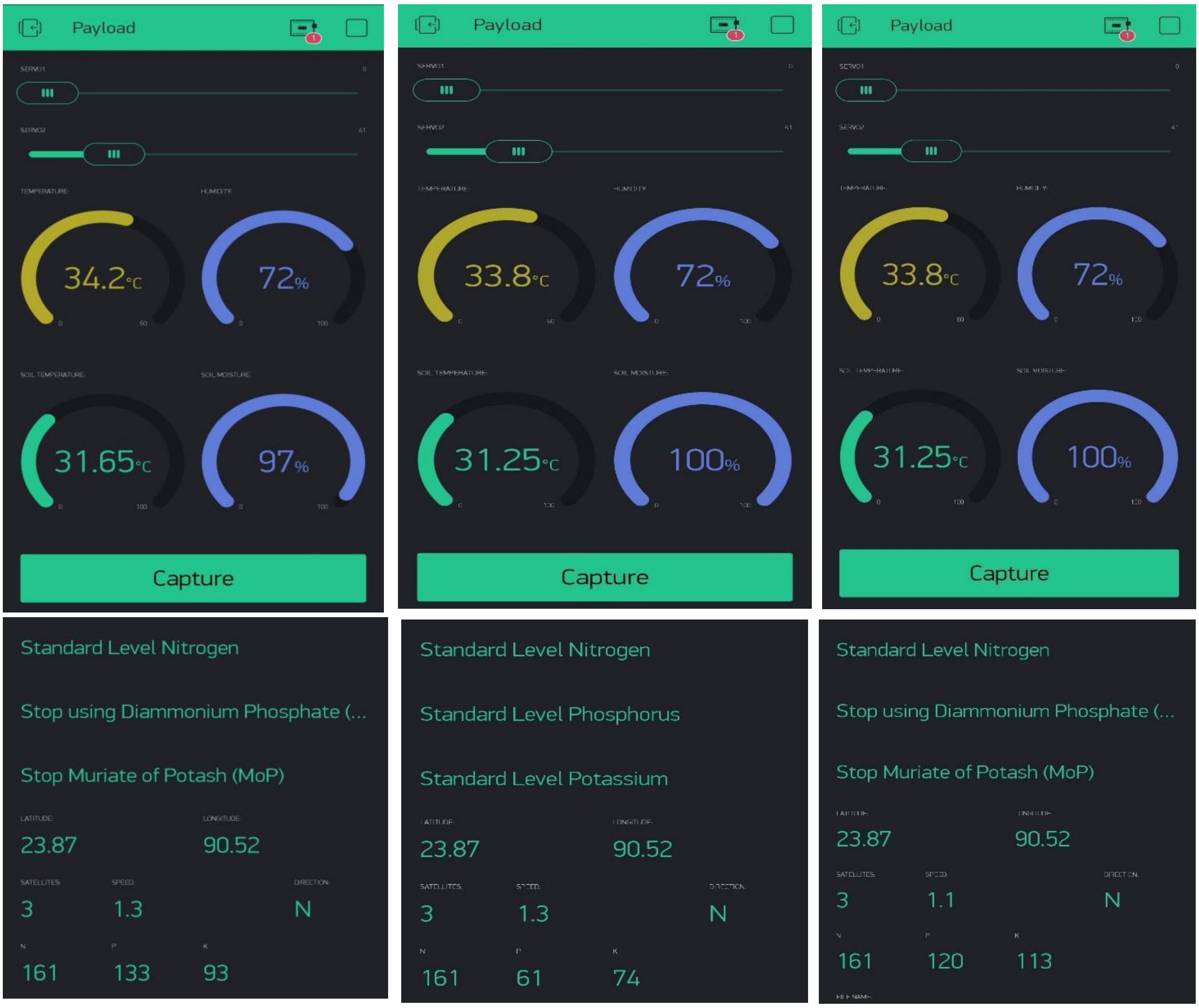


Fig. 31: Fertilizer Selection

Several examples of how our program chooses fertilizer are shown in the above figures. The app displays the air temperature, humidity, soil temperature, and soil moisture in the panel up top. The level of nitrogen, phosphorus, and potassium are shown below, and it is advised to use the appropriate fertilizer if it is below the standard or to stop using it altogether if it is above the standard. Additionally, the app displays latitude and longitude.

5.3 Evaluate the Solution to Meet Desired Need

The optimal choice, which we selected, can do the followings;

- **Capturing Images:** The camera module (ESP32-cam) is capable of capturing images with a 1600*1200 resolution that is adequate for our dataset. If we could take our UAV near the field then this quality of images would have been enough for image processing.
- **Acquiring Sensor Data:** Accurate results are produced by sensors like soil moisture sensors, NPK sensors, and temperature and humidity sensors.

- **Dataset:** This is where we ran into some issues because we were short on time and could not gather enough images for our dataset and also, we have used images taken by the UAV camera when the UAV was not flying.
- **Disease Detection**: Even for such a small dataset, our algorithm for disease detection achieves 92.20% accuracy for training and 93.57% accuracy for validation.
- **Fertilizer selection:** Using sensor data, we can choose and recommend NPK fertilizers with accuracy.
- **Budget Restriction:** Because of the project's financial restrictions, we were unable to design a more expensive device that would have produced better results. But our design was capable enough to act as a less expensive alternative to the pricy UAVs that are currently available.

5.4 Conclusion

The UAV is functioning properly and is capable of taking images perfectly, but unfortunately, we could not take closer pictures. Which is why, we can state that the system we have constructed was not capable of fulfilling one fundamental objective that is, creating a dataset with images taken by the flying UAV. Because of this, the system that we built can be called as a partially complete project. It fits rest of the requirements we previously stated and fulfills almost all of the desired needs. The system's usability and safety were always put first during the research and development phase because this project includes people's property. Even a small amount of negligence could put people's property in danger, which would be contradictory to the project's fundamental objective. In order to ascertain the system's reliability, features, and ideal operating circumstances, many experiments have been run on it. As a result, this will exactly resemble the desired result.

Chapter 6

Impact Analysis and Project Sustainability. [CO3, CO4]

6.1 Introduction

Each and every project is designed and executed to fulfill the aim. On the other hand, it has to keep in mind the impact and to solve or upgrade societal, cultural, health and other issues as well. Any unpleasant or unwanted output can ruin the whole aim to reach the goal. If the mechanisms are not executed properly, people might face intricacy. Moreover, it is important to make a sustainable invention so that users can easily operate it and use it for the long term. While planning a project we should be aware of impact and sustainability which are basically the approach to balance the environmental, social, and economic aspects of project-based work to meet present needs without harming future generations.

6.2 Assess the Impact of Solution

The point of our proposed project is to reduce the labor and time. In a very short period, farmers will be able to know the conditions of the crops and decide which steps (fertilizers, medicines for disease, water etc.) are necessary for which part of the field. For that reason, they will be able to protect the crops from any kind of unwanted harm and so, they will produce more crops than before. It will make them strong in every aspect of their life.

6.2.1 Societal and Cultural Context

- As UAVs have unlimited potential in the agriculture domain it can be economically progressive for a country by saving the crops from early damages [30].
- Betterment in the farming community will be assured as they will get rid of the hunger problems and get easy access to their basic needs [31].
- All the farmers need to be united to work since it is a new addition in farming projects. So, a friendly environment will be created among everyone. They will share their happiness and sorrows and come to find the best solution.
- Obtaining data can assist farmers in managing irrigation more efficiently hence reducing water consumption which protects the environment [32].

6.2.2 Health Context

- Availability of food can be assured for all people who will result in our nation's self-sufficiency in food production [31].
- At present, the health conditions of our people are at stake. Nutritious food can improve health conditions as a well-balanced diet can equally improve health [31].

6.2.3 Environmental Context

From our project, we are able to know the soil condition and select fertilizer from that. This thing will give knowledge for not using excessive amounts of pesticides and fertilizers. As a result, the soil will be protected. Besides, farmers can use this particular field for a very long time since superfluous use of pesticides kills the fertility of the soil.

6.2.4 Legal and Safety Context

We will take legal permission before flying the Unmanned Aerial Vehicle over the field. So, there will be no issue with this matter. On the other hand, we will always carefully fly it with the help of the experts, so no harm will be caused to any life. Since, this is a new addition in smart framing; we will not allow anyone who has not enough knowledge or capability to run the prototype.

6.3 Evaluate the Sustainability

While planning a project we should be aware of sustainability which is basically an approach that balances the environmental, social, and economic aspects of project-based work to meet present needs without harming future generations.

Table 7: SWOT Analysis

	Positive	**Negative**
	Strengths	***Weaknesses***
Internal	• Developed with modern technology. • Large Scope of monitoring. • Good Communication capability. • Disease detection. • Automatic Fertilizer selection. • Can help to increase food production. • Long time durability	• Initially expensive. • Hard to control since it is not stable enough • Not water-resistant. • Could not take dataset for disease detection while flying • Took soil data manually
	Opportunities	***Threats***
External	• Precision agriculture is totally new for Bangladesh, so less competition. • Can grab the attention of the government.	• The prototype can face cyber-attacks. • Need more time to get used to it.

We can observe from the tabular SWOT analysis that the strengths and opportunities outweigh the weaknesses and threats.

We are employing modern technologies to develop and maintain this prototype, which will be as relevant as it is now in the near future. This prototype will have features like disease detection and automated fertilizer selection. When this type of precision agricultural-based prototype becomes available in the farming sector, farmers will be able to specify the disease type and position easily. It will reduce the use of unnecessary fertilizer and pesticides. As we know, using more fertilizer and pesticides is harmful to the environment and the ecosystem. So, this prototype can bring balance to the ecosystem as well as prevent environmental pollution. In this way, it can bring environmental sustainability. Farmers will be able to save money by using less fertilizer and pesticides. Finally, when the government introduces this type of prototype to farmers, it will promote equity in the farming community, which will lead to social sustainability.

6.4 Conclusion

Initially, our project will have a great impact for research purposes only. After that, when it comes to the use of the farmers with the help of the experts, it will lessen the extreme hard work and unpredictable worries about crop yield. One system can monitor all the fields of an entire village or union for a very long period since it has long-term durability and balances all the aspects like societal, environmental, economic, and so on. In one word, our project is sustainable and it can bring a smile to the faces of the farmers as well as the general people.

Chapter 7

Engineering Project Management. [CO11, CO14]

7.1 Introduction

To complete a project by maintaining appropriate steps within a target time is known a project management. It is said that designing and organizing are the pillars of every project. A backup strategy is formulated before the start of any project to take into account potential risks. While working, there might be so many errors that we cannot meet the desired result within the estimated time. By considering all that, we also need to keep some extra time to complete those. Sometimes, people forget to keep this extra time and start working at the eleventh hour and cannot complete their tasks properly, but we tried to work the whole year so that we could manage all the technical malfunctions and challenges. A good project manager is always alert to make a good plan and maintain it, but it is not only his own duty, rather it is a team effort and everybody has to participate in it. Whenever all the members work accordingly, the project shows reliable results. Project management is the most important criteria for reaching the goal and getting the ultimate outcomes.

7.2 Define, Plan and Manage Engineering Project

The ability to track the overall development of the created plan is demonstrated by project management. This includes skills in project definition, planning, and management. For our smart agriculture management project, at first, we need to decide in which field we would work because this has a huge sector. So, we have defined and claimed to work on unmanned aerial vehicles, and according to that, we have established all the upcoming work. This is how we tried to manage.

