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Smart Irrigation By Using Drone

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ABSTRACT:

This project aims to develop an integrated drone system tailored specifically for agricultural applications, leveraging advanced hardware and software