7.2.1 Project Planning of EEE400P

A project needs proper guidelines to be executed from the very beginning. We started our Final Year Design Project (FYDP) in Fall2021, which was EEE400P. After knowing the ATC, we immediately started our meeting. After some meetings and group discussion with ATC members and group mates, we have decided that we will start working on a smart agriculture management system for fertilizer selection and disease detection. At first, we had gone through so many papers in this field and had so many ideas. We divided our work among the group members and kept the ATC informed about our progress. We focused on specifications, requirements, literature gaps, budget and planning, application codes etc. Each person completed their own work and always tried to help others. Considering all the factors, we proposed our project and completed EEE400P. The Gantt chart for EEE400P is shown below:

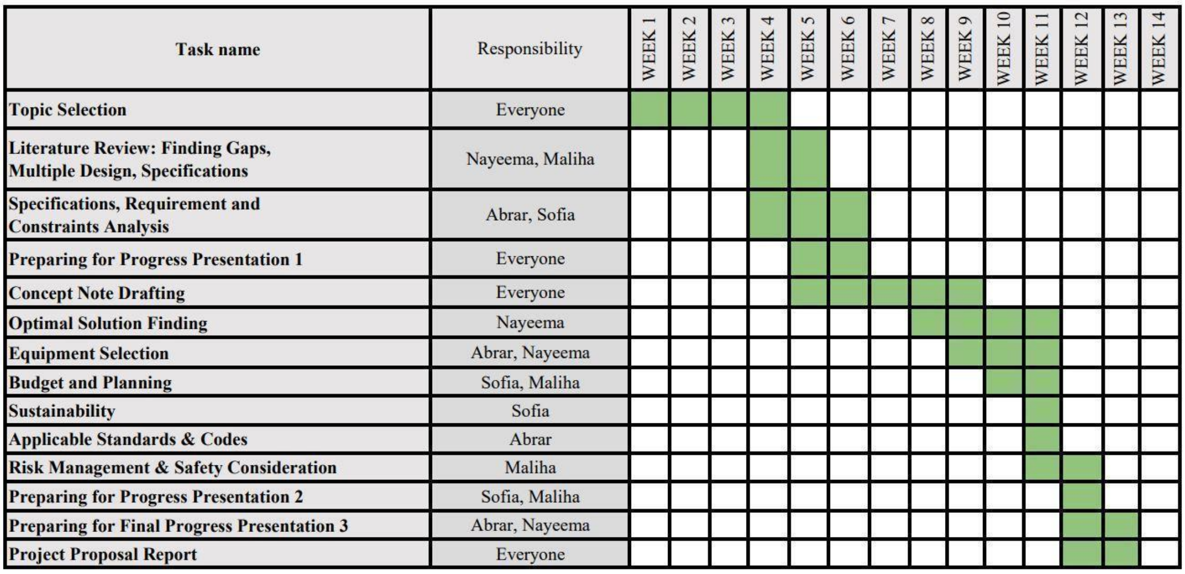


Fig. 32: Project Plan of EEE400P

7.2.2 Project Planning of EEE400D

After completing EEE400P, we started planning on design and all development. We again started our group discussion and ATC meeting. From the very beginning of EEE400D, our respective ATC members advised us to work on designing methods using appropriate modern engineering tools. We spend a good amount of time on designing all the alternative solutions and finding the optimal design. Once it was finalized, we rearranged our budget and ordered the protocols. After that, we commenced hardware implementation of our optimal design solution, prepared our documentation, and completed EEE400D by giving presentations and submitting reports. Here is our Gantt chart for EEE400D attached below:

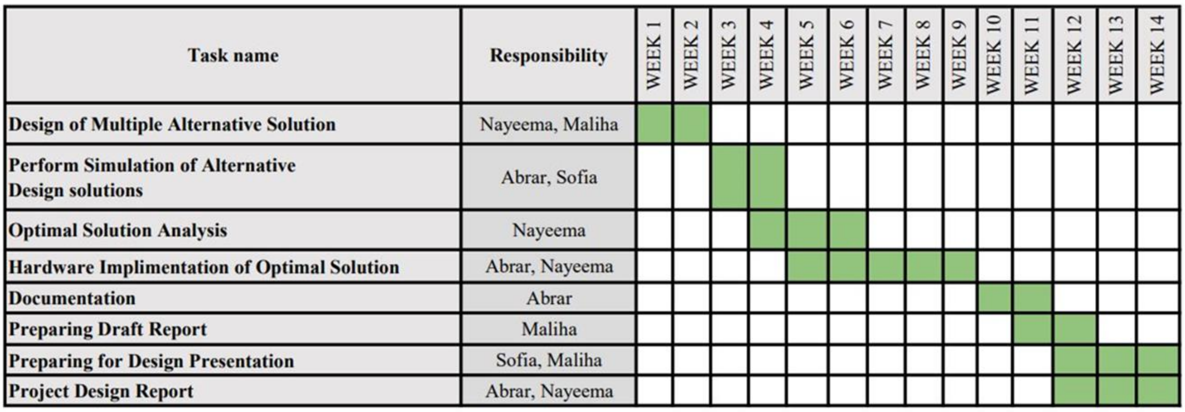


Fig. 33: Project Plan of EEE400D

7.3 Evaluate Project Progress

From the preliminaries, we have gone through so many research papers and then come to a decision. We tried to step up every phase cautiously. However, due to unavoidable circumstances like the shortage and high price of components due to the COVID situation, minor accidents, sickness of the group members, inappropriate weather for data collection—all these troubles we had to face altogether. Thereafter, we did not stop. We rearranged all the work and tried to overcome all the troubles.

7.3.1 Implementation

Step by step, we have worked. We made plans and tried to maintain those. This is basically what project management is. Only by adhering to and carrying out the plan; it is possible to achieve the goal. But man is not perfect, so it did not go as planned due to some accidental cases. But we worked so hard to complete it within the estimated time. While starting our work, we had to face so many difficulties. Due to COVID, suddenly the price of all the components rose and we had to think about alternatives. Moreover, certain hardware components were eliminated due to functional issues. After so many test cases, we could find some hope. We went for data collection in the Purbachal China Town area. There we found rice fields and collected data. We went there multiple times to get more accurate data. Accidents are uncertain. At the beginning, we had accidents with our UAV several times since none of us were experts in this field. The propeller and motor were ruined. We came to learn from that also. These things enlarge our learning capacity. Then we decided to take experts for flying purposes. However, we have come to learn that planning and execution are not the same. Implementing the plan is more difficult and needs so much practical work that you have to consider all the difficulties that might occur. Since our prototype is not that much stable, we had to change our decision and we took pictures from UAV camera and collect soil data by going near to the field rather flying it and all of these are already mentioned in the report. We could not implement it according to our plan and this gave us lessen for the rest of our life. No matter how, we enjoyed this EEE400C phase. This is our Gantt Chart, which shows our group work execution for this semester:

Task name	Responsibility	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 7	WEEK 8	WEEK 9	WEEK 10	WEEK 11	WEEK 12	WEEK 13
Project Planning	Everyone	■												
Hardware (Payload) Development	Abrar, Maliha	■	■	■	■									
App Development	Abrar, Nayeema	■	■	■	■									
DL Training	Nayeema, Sofia	■	■	■	■	■								
Prototype Testing and Evalution	Nayeema, Maliha				■	■	■	■						
Adjustment	Abrar, Sofia				■	■	■	■						
Data Collection	Abrar, Nayeema						■	■	■	■	■	■	■	
Data Analysis	Abrar, Nayeema							■	■	■	■	■	■	■
Result Analysis	Sofia, Maliha							■	■	■	■	■	■	■
Preparing Draft Report	Everyone							■	■	■	■	■	■	
Preparing for Project Presentation	Everyone												■	■
Documentation	Sofia, Maliha													■
Project Final Report	Everyone													■

Fig. 34: Project Plan of EEE400C

7.3.2 Risk Management and Contingency Plan

While planning and developing the idea of a project, we must consider the possibility of risks since it can take place at any time and in any location and we do not have any control over it. First, we should list some types of risks that might occur and then analyze them, coming up with the idea of understanding the level of risk and the alternative plans. It is necessary that we all be proactive instead of reactive. [33] [34]

Table 8: Risk Management and Contingency Plan

Types of Risks	Level (Low/Medium/ High)	Contingency Plan	Alternate Plan	Responsible Member
Technical malfunction	Medium	Will check every part each time before and after flying	Changing parts	All
Losing control over UAV	Medium	Double checking the control system and flying carefully	Becoming skilled	Nayeema & Abrar
Blurry images	Low to Medium	Capturing images for multiple times	Double checking the camera device	Sofia & Maliha

7.3.3 Safety Consideration

For the physical safety of the drone, we have to take the following frame into consideration. The body frame must be capable of holding its own weight as well as the payload. If the payload breaks from the drone at any height, it might result in serious damage or even death. So, every time we consent to the people of our experimental zone.

Sometimes, cyber-attacks like hacking the drone's control, stealing, or manipulating the image data can occur. Drones are similar to aerial computers. Operating systems, network connections, and hardware all contain program code. So, in terms of hacking, a drone is similar to a computer. Also, maintaining a malware-free environment is vital if you are controlling your drone from a computer, tablet, or mobile device. It might be disastrous if the controller loses control of the machine. An UAV that crashes from any height could cause significant injury or perhaps death.

7.3.4 Evaluation

Though we were not updated every week, somehow, we managed. When it comes to the evaluation, we can say our objectives are partially fulfilled. Our prototype can capture images. From images, we are detecting disease. We can know the soil moisture, soil temperature, and humidity. From these information, one can easily understand the situation of the soil and the crop yield. Though, we are not executing those while flying.

7.4 Conclusion

Bringing something new is not an easy task at all. Behind the scene, every project has so many failure stories and we are also not different from it. If and only if everything is maintained as planned, it can be said that the project can see the face of glory.

Chapter 8

Economical Analysis. [CO12]

8.1 Introduction

The study of economic systems is referred to as "economic analysis". It could also provide a peek inside a specific sector or production process. In short, costs and benefits calculations are a key component of economic analysis. The goal of the analysis is to ascertain how efficiently the economy, or a particular sector of it, is running. For instance, the amount of profit a company makes is the main focus of an economic analysis of that company. It starts by assessing projects according to their ability to generate revenue in order to promote better resource allocation. It also makes it possible to make quick decisions, show how resources are being used most effectively, and estimate project results utilizing data-driven techniques.

8.2 Economic Analysis

Economic analysis is a tool for assisting in improved asset allocation, which can result in increased pay for ventures. The goal of an economic analysis for a project is to present a realistic picture of the current financial situation. What effects, if any, has the current financial situation had or will have on the capacity of the organization to generate revenue? As a result, designing such a framework for an agricultural management system with unmanned aerial vehicles demands significant resources. This makes it possible for an effective plan to achieve the desired goal. To perform an economic analysis, we should first determine the costs that will be incurred, next assess the advantages that will be generated by the prototype, and lastly, weigh the expenses and benefits to decide whether it would be wise to spend. After implementation, maintenance may be the main issue. To start a new project, consider recruiting new personnel and maintaining the assets and customer service regularly to provide the best upkeep and return to consumers. Currently, technologies for collecting soil data and identifying crop diseases are still operated manually. The method used to choose the fertilizer is also arbitrary and guess-based. The stakeholders in this industry currently heavily rely on manuals or local dealers to learn about the calculations for soil moisture and nutrients. The situation for detecting diseases is the same. In comparison to the existing manual system, our technology offers a way to automatically monitor and suggest the stakeholders. As stakeholders won't need to purchase testing kits on a regular basis to know about the parameters affecting crops, our technology will become more cost-effective if it can engage in mass production.

8.3 Cost Benefit Analysis

The viability of a project is determined using cost-benefit analysis, which provides an overview of the project in terms of its present, future, and risk elements. A cost-benefit analysis has the advantage of providing accurate, quantitative direction for decisions pertaining to the future of the product if it is conducted correctly and with specific predictions. The market offered a wide range of components and sensors for the development of the prototype design, making it difficult to choose the best option in terms of price and function. We must choose the component that is both cost-efficient and productive if we want to get the best quality results. For a project to be cost-effective, it is not necessary to finish it for the lowest price. The project's material efficiency, performance, and durability are the most crucial aspects. This system needs to incorporate a variety of components, but we must be aware of the cost and the consumers' capacity to pay for the final product. However, each of the items chosen for the prototype design has certain pros and cons. This management procedure is crucial if the end product is to ensure client fulfillment. Though our project is based on firming, our target consumer is the government. Because the government already has area-based agricultural officers, they will use this prototype to collect necessary data and also suggest things to the farmers about fertilizer, pesticides, water level, etc.

8.3.1 Current System Comparison:

There are numerous techniques to accomplish the objectives in the agricultural system, but they are manual and infrequently utilized in Bangladesh. Even in developed nations, using unmanned aerial vehicles is rare. Only a few manufacturers, like DJI, are manufacturing UAVs for agricultural usage. DJI has a few models like DJI Agras T10, Agras T30, Agras T16, MG-1P etc.

These drones have high stability, weight carrying capability, better quality cameras which are costs almost 7000$ to 15000$ which is almost 8 lacs to 17 lacs taka. Although the quality is poor, our model has the same features and costs approximately thirty four thousand taka.

8.3.2 Component Analysis:

UAV Controller:

We used the KK 2.1.5 flight controller, which is a wonderfully capable and reliable flight controller. It already has a variety of pre-installed multi-rotor craft designs available for selection. Using simple on-screen instructions and four buttons to explore the menus, onboard firmware and an LCD screen make setup incredibly simple. However, this flying controller is entirely manual. Without a skilled pilot, it is quite difficult to control. Additionally, it lacks an altitude holding system.

On the other hand, there are automated flight controllers with the altitude hold option, such as Ardupilot, Openpilot, and Pixhawk. It can discover its course using GPS and maintain a consistent altitude for a considerable amount of time, even if it also requires an expert pilot to fly.

The cost of the controllers is the primary factor for employing the KK 2.1.5 flight controllers. In comparison to the KK flight controller, other flight controllers are around a sixth to an eighth of the price. A KK flight controller is priced between 3500 and 4000 takas.

Processor:

In order to capture images and collect data for this prototype, we used the ESP8266, which is simply a microcontroller. It is not capable of onboard disease detection. For this reason, we

are uploading the images and data we have acquired from the field to a cloud server. After that, we used our computer to perform the disease detection.
On the contrary, if we can use a Raspberry Pi in this prototype, it can perform both collection and analysis on board because the Raspberry Pi is a microprocessor, also referred to as a microcomputer.
Due to the Raspberry Pi's limited availability, the ESP8266 is preferred over it. The exorbitant cost of the ESP8266 Raspberry PI is still another factor. The cost of a Raspberry Pi is about 30 times the price of an ESP8266. Where A ESP8266 costs 450-600 taka, a Raspberry Pi costs almost 15000-16000 taka.

Camera:
In this prototype, a two-megapixel camera called the "ESP32-CAM WiFi + Bluetooth Camera Module Development Board ESP32 With Camera Module OV2640" was utilized to take images. Most of the time, we could not receive the required level of image quality for the lower resolution. Although there are several additional cameras, such as the five-megapixel OV5675. But these models are also unavailable in Bangladesh. We can also utilize the eight-megapixel Pi camera, but since we do not have a Raspberry Pi in our system, we are unable to use the Pi camera.

As we can see, our biggest limitation is our budget, but if our prototype receives sufficient funding, we can add the necessary parts to make it efficient. It will be capable of completing the tasks properly.

8.4 Evaluate Economic and Financial Aspects

This project will be advantageous from an economic and financial standpoint because we can create the system to meet the requirements of any farmer, agricultural official, or researcher. Numerous significant crop quality factors are suggested by and monitored by this technology. As a result, in addition to firming, this project has numerous other applications. Building up the commercial infrastructure for any given field will necessitate a proper fund. We'll need a proper amount, and with this money, we can make system improvements that will boost system performance. The current manual fertilizer and pesticide selection methods for crops will be replaced by UAV base agricultural management systems for soil data collecting, disease detection, and autonomous fertilizer selection in our nation. Unnecessary fertilizer as well as pesticide use will also come to an end. This will have a positive impact on our economy over time. The following sum of money has been set aside for the execution of a prototype:

Table 9: Budget

Name	Quantity	Price	Amount
1000kv Brushless Motor 1CW & 1CCW (4x)	4	450	1800
Electric Speed Controller (4x)	4	500	2000
KK2.1.5 flight controller	1	2700	2700

I-A6B	1	5200	5200
FS Remote			
Frame F450	1	1100	1100
Landing kit	1	250	250
LiPo Battery 2200mAh 11.1V 3S & Charger	1	2300	2300
Lipo charger	1	350	350
Propellers	2	200	400
Pan-tilt Servo Bracket Kit	1	105	105
ESP8266 NodeMCU V3 Development Board with CH340	1	470	470
Breadboard Power Supply Stick (3.3V/5V)	1	118	118
Capacitive Soil Moisture Sensor	1	300	300
DHT22 Digital Temperature Humidity Sensor Module	1	490	490
ESP32-CAM Wifi+Bluetooth Camera Module OV2640	1	1250	1250
U-Blox NEO-6M GPS Module	1	845	845
Waterproof DS18B20 Digital Thermal Probe	1	270	270
Mini Servo SG90	1	195	195
NPK Sensor	1	14000	14000
Total			34143

Finally, the costs and advantages of this project are contrasted to see if the advantages outweigh the disadvantages. As we've already stated, the advantages—both monetary and intangible—far outweigh the disadvantages. The economy and society will both benefit greatly from this undertaking. Additionally, we have made every effort to keep expenses as low as possible, and we anticipate that future technological developments will result in assisted gadgets that are easier to use.

8.5 Conclusion

In this chapter, we have examined how the project's implementation will impact the economy. An economic analysis was conducted for this. We also considered the potential advantages that this initiative might bring. The future performance of the project must be understood from an economic and financial perspective. The financial analysis evaluates the required resources, and the economic analysis aids in project maintenance and sustainability. The only factors that prevent a project from being sustainable are the system's effectiveness and work efficiency.

Chapter 9

Ethics and Professional Responsibilities [CO13, CO2]

9.1 Introduction

A set of guidelines called ethical considerations in research can guide the project designs and practices to the right direction. It is considered to be one of the most important parts of the research that should be followed while designing the project. Along with knowledge and technological advancement, good designs have advanced. However, as people have progressed, they have a desire to rule over nature. Because of their aspirations, they have gotten better at creating beautiful designs. But it is also important to protect nature as much as taking advantage of the living environment and to avoid behaviors that will disturb the natural balance. A product created in violation of moral standards may be harmful to the user, the environment, society, and the economy. As engineers or designers, they have to be in the design phase from the very beginning. In terms of responsibility and ethics, engineers are responsible toward society, to their profession, to the stakeholders, colleagues, and subordinates, and are liable to themselves. If engineers create environmentally responsible, socially responsible, and respectful designs, society will appreciate them more and they will feel more secure in their sense of responsibility for all living things. [35].

9.2 Identify Ethical Issues and Professional Responsibility

Ethics refers to the best possible decision to take concerning the environment, resources, and people. While executing a project, ethical considerations can reduce the risk, advance positive results, increase trust, and build reputations and success for the long term. As engineers or designers, the identification of ethical issues while designing a project has been recognized as the most important part of professional responsibility. So, we also tried to look into the matter while designing our prototype.

- First, in our project, we built UAVs in order to fulfill our objectives. So, as we are using it for agricultural purposes to detect crop disease, select fertilizer, do soil data analysis, or monitor crop growth, it is necessary that our UAV should be taken off near a field. As a result, there can be an ethical issue as it is used for public purposes, and we have to get legal approval. So, our project will not take off without legal approval from the Civil Aviation Authority of Bangladesh.

- Additionally, many individuals lack adequate understanding of UAVs, so using UAVs in a region can be difficult. Due to their lack of knowledge about UAVs, individuals may become scared of them or hurt themselves by causing disruption, which could be a problem for our project's implementation as we utilize them to gather data for a certain region. Curiosity can also be harmful to the success of our project. To avoid these types of problems, the consent of the people of that area should be obtained before using the UAV.
- Additionally, since one of our goals is to identify agricultural diseases, we must take pictures of the crops using our app in order to do so. Throughout the process, our prototype can also capture images of people nearby, including farmers and other

locals. As a result, individuals could worry about their lives in general or their confidentiality in particular. [36]

Codes are a collection or catalog of moral rules that are appropriate for the intended application and the related people. Well-known examples are “The Code of Ethics of Electrical Engineering (IEEE),” To develop this project, we have to maintain some IEEE Standards:

9.3 Apply Ethical Issues and Professional Responsibility

As engineers or designers, not only identification but also application of ethical issues while designing the project has been recognized as the most important part of professional responsibility.

When creating the project, the dangers that our prototype contains are examined; potential risks are identified beforehand, and recommendations are given for appropriate solutions. The solutions can be:

- As engineers it is our responsibility to prioritize the safety, health and well-being of society while carrying out our professional duties. In order to achieve our goals, we must pay close attention to the legal requirements that our project demands. In order to fly and take off the UAV, we must obtain permission with the appropriate paperwork; otherwise, we cannot begin testing and working. Besides without taking permission, it can be proved as an obligation to the rules and regulations.
- We should obtain the approval of the public for that specific location because many people lack a proper understanding of UAVs. Before the day of the UAV operation and data collection, we should make an announcement through the targeted area. In this situation, it also has some drawbacks, such as the need to raise awareness among the populace that using the UAV could be dangerous because a curious crowd will assemble around while it is in operation. As engineers, we must spread awareness that crowding people together can be risky when landing as a result we can fulfill our responsibility toward society.
- Moreover, to fulfill our objectives there are some factors we need to look on. Throughout the implementation process we have to be careful about the responsibilities that we have towards society. As engineers, it is a part of professional responsibility to ensure anonymity and confidentiality of that locality. Like maybe in the process capturing images of people can create insecurity among them but we have to ensure them that their information is safe with us. We are working with absolute confidentiality in our project. Ensuring confidentiality can establish a professional reputation for the validity of our services and they can have a good faith on us.

9.3.1 Professional Responsibility

In our project we have some drawbacks like- capturing images with UAVs could not be possible because it was creating a huge air wave when it came near to the paddy field and also it was cutting down rice leaves that hampered the field. As a result, the air wave could not give us steady images that we must needed for disease detection purpose. So, what we actually did we captured all the images manually with the help of ESP32-cam which is a part of the payload of our hardware model. Therefore, we used our manually captured images for our datasets and used algorithms on them to fulfill one of our objectives that is disease detection of rice leaves. For this reason, we got accuracy results and our obtained results from those images but we could not be able to make a full functioned project as we needed a much steadier UAV to do that. We are aware that we must follow the rules and as a professional responsibility we fail to do so. We have designed our prototype and system as our requirement but cannot utilize it properly.

It is crucial for electrical engineers to uphold a code of designing ethics because our development is about to enter a period of innovation that will affect all citizens. So, it is very necessary to apply ethical issues and utilize all available means to immediately implement the necessary adjustments or interventions in the workplace to stop the damage.

9.4 Conclusion

The designer has a duty to take ethical considerations into account since good designs are also ethical designs. It has been suggested that risk assessments and prevention measures be carried out on the intended products before usage, and ethical assessments should be carried out similarly [35].

Outstanding designs are those in which the designer considers social responsibility and the ethical standards of a developed product. The ethical design criterion should be modified and applied as one of the fundamental principles of design requirements if we want to leave our generations with a planet that is sustainable in the future [35].

Chapter 10

Conclusion and Future Work.

10.1 Project Summary/Conclusion

In brief, our project is not fully successful in acquiring images as every time we have done that manually with our payload system not using UAV. So actually, we have captured images manually by our payload system and images are stored on the cloud server. Not only that, every time we show captured images on the display of the app which we have built in Blynk also our app can tell us about fertilizer selection. Moreover, we monitor the crop growth of the field to see how much it has grown. Basically, our payload system is functional but using UAV could not give us results that we needed so we have to choose such a way by manually doing it.

On the contrary, there is a pitfall that captured images from using UAVs are not that much clearer and closer since the UAV creates a huge air wave in the field and that damages the leaves when it is near to the top of the crops. This happened since rice leaves are much thinner and weightless, so the leaves were spreading and the camera was not able to take clear and close-up pictures. So, what we did was, we manually held the UAV on hand, and captured the images from the camera of the UAV to collect a clear data set. By doing so, we were able to obtain a clear dataset and work on it. From that, we detect diseases like brown spots on rice leaves. Brown spot is one of the most common and dangerous diseases for rice crops. On an average, in South and Southeast Asia, the disease reduces lowland rice yields overall by 7% due to high humidity [8]. The accuracy rate of detecting the disease is 92.20% and the validation accuracy was 93.57%. We did this using Google Colab and ResNet152 version 2.

Besides, we are also able to select fertilizers autonomously. Nitrogen, Phosphorus and Potassium are the most important elements in the soil for rice. Since we hired an NPK sensor, we collected data from the soil and saw the quantity of those. So, our app Blynk can show whether the soil has the right amount of chemicals or more or less. According to the standard, the result shows what to do—should we stop using fertilizer or use more? For deficiency of nitrogen, the app shows to "use urea", for Phosphorus and Potassium deficiency, it shows to "use Di-ammonium Phosphate (DAP)" and "Muriate of Potash (MoP)" accordingly. If the chemicals are present more than the standard, it shows to stop that fertilizer immediately. Moreover, it shows that the level is standard if it is so.

So, from the project summary, we can say our objectives are almost fulfilled considering all the limitations.

10.2 Future Work

Each and every project has some drawbacks, and from that, people get knowledge and plan to do future work. Our project is not indifferent to it. We also faced some difficulties and learned how to improve the project. From all the barriers, we grasp some sectors to improve.

Processor Quality: The Raspberry Pi gives on-board results. So, users can see the live images by then. It costs almost 15,000 takas. Due to financial issues and unavailability, we used ESP8266 and could not use it. Otherwise, we would get a better processor unit.

Camera Quality: The Pi camera has better picture quality at 8 megapixels. Images of this quality, using a UAV, can acquire very clear pictures, and this can detect diseases like brown spot more accurately. We have got 92.20% accuracy in our case by using an ESP32 camera of 2 Megapixel, but the success rate will increase unconditionally if we can manage a pi camera.

Stability: For the UAV stability, we have used a KK2.1.5 flight controller, which costs only 2700 taka, and this cannot make the device much more stable. On the contrary, Ardupilot or Pixhawk can make the UAV so stable that it can take such clear images, and as we know, more clear images can give a much more precise result. Here the cost will increase by 4000 to 9000 takas more.

Duration of Research: Rice needs at least five to six months to grow. We need enough time to properly monitor this. In future, we are planning to start monitoring it from the beginning of seeding till it is ready to pluck.

Different Crops: We have decided to do some work on different plants once our device is upgraded with all those better qualities mentioned above. Initially, we have a plan to do work on tomatoes, sugarcane, pineapple, tea garden, and so on.

Chapter 11

Identification of Complex Engineering Problems and Activities.

11.1: Identify the Attribute of Complex Engineering Problem (EP)

	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)

Depth of Knowledge Required: In depth knowledge about algorithms, hardware system, software, the functionality of components is required for practical implementation of our project and we have gathered huge knowledge from literature review and practical implementation.

Depth of Analysis Required: We have formulated three suitable models and by a deep analysis through comparing and abstract thinking we have come to reach the optimal circuit design.

Familiarity of Issues: Familiarity is seen in developed countries but new and additional features are presented for our country.

Extent of Stakeholder Involvement and Needs: We have tried to build the most suitable model for our project and created an app-based payload system to easily handle it. The access to information through mobile apps and easement in operating system will increase stakeholder engagement.

11.3 Identify the Attribute of Complex Engineering Activities (EA)

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

11.4 Provide Reasoning How the Project Address Selected Attribute (EA)

Range of Resource: Our project met a diverse range of resources. Like, so many literature reviews for gathering knowledge on information and technology, worked according to our plan, we had discussion on confirming the components what we need according to our requirements to build a prototype, and for budget selection etc. Altogether we came up with a good design and establishment.

Level of Interaction: We needed to speak with a lot of specialists in order to gather the most support for our design approach.

Consequences for Society and the Environment: Will bring abundant change in economic progress as well as bring equity in the farming community as our prototype is designed in its best way to help the farmers and the people. The soil will be saved from excess pesticides as our app will tell when to use a fertilizer or when to stop. So, no harmful gas/element will be released.

Familiarity: Familiar/common for developed countries but new and additional features are present for our country. We are all aware of the issues with agriculture that exist in our country, and our idea only seeks to improve society by introducing smart farming.

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Appendix

Summary of Team Logbook

ATC Details		
ATC 5	**Name**	**E-mail Address**
Chair	Dr. Abu S.M. Mohsin	asm.mohsin@bracu.ac.bd
Member	Taiyeb Hasan Sakib	taiyeb.sakib@bracu.ac.bd

Final Year Design Project			
Student Details	**Name & ID**	**E-mail Address**	**Phone**
Member 1	Md Abrar Hossen Faiyaz ID: 18321038	md.abrar.hossen.faiyaz@g.bracu.ac.bd	01977671998
Member 2	Maliha Binte Mohsin ID: 18321010	maliha.binte.mohsin@g.bracu.ac.bd	01619486356
Member 3	Nayeema Nahreen ID: 18321005	nayeema.nahreen@g.bracu.ac.bd	0175590815
Member 4	Sofia Ahmed Oaishi ID: 18321029	sofia.ahmed.oaishi@g.bracu.ac.bd	01849640870

Work summary of EEE400P

Date/Time	Attendee	Summary of Meeting Minutes	Responsible	Comment by ATC
10.10.2021 (Group Meeting)	Group members	To find a suitable project topic	All members	
22.10.2021 (Group Meeting)	Group members	Discussion on everyone's gathered idea and initially chose a project on CanSat	All members	
31.10.2021	ATC panel and group members	Proposed the initial idea about CanSat	Task 1: Initial Ideas: Nayeema &Abrar Task 2: Idea about CanSat: Maliha &Sofia	suggested to gather more information
05.11.2021 (Group Meeting)	Group members	Object detection for rescue site using CanSat	Task: Proper knowledge of using CanSat: Nayeema &Abrar	
07.11.2021	ATC panel and group members	Proposed a project on Object detection for rescue site using CanSat	All members	gave idea about object detection on rescue site as well as for agricultural sector
10.11.2021 (Group Meeting)	Group members	Prepared draft copy of Concept note on "Aerial Image Transmission and Object Detection System for Surveillance of Rescue Sites"	Task 1: Concept building: Maliha & Abrar Task 2: Working on draft copy: Nayeema & Sofia	
13.11.2021	ATC panel and group members	Discussion on the proposed idea	All members	Suggested to go for agro sector for better data collection
13.11.2021 (Group Meeting)	Group members	Research on Agricultural project papers	Task 1: Concept building: Maliha &Abrar Task 2: Working on draft copy: Nayeema & Sofia	
14.11.2021(Group Meeting)				
16.11.2021(Group Meeting)				
16.11.2021	ATC panel and group members	Proposed the idea for Agricultural sector using Rover	Task 1. Literature Review: Nayeema & Maliha	recommend for UAV
17.11.2021 (Group Meeting)	Group members	Preparing slides for presentation 1	Task 1: Making slides: Sofia & Maliha Task 2: Suggestions on making slides: Abrar &	

			Nayeema	
19.11.2021 (Group Meeting) 23.11.2021	Group members	Preparing "draft copy of concept note''	Task: Making slides: Abrar & Nayeema	
28.11.2021	ATC panel and group members	Discussion on "draft copy of concept note''	All members	Advised to add some changes
02.12.2021 (Group Meeting) 04.12.2021 (Group Meeting) 05.12.2021 (Group Meeting)	Group members	Making final copy of concept note	Task 1: Working as advise: Maliha & Abrar Task 2: Working on final copy: Nayeema & Sofia	
09.12.2021 12.12.2021	Group members	Discussion on choosing the components and preparing the plan	Abrar & Nayeema	
19.12.2021	ATC panel and group members	Discussion on components	All members	Recommended to do more study on specifications and prepare component level flowchart
22.12.2021 (Group Meeting)	Group members	Analyzing specifications and component level flowchart	Task 1: Specification: Abrar Task 2. Component Level: Sofia	
25.12.2021 (Group Meeting)	Group members	Making Budget	Task: Taking knowledge of components for budget making: Sofia & Maliha	
28.12.2021 (Group Meeting) 29.12.2021	Group members	Making "Progress presentation 2'' slides	Sofia & Maliha	
30.12.2021	ATC panel and group members	Deep discussion on overall project and about Algorithm	All members	Complete the report and slides as recommended
31.12.2021 (Group Meeting)	Group members	Planning and dividing the rest of the works for final presentation and submission	Task 1: Working as advise: Maliha & Abrar Task 2: Working on final copy: Nayeema & Sofia	
02.12.2021 (Group Meeting)	Group members	Preparing the report	All members	
04.12.2021	Group	Updating the	Task: Updating:	

(Group Meeting)	members	"Progress presentation 2'' slides for "Final Progress presentation 3''	Abrar & Nayeema	
05.12.2021	ATC panel and group members	Giving mock presentation	All members	Advised to maintain the time and for some updates on slides
06.12.2021 (Group Meeting)	Group members	Preparing the report	Task 1: Working on report: Abrar & Nayeema Task 2: Working on updates:Maliha &Sofia	
08.12.2021 (Group Meeting)	Group members	Giving final touch on report according to ATC's suggestion	All members	

Work summary of EEE400D

Date/Time	Attendee	Summary of Meeting Minutes	Responsible	Comment by ATC
05.02.2022 (Group Meeting)	Group members	Planning of the semester	Sofia, Abrar	
09.02.2022 (ATC Panel Meeting)	ATC panel and group members	Introduction and guidelines	All members	Suggested to work on multiple designs.
12.02.2022 (Group Meeting)	Group members	Choosing the best software to implement the design	All members	Suggested to use Proteus 8, MATLAB, Fusion360.
14.02.2022 (ATC Panel Meeting)	ATC panel and group members	Suggestion on software	All members	Revise the component list. Work more on multiple designs.
15.02.2022 (Group Meeting)	Group members	Designing the multiple alternative solution in software	Task 1: for Model 2: Maliha Task 2: for Model 3: Nayeema	Continue designing
21.02.2022	Canceled due to National Holiday			
22.02.2022 (Group Meeting)	Group members	Performing simulation of alternative design solutions and finding optimal solution	Task 1: Design: Abrar, Sofia Task 2: Optimal solution:	Continue designing

			Nayeema	
28.02.2022 (ATC Panel Meeting)	ATC panel and group members	Showing simulation and discussion on optimal solution	Task 1: Simulation: Sofia, Abrar Task 2: Optimal design: Nayeema, Maliha	Advised to add some changes. Focus on Optimal design.
01.03.2022 (Group Meeting)	Group members	Making changes as suggested and preparing presentation slide	Task 1: Bringing changes: Abrar, Sofia Task 2: Preparing slides: Nayeema, Maliha	Focus on optimization
02.03.2022 (Group Meeting)				
07.03.2022 (ATC Panel Meeting)	ATC panel and group members	Hardware implementation of Optimal solution	All members	Suggested to start hardware implementation.
08.03.2022 (Group Meeting)	Group members	Discussion on making of the prototype	All members	Recommend to buy components
10.03.2022-16.03.2022	MID BREAK			
18.03.2022 (Group Meeting)	Group members	Hardware implementation	All members	
21.03.2022 (ATC Panel Meeting)	ATC panel and group members	Gave update on the hardware implementation which is in progress	All members	Continue the work
24.03.2022 (Group Meeting)	Group members	Finishing Hardware implementation	All members	Continue the work
28.03.2022 (ATC Panel Meeting)	ATC panel and group members	Showing the prototype	All members	Add the image capturing unit
04.04.2022 (ATC Panel Meeting)	ATC panel and group members	Allover guidelines	All members	Start working on draft report
07.04.2022 (Group Meeting)	Group members	Discussion on image capturing process	Nayeema, Maliha	———
15.04.2022 (Group Meeting)	Group members	Preparing draft report	Task: Sofia, Abrar, Maliha	Start working on report

18.04.2022 (ATC Panel Meeting)	ATC panel and group members	Discussion on sensors	All members	Find some alternative sensors
20.04.2022 (Group Meeting)	Group members	Preparing draft slides & draft Report	Task 1: Draft slides: Maliha Task 2: Draft Report: Nayeema	Start preparing on final slides and report
21.04.2022 (Group Meeting)				
24.04.2022 (Group Meeting)				
25.04.2022 (ATC Panel Meeting)	ATC panel and group members	Showing slides and discussion on report	All members	Suggestion to bring some changes, adding general requirements
26.04.2022 (Group Meeting)	Group members	Preparing final slides	Abrar, Sofia	Continue
26.04.2022 (ATC Panel Meeting)	ATC panel and group members	Mock presentation	All members	To maintain time limitations
27.04.2022 (Group Meeting)	Group members	Preparing Report	All members	Revise the citation and log book
28.04.2022(Group Meeting)				
29.04.2022 (Group Meeting)	Group members	Updating Report	All members	

Work summary of EEE400C

Date/Time	Attendee	Summary of Meeting Minutes	Responsible	Comment by ATC
31.05.2022 (Group meeting)	Group members	Project Planning	Nayeema, Abrar	
02.06.2022 (Group meeting)	Group members	Discussion on payload development	Abrar, Maliha	
06.06.2022 (ATC panel meeting)	ATC panel and group members	Overview of EEE400C, informed ATC about buying issue of NPK sensor	All members	suggested to work sincerely and to hire NPK sensor
09.06.2022	Group	Source of searching	Sofia, Nayeema	

(Group meeting)	members	NPK sensor		
14.06.2022 (ATC panel meeting)	ATC panel and group members	Given update of sensors and saying about the difficulties on working Live stream	All members	Work on payload and can skip live stream and working on backend
15.06.2022 (Group meeting)	Group members	Preparing payload and home task for Blynk app	Task 1: Payload: Maliha, Abrar, Sofia Task 2: Blynk App: Abrar, Nayeema	
20.06.2022 (Group meeting)	Group members	Developing Blynk app	Abrar, Maliha	
22.06.2022 (Group meeting)	Group members	Dataset collection with breadboard payload (test)	All members	
28.06.2022 (ATC panel meeting)	ATC panel and group members	Showing the breadboard model of payload with Blynk app	All members	recommend for not using breadboard for payload. Gave some dataset resources
06.07.2022 (Group meeting)	Group members	Designing payload box with SolidWorks	Abrar, Sofia, Nayeema	
17.07.2022 (ATC panel meeting)	ATC panel and Group members	Seeking permission for using hired NPK Sensor as it is not available in Bangladesh	Sofia, Abrar	Get permission for using NPK
19.07.2022 (Group meeting)	Group members	3D printing	Nayeema, Maliha	
25.07.2022 (Group meeting)	Group members	Preparing Slides for progress presentation	Maliha, Sofia, Abrar	
26.07.2022 (ATC panel meeting)	ATC panel and Abrar	Asked for signing a consent paper	Abrar	Signed the paper
27.07.2022 (ATC panel meeting and Group	ATC panel and group members	Discussion on components	All members	Work on progress presentation

Meeting)	Group members	Went for data collection and prepared slides	All members	
01.08.2022 (Group meeting) 03.08.2022 (Group meeting)	Group members	Repairing the prototype which met accident earlier	Nayeema, Maliha	
05.08.2022 (Group meeting)	Group members	Went for Data collection	All members	
11.08.2022 (Group meeting)	Group members	Repairing the prototype which met accident earlier	Sofia, Abrar	
13.08.2022 (Group meeting)	Group members	Started working on disease detection and algorithm part	All members	
17.08.2022 (ATC panel meeting)	ATC panel and group members	Gave update about working disease detection	Nayeema	Suggested to take images by flying the UAV
19.08.2022 (Group meeting) 22.08.2022 (Group meeting) 23.08.2022 (Group meeting)	Group members	Preparing the report	Sofia, Nayeema, Maliha	
24.08.2022 (ATC panel meeting)	ATC panel and group members	Gave update on Disease detection on collected data and Fertilizer selection	All members	Collect more data by using own prototype and suggested to change some parameters in Google Colab
25.08.2022 (Group meeting)	Group members	Went for data collection	All members	
28.08.2022 (Group meeting)	Group members	Preparing report	Sofia & Maliha	

29.08.2022 (ATC panel meeting)	ATC panel and Nayeema, Sofia, Maliha	Showing update on disease detection from own collected data	Nayeema, Sofia, Maliha	Asked for making documentation while flying UAV
30.08.2022 (Group meeting)	Group members	Documentation and data collection	All members	
31.08.2022 (ATC panel meeting)	ATC panel and group members	Gave all the updates and took the final and last moment suggestion	All members	Enrich slides with more information and new updated works
01.09.2022 (Group meeting)	Group members	Giving final touch on report according to ATC's suggestion	All members	
02.09.2022 (Group meeting)				

Collected Data

Date	Sample	GPS		Sensors				NPK		
		Latitude	Longitude	Day Temperature C°	Soil Temperature C°	Soil Moisture %	Humidity %	N mg/Kg	P mg/Kg	K mg/Kg
27.07.22	1	23.870859	90.519961	34	33.1	97	68	157	125	106
	2	23.870949	90.519861	32.2	31.69	97	71	161	132	118
	3	23.870888	90.519793	33.8	32.6	41	77	169	123	122
	4	23.871042	90.519698	34.3	31.75	98	67	159	118	94
	5	23.870843	90.519531	34.2	31.6	100	67	161	123	104
	6	23.870826	90.519516	34.7	31.8	99	71	170	141	105
	7	23.870675	90.519414	33.7	32.1	96	70	169	138	114
	8	23.870558	90.518856	34.2	31.65	97	72	161	120	113
	9	23.870865	90.518758	33.5	31.35	96	71	155	122	101
	10	23.871105	90.518909	34.3	31.8	98	67	149	146	108
	11	23.871351	90.518976	33.9	31.35	95	70	153	119	116
	12	23.871476	90.519095	34	31.29	97	68	160	128	115
	13	23.871294	90.519266	33.8	31.25	100	71	161	133	93
	14	23.871612	90.518919	34.1	31.1	94	67	171	132	104
	15	23.871223	90.518763	34.5	31.95	98	72	174	127	115
05.08.22	1	23.870863	90.519962	38	37.6	95	72	164	130	121
	2	23.870953	90.519859	37.4	36.6	97	75	162	128	119
	3	23.870884	90.519795	36.5	35.2	97	71	158	132	124
	4	23.871045	90.519701	37.2	36.9	92	73	159	125	92
	5	23.870844	90.519531	36.1	35.9	86	73	145	123	94
	6	23.870828	90.519517	37.5	36.67	91	72	169	138	124
	7	23.870676	90.519416	36.6	35.85	89	70	150	132	100
	8	23.870558	90.518857	38.1	36.1	82	79	157	122	111
	9	23.870867	90.518759	36.1	35.2	98	74	171	146	106
	10	23.871108	90.518911	36.6	35.4	88	73	152	120	124
	11	23.871351	90.518976	37.6	35.8	89	72	167	135	118
	12	23.871478	90.519096	38.3	35.75	92	75	149	127	124
	13	23.871295	90.519268	37.9	35.33	86	74	165	141	112
	14	23.871611	90.518921	38.6	35.67	97	80	155	118	107
	15	23.871227	90.518763	38.2	36.13	100	72	158	119	96
13.08.22	1	23.870675	90.519861	33.58	31.65	100	64	183	61	72
	2	23.870558	90.519793	33.15	31.35	98	64	189	65	62
	3	23.870865	90.519698	34.77	31.69	97	63	181	77	71
	4	23.871105	90.519531	33.19	32	98	62	169	55	75
	5	23.871351	90.519516	33.86	31.69	96	67	175	66	83
	6	23.871476	90.519414	34.55	32.42	100	62	174	59	78
	7	23.871294	90.518856	33.17	32.34	97	66	158	55	83
	8	23.871612	90.518758	34.75	32.03	100	62	140	68	82
	9	23.871223	90.518909	33.37	32.11	99	66	186	79	74
	10	23.870863	90.518976	34.54	32.25	96	66	183	65	75
	11	23.870953	90.519095	34.78	32.62	99	64	189	72	61
	12	23.870884	90.519266	33.68	32.14	96	63	181	83	70
	13	23.871045	90.518919	34.58	32.07	96	67	152	57	72
	14	23.870844	90.518763	33.5	31.3	100	63	153	77	89
	15	23.870828	90.519962	33.31	32.43	99	67	158	83	75

	16	23.870675	90.519859	33.17	31.28	99	64	166	76	74
	17	23.870558	90.519795	33.04	32.27	96	64	163	83	61
	18	23.870865	90.519701	33.02	32.2	96	67	187	62	71
	19	23.871105	90.519531	33.63	31.13	98	67	143	71	86
	20	23.871351	90.519517	34.27	31.68	99	63	168	73	88
	21	23.871476	90.519416	34.56	31.79	96	67	185	63	74
	22	23.871294	90.519698	34.24	32.37	97	65	179	80	67
	23	23.871612	90.519531	34.46	32.34	96	67	145	73	62
	24	23.871223	90.519516	34.63	32.69	97	63	146	50	64
	25	23.870863	90.519414	33.71	32.32	98	67	166	74	88
	26	23.870953	90.518856	33.72	31.39	100	62	149	83	90
	27	23.870884	90.518758	33.85	32.03	96	64	174	60	91
	28	23.871045	90.518909	33.59	32.76	97	67	164	62	84
	29	23.870844	90.519698	34.12	31.02	97	63	165	61	60
	30	23.870828	90.519531	34.03	32.51	96	65	157	82	80
17.08.22	1	23.870676	90.519698	35.29	32.34	98	59	155	61	72
	2	23.870558	90.519414	35.67	32.1	100	57	154	75	70
	3	23.870867	90.519793	34.83	32.73	99	60	187	82	89
	4	23.871108	90.518856	34.85	32.68	98	60	144	77	88
	5	23.871351	90.518921	35.51	32.88	99	61	158	63	75
	6	23.871478	90.519861	34.86	32.34	99	59	181	50	86
	7	23.871295	90.519698	35.03	32.56	100	60	169	65	70
	8	23.871611	90.519414	35.33	32.78	100	55	151	71	94
	9	23.871227	90.519793	35.57	32.46	100	59	184	68	89
	10	23.870675	90.518856	35.42	32.52	99	60	155	65	68
	11	23.870558	90.518921	35.56	32.92	100	58	161	62	70
	12	23.870865	90.519861	35.33	32.49	98	55	158	59	70
	13	23.871105	90.519698	35.1	32.09	100	58	160	61	69
	14	23.871351	90.519414	35.84	31.96	98	61	157	61	73
	15	23.871476	90.519793	35.99	32.22	98	60	164	70	85
	16	23.870949	90.518856	35.61	32.28	99	55	165	62	87
	17	23.870888	90.518921	35.76	32.61	98	55	164	79	61
	18	23.871042	90.519861	35.43	32.62	99	57	157	67	95
	19	23.870843	90.519517	35.63	32.37	100	57	149	70	63
	20	23.870826	90.519416	35.34	32.51	100	55	146	54	71
	21	23.870675	90.518857	35.97	32.55	100	61	170	71	78
	22	23.870558	90.518759	35.46	32.63	100	61	176	78	91
	23	23.871223	90.518911	35.23	31.97	99	60	163	79	65
	24	23.870863	90.518976	35.08	32.8	99	57	144	83	73
	25	23.870953	90.519096	35.63	32.19	100	58	190	53	73
	26	23.870884	90.519268	35.61	31.97	99	59	164	63	68
	27	23.870828	90.518921	35.55	31.95	100	55	165	59	69
	28	23.870675	90.518763	35.72	32.57	100	60	169	59	65
	29	23.870558	90.519861	35.71	32.98	99	57	162	59	66
	30	23.870865	90.519793	35.38	32.3	99	60	156	64	67
	31	23.871105	90.519698	36	32.34	99	61	161	62	71
	32	23.871351	90.519531	35.89	32.57	99	55	159	63	64
	33	23.871476	90.519517	34.82	32.36	100	55	161	59	69
	34	23.871294	90.519416	34.95	32.92	98	59	166	62	70
	35	23.871612	90.519698	34.81	32.84	98	56	164	62	68
20.08.22	1	23.871223	90.519531	32.99	31.22	100	64	168	63	69
	2	23.870863	90.519516	33.71	31.4	99	65	164	62	69

	3	23.870953	90.519414	33.04	31.04	100	66	160	64	71
	4	23.870884	90.518856	33.3	31.16	98	62	166	64	65
	5	23.870558	90.518758	33.83	31.76	100	65	160	62	70
	6	23.870867	90.518909	33.33	31.35	98	62	162	61	66
	7	23.871108	90.519698	33.87	31.41	99	64	169	63	66
	8	23.871351	90.519531	33.86	31.98	100	63	166	58	64
	9	23.871478	90.519698	33.6	31.55	98	65	170	60	68
	10	23.871295	90.519414	33.02	30.84	98	66	168	64	69
	11	23.871611	90.519793	33.47	31.28	99	63	165	61	70
	12	23.871227	90.518856	33.62	31.16	99	63	156	58	66
	13	23.870675	90.519698	33.93	31.59	98	65	160	63	65
	14	23.870558	90.519531	33.64	31.9	99	66	159	62	69
	15	23.870865	90.519516	33.33	31.59	100	65	164	58	67
	16	23.871105	90.519414	33.8	31.74	100	64	167	63	70
	17	23.871351	90.518856	32.95	31.14	98	65	159	62	67
	18	23.871476	90.518758	33.28	30.93	98	64	158	62	65
	19	23.871223	90.518909	32.94	31.23	99	64	159	62	70
	20	23.870676	90.518976	32.8	30.93	98	61	155	59	68
24.08.22	1	23.870558	90.519095	34.19	31.27	100	67	154	51	67
	2	23.870867	90.519266	34.29	31.15	99	64	143	51	67
	3	23.871108	90.519266	33.58	31.01	100	66	154	55	62
	4	23.871351	90.518919	34.47	31.66	99	64	145	51	67
	5	23.871478	90.518763	34.75	31.05	100	67	151	48	67
	6	23.871295	90.519962	34.15	30.93	100	64	144	55	66
	7	23.871611	90.519859	33.66	30.82	99	67	141	51	62
	8	23.871227	90.519795	34.7	30.56	99	64	147	49	66
	9	23.871223	90.519701	34.25	30.53	100	64	146	50	65
	10	23.870863	90.519531	33.62	31.83	99	64	142	49	63
	11	23.870953	90.519517	34.55	31.44	100	65	153	53	63
	12	23.870884	90.519416	34.12	30.67	99	67	153	47	62
	13	23.870676	90.518857	34.27	31.82	100	66	151	53	63
	14	23.870558	90.518759	33.66	31.89	99	66	150	48	67
	15	23.870867	90.519698	33.74	30.51	100	64	152	48	67
	16	23.871108	90.519531	33.96	31.97	99	68	151	49	67
	17	23.871351	90.519516	33.6	30.93	99	65	150	50	62
	18	23.871478	90.519414	34.51	31	99	66	147	55	64
	19	23.871295	90.518856	33.54	31.24	99	64	153	52	62
	20	23.871611	90.518758	34.67	31.59	99	64	143	55	66
	21	23.871227	90.518909	34.43	31.4	99	64	142	50	65
	22	23.871478	90.518976	33.61	31.05	99	64	151	51	64
	23	23.871295	90.519095	33.52	31.09	99	66	155	50	64
	24	23.871611	90.519266	34.7	31.24	100	68	150	55	62
	25	23.871227	90.518919	34.34	30.69	100	65	144	55	64
	26	23.870675	90.518763	34.63	31.64	99	65	144	53	62
	27	23.870558	90.519962	33.83	31.51	99	68	143	51	63
	28	23.870865	90.519859	34.62	31.87	99	67	142	50	64
	29	23.870828	90.519795	34.28	31.19	100	66	151	51	65
	30	23.870675	90.519701	34.13	30.68	99	65	149	51	63
	31	23.870558	90.519531	34.74	30.77	100	66	147	49	64
	32	23.870865	90.519698	33.98	31.27	99	66	142	50	63
	33	23.871105	90.519414	34.5	31.56	100	64	145	52	63
	34	23.871351	90.519793	33.82	31.09	100	65	151	49	63

	35	23.871476	90.518856	33.9	31.82	99	67	150	53	65
	36	23.871294	90.518921	34.66	31.11	100	65	147	52	62
	37	23.871612	90.519861	34.79	31.47	100	66	143	48	64
	38	23.871223	90.519793	33.7	31.65	100	64	146	52	67
	39	23.870863	90.520955	34.36	30.93	99	66	142	54	65
	40	23.870667	90.520706	33.93	31.65	99	68	154	49	63
	41	23.870167	90.521457	34.31	31.22	100	64	155	55	63
	42	23.869667	90.521208	33.79	30.84	99	66	152	48	64
	43	23.870676	90.519861	33.9	31.28	99	64	149	47	66
	44	23.870558	90.519517	33.9	31.79	99	66	145	49	66
	45	23.870867	90.519416	34.08	30.73	99	67	153	51	64
29.08.22	1	23.871108	90.518857	37.51	32.44	99	71	165	57	71
	2	23.871351	90.518759	38.02	32.55	98	74	164	61	69
	3	23.871478	90.518911	37.05	33.15	98	76	171	61	69
	4	23.871295	90.518976	36.28	33.25	100	75	162	59	70
	5	23.871611	90.519003	38.4	32.64	98	76	162	57	70
	6	23.870859	90.510539	37.03	32.81	100	75	173	58	71
	7	23.870949	90.519148	36.87	32.46	99	73	174	57	69
	8	23.870888	90.519157	37.33	32.2	100	71	166	60	69
	9	23.871042	90.519266	36.53	33.06	100	72	174	61	70
	10	23.870843	90.519575	38.34	32.83	99	72	163	61	71
	11	23.870826	90.519384	38.26	33.33	100	76	174	59	71
	12	23.870675	90.519393	37.61	33.16	100	72	162	61	69
	13	23.870558	90.519402	37.34	33.6	99	76	173	59	70
	14	23.870865	90.519461	36.96	33.17	98	76	171	57	71
	15	23.870867	90.519512	37.74	33.59	100	71	164	60	69
	16	23.871108	90.519861	37.62	32.91	99	74	172	61	71
	17	23.871351	90.519793	36.75	33.55	99	74	171	61	68
	18	23.871478	90.519698	36.6	32.75	99	72	167	60	68
	19	23.871295	90.519531	37.96	32.72	99	76	175	61	69
	20	23.870888	90.519516	36.82	32.55	100	73	173	59	68
	21	23.871042	90.519414	37.91	33.56	98	73	170	57	71
	22	23.870859	90.518856	38.44	32.38	99	73	165	61	71
	23	23.870949	90.519861	36.51	33.54	99	72	165	60	69
	24	23.870888	90.519793	37.62	33.49	100	72	171	57	68
	25	23.871042	90.519698	36.72	32.48	99	72	172	57	71
	26	23.870843	90.519531	36.64	33.53	98	76	161	61	71
	27	23.870826	90.519516	37.15	32.73	99	76	168	57	71
	28	23.870675	90.519414	37.02	33.06	99	71	164	57	71
	29	23.870558	90.518856	37.22	33.18	99	73	167	57	69
	30	23.870865	90.518758	37.77	32.33	98	76	174	59	71
	31	23.870859	90.518909	38.32	33.38	100	71	166	60	68
	32	23.870949	90.518921	37.79	32.45	98	74	164	59	69
	33	23.870888	90.518763	37.08	32.92	100	74	161	61	69
	34	23.871042	90.519861	37.6	33.45	99	73	167	58	71
	35	23.870843	90.519793	38.18	33.56	99	74	170	58	68
	36	23.870826	90.519698	38.2	32.62	98	75	171	59	70
	37	23.870675	90.519531	37.89	33.18	100	74	162	59	71
	38	23.870558	90.519516	36.92	33.41	100	71	175	58	68
	39	23.870865	90.519414	37.37	32.53	98	76	168	58	71
	40	23.871105	90.518856	38.08	32.83	100	75	169	57	71
	41	23.870865	90.518758	37	33.12	100	73	175	57	71

	42	23.871295	90.518909	38.06	32.5	99	75	173	60	68
	43	23.871611	90.518976	37.08	33.33	100	75	164	61	71
	44	23.871227	90.519095	38.54	32.8	99	71	168	61	70
	45	23.870675	90.519266	37.63	32.8	100	75	169	59	68

In the following part we will see the sensor output vs. sample graph.

Related Code

ESP8266

ESP32-Cam

```
// Enter your WiFi ssid and password
const char* ssid     = "IOT_Devices";   //your network SSID
const char* password = "12345678";   //your network password

String myScript = "/macros/s/AKfycbxkMAOQ2w-VfYIQ4fLTnXnZ7Be9oPdUVXc8TAxSSQcrreix39mGqWeFDmGBcYgOmmMp/exec";
//Create your Google Apps Script and replace the "myScript" path.
String myLineNotifyToken = "myToken=";    //Line Notify Token. You can set the value of xxxxxxxxxx empty if you don't want to send picture to Linenotify.
String myFoldername = "&myFoldername=ESP32-CAM";
String myFilename = "";
String myImage = "&myFile=";

#include <WiFi.h>
#include <WiFiClientSecure.h>
#include "soc/soc.h"
#include "soc/rtc_cntl_reg.h"
#include "Base64.h"
#include <BlynkSimpleEsp32.h>
#include "esp_camera.h"

// WARNING!!! Make sure that you have either selected ESP32 Wrover Module,
//            or another board which has PSRAM enabled

//CAMERA_MODEL_AI_THINKER
```

```
#define PWDN_GPIO_NUM     32
#define RESET_GPIO_NUM    -1
#define XCLK_GPIO_NUM      0
#define SIOD_GPIO_NUM     26
#define SIOC_GPIO_NUM     27

#define Y9_GPIO_NUM       35
#define Y8_GPIO_NUM       34
#define Y7_GPIO_NUM       39
#define Y6_GPIO_NUM       36
#define Y5_GPIO_NUM       21
#define Y4_GPIO_NUM       19
#define Y3_GPIO_NUM       18
#define Y2_GPIO_NUM        5
#define VSYNC_GPIO_NUM    25
#define HREF_GPIO_NUM     23
#define PCLK_GPIO_NUM     22
char auth[] = "WMQFii9tApyxb75ETuRuNWbsaKZdev4n";
//String SendCapturedImage();
String fName="";
BLYNK_WRITE(V13)
{
  int pin = param.asInt();
  if(pin==1){
    Blynk.syncVirtual(V12);
    SendCapturedImage();
    Blynk.virtualWrite(V13, 0);
  }

}
BLYNK_WRITE(V12)
{
  myFilename="&myFilename=";
  fName = param.asString();
  myFilename.concat(fName);
  Serial.println("File:"+myFilename);
}
void setup()
{
  WRITE_PERI_REG(RTC_CNTL_BROWN_OUT_REG, 0);

  Serial.begin(115200);
  delay(10);
```

```
WiFi.mode(WIFI_STA);

Serial.println("");
Serial.print("Connecting to ");
Serial.println(ssid);
WiFi.begin(ssid, password);

long int StartTime=millis();
while (WiFi.status() != WL_CONNECTED)
{
  delay(500);
  if ((StartTime+10000) < millis()) break;
}

Serial.println("");
Serial.println("STAIP address: ");
Serial.println(WiFi.localIP());

Serial.println("");

if (WiFi.status() != WL_CONNECTED) {
  Serial.println("Reset");

  ledcAttachPin(4, 3);
  ledcSetup(3, 5000, 8);
  ledcWrite(3,10);
  delay(200);
  ledcWrite(3,0);
  delay(200);
  ledcDetachPin(3);

  delay(1000);
  ESP.restart();
}
else {
  //ledcAttachPin(4, 3);
 // ledcSetup(3, 5000, 8);
  Blynk.config(auth, "***.***.***.**",****);
  Blynk.run();
 /* for (int i=0;i<5;i++) {
    ledcWrite(3,10);
    delay(200);
    ledcWrite(3,0);
    delay(200);
```

```
  }
  ledcDetachPin(3); */
}

camera_config_t config;
config.ledc_channel = LEDC_CHANNEL_0;
config.ledc_timer = LEDC_TIMER_0;
config.pin_d0 = Y2_GPIO_NUM;
config.pin_d1 = Y3_GPIO_NUM;
config.pin_d2 = Y4_GPIO_NUM;
config.pin_d3 = Y5_GPIO_NUM;
config.pin_d4 = Y6_GPIO_NUM;
config.pin_d5 = Y7_GPIO_NUM;
config.pin_d6 = Y8_GPIO_NUM;
config.pin_d7 = Y9_GPIO_NUM;
config.pin_xclk = XCLK_GPIO_NUM;
config.pin_pclk = PCLK_GPIO_NUM;
config.pin_vsync = VSYNC_GPIO_NUM;
config.pin_href = HREF_GPIO_NUM;
config.pin_sscb_sda = SIOD_GPIO_NUM;
config.pin_sscb_scl = SIOC_GPIO_NUM;
config.pin_pwdn = PWDN_GPIO_NUM;
config.pin_reset = RESET_GPIO_NUM;
config.xclk_freq_hz = 20000000;
config.pixel_format = PIXFORMAT_JPEG;
//init with high specs to pre-allocate larger buffers
if(psramFound()){
  config.frame_size = FRAMESIZE_UXGA;
  config.jpeg_quality = 10;  //0-63 lower number means higher quality
  config.fb_count = 2;
} else {
  config.frame_size = FRAMESIZE_SVGA;
  config.jpeg_quality = 12;  //0-63 lower number means higher quality
  config.fb_count = 1;
}

// camera init
esp_err_t err = esp_camera_init(&config);
if (err != ESP_OK) {
  Serial.printf("Camera init failed with error 0x%x", err);
  delay(1000);
  ESP.restart();
}
```

```
  //drop down frame size for higher initial frame rate
  sensor_t * s = esp_camera_sensor_get();
  s->set_framesize(s,                    FRAMESIZE_VGA);                              //
UXGA|SXGA|XGA|SVGA|VGA|CIF|QVGA|HQVGA|QQVGA
}

void loop()
{
 Blynk.run();

  //SendCapturedImage();
 // delay(5000);
}

String SendCapturedImage() {
  const char* myDomain = "script.google.com";
  String getAll="", getBody = "";

  camera_fb_t * fb = NULL;
  fb = esp_camera_fb_get();
  if(!fb) {
    Serial.println("Camera capture failed");
    delay(1000);
    ESP.restart();
    return "Camera capture failed";
  }

  Serial.println("Connect to " + String(myDomain));
  WiFiClientSecure client_tcp;
  client_tcp.setInsecure();   //run version 1.0.5 or above

  if (client_tcp.connect(myDomain, 443)) {
    Serial.println("Connection successful");

    char *input = (char *)fb->buf;
    char output[base64_enc_len(3)];
    String imageFile = "data:image/jpeg;base64,";
    for (int i=0;i<fb->len;i++) {
      base64_encode(output, (input++), 3);
      if (i%3==0) imageFile += urlencode(String(output));
    }
    String Data = myLineNotifyToken+myFoldername+myFilename+".jpg"+myImage;

    client_tcp.println("POST " + myScript + " HTTP/1.1");
```

```
  client_tcp.println("Host: " + String(myDomain));
  client_tcp.println("Content-Length: " + String(Data.length()+imageFile.length()));
  client_tcp.println("Content-Type: application/x-www-form-urlencoded");
  client_tcp.println("Connection: keep-alive");
  client_tcp.println();

  client_tcp.print(Data);
  int Index;
  for (Index = 0; Index < imageFile.length(); Index = Index+1000) {
    client_tcp.print(imageFile.substring(Index, Index+1000));
  }
  esp_camera_fb_return(fb);

  int waitTime = 10000;   // timeout 10 seconds
  long startTime = millis();
  boolean state = false;

  while ((startTime + waitTime) > millis())
  {
    Serial.print(".");
    delay(100);
    while (client_tcp.available())
    {
        char c = client_tcp.read();
        if (state==true) getBody += String(c);
        if (c == '\n')
        {
          if (getAll.length()==0) state=true;
          getAll = "";
        }
        else if (c != '\r')
          getAll += String(c);
        startTime = millis();
     }
     if (getBody.length()>0) break;
  }
  client_tcp.stop();
  Serial.println(getBody);
}
else {
  getBody="Connected to " + String(myDomain) + " failed.";
  Serial.println("Connected to " + String(myDomain) + " failed.");
}
```

```
  return getBody;
}


String urlencode(String str)
{
    String encodedString="";
    char c;
    char code0;
    char code1;
    char code2;
    for (int i =0; i < str.length(); i++){
      c=str.charAt(i);
      if (c == ' '){
        encodedString+= '+';
      } else if (isalnum(c)){
        encodedString+=c;
      } else{
        code1=(c & 0xf)+'0';
        if ((c & 0xf) >9){
            code1=(c & 0xf) - 10 + 'A';
        }
        c=(c>>4)&0xf;
        code0=c+'0';
        if (c > 9){
            code0=c - 10 + 'A';
        }
        code2='\0';
        encodedString+='%';
        encodedString+=code0;
        encodedString+=code1;
        //encodedString+=code2;
      }
      yield();
    }
    return encodedString;
}
```

Base64.cpp

```
/*
 * Copyright (c) 2013 Adam Rudd.
 * See LICENSE for more information
```

```
 * https://github.com/adamvr/arduino-base64
 */
#if (defined(__AVR__))
#include <avr\pgmspace.h>
#else
#include <pgmspace.h>
#endif

const char PROGMEM b64_alphabet[] = "ABCDEFGHIJKLMNOPQRSTUVWXYZ"
		"abcdefghijklmnopqrstuvwxyz"
		"0123456789+/";

/* 'Private' declarations */
inline void a3_to_a4(unsigned char * a4, unsigned char * a3);
inline void a4_to_a3(unsigned char * a3, unsigned char * a4);
inline unsigned char b64_lookup(char c);

int base64_encode(char *output, char *input, int inputLen) {
	int i = 0, j = 0;
	int encLen = 0;
	unsigned char a3[3];
	unsigned char a4[4];

	while(inputLen--) {
		a3[i++] = *(input++);
		if(i == 3) {
			a3_to_a4(a4, a3);

			for(i = 0; i < 4; i++) {
				output[encLen++] = pgm_read_byte(&b64_alphabet[a4[i]]);
			}

			i = 0;
		}
	}

	if(i) {
		for(j = i; j < 3; j++) {
			a3[j] = '\0';
		}

		a3_to_a4(a4, a3);

		for(j = 0; j < i + 1; j++) {
```

```
                output[encLen++] = pgm_read_byte(&b64_alphabet[a4[j]]);
            }

            while((i++ < 3)) {
                output[encLen++] = '=';
            }
        }
        output[encLen] = '\0';
        return encLen;
}

int base64_decode(char * output, char * input, int inputLen) {
        int i = 0, j = 0;
        int decLen = 0;
        unsigned char a3[3];
        unsigned char a4[4];


        while (inputLen--) {
            if(*input == '=') {
                break;
            }

            a4[i++] = *(input++);
            if (i == 4) {
                for (i = 0; i <4; i++) {
                    a4[i] = b64_lookup(a4[i]);
                }

                a4_to_a3(a3,a4);

                for (i = 0; i < 3; i++) {
                    output[decLen++] = a3[i];
                }
                i = 0;
            }
        }

        if (i) {
            for (j = i; j < 4; j++) {
                a4[j] = '\0';
            }

            for (j = 0; j <4; j++) {
```

```
				a4[j] = b64_lookup(a4[j]);
			}

			a4_to_a3(a3,a4);

			for (j = 0; j < i - 1; j++) {
				output[decLen++] = a3[j];
			}
		}
		output[decLen] = '\0';
		return decLen;
}

int base64_enc_len(int plainLen) {
		int n = plainLen;
		return (n + 2 - ((n + 2) % 3)) / 3 * 4;
}

int base64_dec_len(char * input, int inputLen) {
		int i = 0;
		int numEq = 0;
		for(i = inputLen - 1; input[i] == '='; i--) {
			numEq++;
		}

		return ((6 * inputLen) / 8) - numEq;
}

inline void a3_to_a4(unsigned char * a4, unsigned char * a3) {
		a4[0] = (a3[0] & 0xfc) >> 2;
		a4[1] = ((a3[0] & 0x03) << 4) + ((a3[1] & 0xf0) >> 4);
		a4[2] = ((a3[1] & 0x0f) << 2) + ((a3[2] & 0xc0) >> 6);
		a4[3] = (a3[2] & 0x3f);
}

inline void a4_to_a3(unsigned char * a3, unsigned char * a4) {
		a3[0] = (a4[0] << 2) + ((a4[1] & 0x30) >> 4);
		a3[1] = ((a4[1] & 0xf) << 4) + ((a4[2] & 0x3c) >> 2);
		a3[2] = ((a4[2] & 0x3) << 6) + a4[3];
}

inline unsigned char b64_lookup(char c) {
		if(c >='A' && c <='Z') return c - 'A';
		if(c >='a' && c <='z') return c - 71;
```

```
    if(c >='0' && c <='9') return c + 4;
    if(c == '+') return 62;
    if(c == '/') return 63;
    return -1;
}
```

Edgent_ESP8266

```
#define BLYNK_PRINT Serial
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>
#include <DHT.h>
#include <OneWire.h>
#include <DallasTemperature.h>
#include <Servo.h>
#include <TinyGPS++.h>
#include <SoftwareSerial.h>
char auth[] = "WMQFii9tApyxb75ETuRuNWbsaKZdev4n";

// Your WiFi credentials.
// Set password to "" for open networks.
char ssid[] = "IOT_Devices";
char pass[] = "12345678";

static const int RXPin = 4, TXPin = 5;    // GPIO 4=D2(conneect Tx of GPS) and GPIO 5=D1(Connect Rx of GPS
static const uint32_t GPSBaud = 9600; //if Baud rate 9600 didn't work in your case then use 4800

TinyGPSPlus gps; // The TinyGPS++ object
//WidgetMap myMap(V0);  // V0 for virtual pin of Map Widget

SoftwareSerial ss(RXPin, TXPin);  // The serial connection to the GPS device

BlynkTimer timer;

float spd;       //Variable  to store the speed
float sats;      //Variable to store no. of satellites response
String bearing;  //Variable to store orientation or direction of GPS
Servo s1;
Servo s2;
#define DHTTYPE DHT22
```

```
#define DHTPIN 2
DHT dht(DHTPIN, DHTTYPE);
float temp = 0.0;
float hum = 0.0;
float temperatureC = 0.0;
const int oneWireBus = 14;
const int AirValue = 652;   //you need to replace this value with Value_1
const int WaterValue = 277;
int soilMoistureValue = 0;
float soilmoisturepercent=0;
String fileName="";
// Setup a oneWire instance to communicate with any OneWire devices
OneWire oneWire(oneWireBus);
unsigned int move_index = 1;
float latitude = 0;     //Storing the Lat. and Lon.
float longitude = 0;
// Pass our oneWire reference to Dallas Temperature sensor
DallasTemperature sensors(&oneWire);
BLYNK_WRITE(V0)
{
  int pos=param.asInt();
  Serial.println("Servo1"+String(pos));
  s1.write(pos);
}
BLYNK_WRITE(V1)
{
  int pos=param.asInt();
  Serial.println("Servo2"+String(pos));
  s2.write(pos);
}

void setup()
{
  Serial.begin(115200);
  s1.attach(12,500,2400);
  s2.attach(13,500,2400);
  sensors.begin();
  dht.begin();
  s1.write(0);
  s2.write(0);
  ss.begin(GPSBaud);
  Blynk.begin(auth,ssid,pass, "103.139.234.16",8080);
  Blynk.syncVirtual(V0,V1);
   timer.setInterval(1000L, checkGPS);
```

```
}
void updateDHT(){
  hum = dht.readHumidity();
  temp = dht.readTemperature();
  Serial.println(String(hum)+" "+String(temp));
  if (isnan(hum) || isnan(temp)) {
    Serial.println("NAN");
    hum=0;
    temp=0;
  }
  Blynk.virtualWrite(2, String(temp,2));
  Blynk.virtualWrite(3, String(hum,2));
}
void checkGPS(){
  if (gps.charsProcessed() < 10)
  {
    Serial.println(F("No GPS detected: check wiring."));
    Blynk.virtualWrite(V11, "GPS ERROR");  // Value Display widget  on V4 if GPS not
detected
    Blynk.virtualWrite(V6, "ERROR");
    Blynk.virtualWrite(V7, "ERROR");
    Blynk.virtualWrite(V8, "ERROR");
    Blynk.virtualWrite(V9, "ERROR");
    Blynk.virtualWrite(V10, "ERROR");
  }
}
void soilTemp(){
  sensors.requestTemperatures();
  float temp=temperatureC;
  temperatureC = sensors.getTempCByIndex(0);
  Serial.println("Soil"+String(temperatureC));
  if(temperatureC>84 || temperatureC<0){
    temperatureC=temp;
  }
  Blynk.virtualWrite(4, String(temperatureC,2));
}
void soilMoisture(){
  soilMoistureValue = analogRead(A0);  //put Sensor insert into soil
soilmoisturepercent = map(soilMoistureValue, AirValue, WaterValue, 0, 100);
if(soilmoisturepercent>100){
  soilmoisturepercent=100;
}
if(soilmoisturepercent<0){
  soilmoisturepercent=0;
```

```
}
Blynk.virtualWrite(5, String(soilmoisturepercent,2));
}
void displayInfo()
{
  Serial.println("In Sat");
  if (gps.location.isValid() )
  {
    latitude = (gps.location.lat());     //Storing the Lat. and Lon.
    longitude = (gps.location.lng());
    Blynk.virtualWrite(6,String(latitude,8));
    Blynk.virtualWrite(7,String(longitude,8));
    //myMap.location(move_index, latitude, longitude, "GPS_Location");
    spd = gps.speed.kmph();              //get speed
    Blynk.virtualWrite(8, String(spd,8));

       sats = gps.satellites.value();    //get number of satellites
       Blynk.virtualWrite(9, sats);

       bearing = TinyGPSPlus::cardinal(gps.course.value()); // get the direction
       Blynk.virtualWrite(10, bearing);
  }


}
void joinData(){
  fileName="";

fileName=String(temp,2)+"_"+String(hum,2)+"_"+String(temperatureC,2)+"_"+String(soilm
oisturepercent,2)+"_"+String(latitude,8)+"_"+String(longitude,8);
  fileName.replace(".","A");
  Serial.println("File name: "+fileName);
  Blynk.virtualWrite(12, fileName);
}
void loop() {
  while (ss.available())
    {
      char c = ss.read();
      Serial.write(c); // uncomment this line if you want to see the GPS data flowing
      if (gps.encode(c)) // Did a new valid sentence come in?
       displayInfo();
    }

  timer.run();
```

```
  Blynk.run();
  updateDHT();
  soilTemp();
  soilMoisture();
  joinData();
}
```

camera_pins.h

```
#if defined(CAMERA_MODEL_WROVER_KIT)
#define PWDN_GPIO_NUM    -1
#define RESET_GPIO_NUM   -1
#define XCLK_GPIO_NUM    21
#define SIOD_GPIO_NUM    26
#define SIOC_GPIO_NUM    27

#define Y9_GPIO_NUM      35
#define Y8_GPIO_NUM      34
#define Y7_GPIO_NUM      39
#define Y6_GPIO_NUM      36
#define Y5_GPIO_NUM      19
#define Y4_GPIO_NUM      18
#define Y3_GPIO_NUM       5
#define Y2_GPIO_NUM       4
#define VSYNC_GPIO_NUM   25
#define HREF_GPIO_NUM    23
#define PCLK_GPIO_NUM    22

#elif defined(CAMERA_MODEL_ESP_EYE)
#define PWDN_GPIO_NUM    -1
#define RESET_GPIO_NUM   -1
#define XCLK_GPIO_NUM    4
#define SIOD_GPIO_NUM    18
#define SIOC_GPIO_NUM    23

#define Y9_GPIO_NUM      36
#define Y8_GPIO_NUM      37
#define Y7_GPIO_NUM      38
#define Y6_GPIO_NUM      39
#define Y5_GPIO_NUM      35
#define Y4_GPIO_NUM      14
#define Y3_GPIO_NUM      13
```

```
#define Y2_GPIO_NUM      34
#define VSYNC_GPIO_NUM   5
#define HREF_GPIO_NUM    27
#define PCLK_GPIO_NUM    25

#elif defined(CAMERA_MODEL_M5STACK_PSRAM)
#define PWDN_GPIO_NUM     -1
#define RESET_GPIO_NUM    15
#define XCLK_GPIO_NUM     27
#define SIOD_GPIO_NUM     25
#define SIOC_GPIO_NUM     23

#define Y9_GPIO_NUM       19
#define Y8_GPIO_NUM       36
#define Y7_GPIO_NUM       18
#define Y6_GPIO_NUM       39
#define Y5_GPIO_NUM        5
#define Y4_GPIO_NUM       34
#define Y3_GPIO_NUM       35
#define Y2_GPIO_NUM       32
#define VSYNC_GPIO_NUM    22
#define HREF_GPIO_NUM     26
#define PCLK_GPIO_NUM     21

#elif defined(CAMERA_MODEL_M5STACK_WIDE)
#define PWDN_GPIO_NUM     -1
#define RESET_GPIO_NUM    15
#define XCLK_GPIO_NUM     27
#define SIOD_GPIO_NUM     22
#define SIOC_GPIO_NUM     23

#define Y9_GPIO_NUM       19
#define Y8_GPIO_NUM       36
#define Y7_GPIO_NUM       18
#define Y6_GPIO_NUM       39
#define Y5_GPIO_NUM        5
#define Y4_GPIO_NUM       34
#define Y3_GPIO_NUM       35
#define Y2_GPIO_NUM       32
#define VSYNC_GPIO_NUM    25
#define HREF_GPIO_NUM     26
#define PCLK_GPIO_NUM     21

#elif defined(CAMERA_MODEL_AI_THINKER)
```

```
#define PWDN_GPIO_NUM     32
#define RESET_GPIO_NUM    -1
#define XCLK_GPIO_NUM      0
#define SIOD_GPIO_NUM     26
#define SIOC_GPIO_NUM     27

#define Y9_GPIO_NUM       35
#define Y8_GPIO_NUM       34
#define Y7_GPIO_NUM       39
#define Y6_GPIO_NUM       36
#define Y5_GPIO_NUM       21
#define Y4_GPIO_NUM       19
#define Y3_GPIO_NUM       18
#define Y2_GPIO_NUM        5
#define VSYNC_GPIO_NUM    25
#define HREF_GPIO_NUM     23
#define PCLK_GPIO_NUM     22

#else
#error "Camera model not selected"
#endif
```

Disease Detection with ResNet152

```
from google.colab import drive
drive.mount('/content/drive')

!pip install -q keras

import keras
import tensorflow as tf
tf.__version__

from tensorflow.compat.v1 import ConfigProto
from tensorflow.compat.v1 import InteractiveSession
config = ConfigProto()
config.gpu_options.per_process_gpu_memory_fraction = 0.8
config.gpu_options.allow_growth = True
session = InteractiveSession(config=config)

#Import the necessary libraries
from tensorflow.keras.layers import Input, Lambda, Dense, Flatten
from tensorflow.keras.models import Model
tf.keras.applications.resnet_v2.ResNet152V2
tf.keras.applications.resnet_v2.preprocess_input
tf.keras.preprocessing.image
from tensorflow.keras.preprocessing.image import ImageDataGenerator,load_img
tf.keras.models.Sequential
from tensorflow.keras.applications.inception_v3 import preprocess_input
from tensorflow.keras.preprocessing import image
import numpy as np
from glob import glob
import matplotlib.pyplot as plt

# Re-size the images
IMAGE_SIZE = [224, 224]
train_path = '/content/drive/MyDrive/FYDPC_G12/Dataset/Train'
valid_path = '/content/drive/MyDrive/FYDPC_G12/Dataset/Test'

# Import ResNet152V2 library as shown below and add preprocessing layer to the front
# We will be using ImageNet weights

import tensorflow
```

```
resnet152V2 =tensorflow.keras.applications.ResNet152V2(input_shape=IMAGE_SIZE + [3]
, weights='imagenet', include_top=False)

# Don't train existing weights
for layer in resnet152V2.layers:
    layer.trainable = False

# Getting number of output classes
folders = glob('/content/drive/MyDrive/FYDPC_G12/Dataset/Train/*')

# Our layers
x = Flatten()(resnet152V2.output)
len(folders)

prediction = Dense(len(folders), activation='softmax')(x)
# Create a model object
model = Model(inputs=resnet152V2.input, outputs=prediction)


# Show the structure of the model
model.summary()

# Loss, metrics and optimization method
model.compile(
  loss='categorical_crossentropy',
  optimizer='adam',
  metrics=['accuracy']
)

# Use the Image Data Generator to import the images from the dataset
#from tensorflow.keras.preprocessing.image import ImageDataGenerator
tf.keras.preprocessing.image.ImageDataGenerator

train_datagen = ImageDataGenerator(rescale = 1./255,
                                   shear_range=0.4,
                                   zoom_range=0.4,
                                   rotation_range=40,
                                   horizontal_flip=True,
                                   width_shift_range=0.4,
                                   height_shift_range=0.4,
                                   )

test_datagen = ImageDataGenerator(rescale = 1./255)
```

```
# Provide the same target size as the image size
training_set = train_datagen.flow_from_directory('/content/drive/MyDrive/FYDPC_G12/Dataset/Train',
                                                 target_size = (224, 224),
                                                 batch_size = 64,
                                                 class_mode = 'categorical')


test_set = test_datagen.flow_from_directory('/content/drive/MyDrive/FYDPC_G12/Dataset/Test',
                                            target_size = (224, 224),
                                            batch_size = 64,
                                            class_mode = 'categorical')


# Fit the model
# Run the cell

r = model.fit_generator(
  training_set,
  validation_data=test_set,
  epochs=10,
  steps_per_epoch=len(training_set),
  validation_steps=len(test_set)
)


import matplotlib.pyplot as plt


# Plot the loss
plt.plot(r.history['loss'], label='train loss')
plt.plot(r.history['val_loss'], label='val loss')
plt.legend()
plt.show()
plt.savefig('LossVal_loss')

# Plot the accuracy
plt.plot(r.history['accuracy'], label='train acc')
plt.plot(r.history['val_accuracy'], label='val acc')
plt.legend()
plt.show()
plt.savefig('AccVal_acc')
```

```
from tensorflow.keras.models import load_model
# Save it as a h5 file
model.save('model_resnet152V2.h5')

y_pred = model.predict(test_set)
y_pred

import numpy as np
y_pred = np.argmax(y_pred, axis=1)
y_pred


from tensorflow.keras.models import load_model
from tensorflow.keras.preprocessing import image


model=load_model('model_resnet152V2.h5')


img=image.load_img('/content/drive/MyDrive/FYDPC_G12/Dataset/Validation/BrownSpot/
BS_18.jpg',target_size=(224,224))


x=image.img_to_array(img)
x

x.shape
x=x/255

import numpy as np
x=np.expand_dims(x,axis=0)
img_data=preprocess_input(x)
img_data.shape


model.predict(img_data)


a=np.argmax(model.predict(img_data), axis=1)
if (a==0):
  print ("The Leaf has Brown Spot.")
else:
 print ("The Leaf is Healthy.")
```

Fertilizer Selection with Blynk App

```
import time
import requests
def updateBlynk():
   putHeader={"Content-Type": "application/json"}
   npk=[0,0,0]
   for i in range(14,17):
       val =
requests.get("https://***.***.***.**:****/WMQFii9tApyxb75ETuRuNWbsaKZdev4n/get/V
"+str(i), verify=False)
       val = val.text
       npk[i-14]=int(val[2:len(val)-2])
   time.sleep(0.5)
   if npk[0]<151:
       requests.get("https://
***.***.***.**:****/WMQFii9tApyxb75ETuRuNWbsaKZdev4n/update/V17?value=Use
Urea", verify=False)
   elif npk[0]<175:
       requests.get("https://
***.***.***.**:****/WMQFii9tApyxb75ETuRuNWbsaKZdev4n/update/V17?value=Standa
rd Level Nitrogen",verify=False)
   else:
       requests.get("https://
***.***.***.**:****/WMQFii9tApyxb75ETuRuNWbsaKZdev4n/update/V17?value=Stop
using urea",verify=False)
   time.sleep(0.5)
   if npk[1]<55:
       requests.get("https://
***.***.***.**:****/WMQFii9tApyxb75ETuRuNWbsaKZdev4n/update/V18?value=Use
Diammonium Phosphate (DAP)",verify=False)
   elif npk[1]<65:
       requests.get("https://
***.***.***.**:****/WMQFii9tApyxb75ETuRuNWbsaKZdev4n/update/V18?value=Standa
rd Level Phosphorus",verify=False)
   else:
       requests.get("https://
***.***.***.**:****/WMQFii9tApyxb75ETuRuNWbsaKZdev4n/update/V18?value=Stop
using Diammonium Phosphate (DAP)",verify=False)
   time.sleep(0.5)
   if npk[2]<63:
```

```
        requests.get("https://
***.***.***.**:****/WMQFii9tApyxb75ETuRuNWbsaKZdev4n/update/V19?value=Use
Muriate of Potash (MoP)",verify=False)
    elif npk[2]<75:
        requests.get("https://
***.***.***.**:****/WMQFii9tApyxb75ETuRuNWbsaKZdev4n/update/V19?value=Standa
rd Level Potassium",verify=False)
    else:

requests.get("https://***.***.***.**:****/WMQFii9tApyxb75ETuRuNWbsaKZdev4n/updat
e/V19?value=Stop Muriate of Potash (MoP)",verify=False)
    time.sleep(2)

while True:
    updateBlynk()
```

Assessment Guideline for Faculty

[The following assessment guideline is for faculty ONLY. **This portion is not applicable for students**.]

Assessment Tools and CO Assessment Guideline

	Distribution of assessment points among various COs assessed in different semesters														
PO □	L	C	F	g	c	b	d	c	e	l	k	k	h	i	j
CO □	CO1	CO2	CO3	CO4	CO5	CO6	CO7	CO8	CO9	CO10	CO11	CO12	CO13	CO14	CO15
EEE 400C/ ECE 402C (Out of 100)							30	24	6	4	4	6	7	7	12
Project Final Report/ Project Progress Report							x	x	x	x	x	x	x		x
Demonstration of working prototype							x								x
Progress Presentation/ Final Presentation								x			x				
Peer-evaluation*													x	x	
Instructor's Assessment*													x	x	
Demonstration at FYDP Showcase								x							x

Note: The star (*) marked deliverables/skills will be evaluated at various stages of the project.

Mapping of CO-PO-Taxonomy Domain & Level- Delivery-Assessment Tool

Sl.	**CO Description**	**PO**	**Bloom's Taxonomy Domain/Level**	**Assessment Tools**

CO7	**Evaluate** the performance of the developed solution with respect to the given specifications, requirements and standards	d	Cognitive/ Evaluate	• Demonstration of working prototype • Project Progress Report on working prototype
CO8	**Complete** the final design and development of the solution with necessary adjustment based on performance evaluation	c	Cognitive/ Create	• Project Final Report • Final Presentation • Demonstration at FYDP Showcase
CO9	**Use** modern engineering and IT tools to design, develop and validate the solution	e	Cognitive/ Understand, Psychomotor/ Precision	• Project Final Report
CO10	**Conduct** independent research, literature survey and learning of new technologies and concepts as appropriate to design, develop and validate the solution	l	Cognitive/ Apply	• Project Final Report
CO11**	**Demonstrate** project management skill in various stages of developing the solution of engineering design project	k	Cognitive/ Apply Affective/ Valuing	• Project Final Report • Project Progress presentation at various stages
CO12	**Perform** cost-benefit and economic analysis of the solution	k	Cognitive/ Apply	• Project Final Report
CO13	**Apply** ethical considerations and professional responsibilities in designing the solution and throughout the project development phases	h	Cognitive/ Apply Affective/ Valuing	• Peer-evaluation, • Instructor's Assessment • Final Report
CO14**	**Perform** effectively as an individual and as a team member for successfully completion of the project	i	Affective/ Characterization	• Peer-evaluation • Instructor's Assessment

CO15**	**Communicate** effectively through writings, journals, technical reports, deliverables, presentations and verbal communication as appropriate at various stages of project development	j	Cognitive/ Understand Psychomotor/ Precision Affective/ Valuing	• Project Final Report • Progress Presentations, • Final Presentation • Demonstration at FYDP Showcase

Note: The double star (**) marked CO will be assessed at various stages of the project through indirect deliverables.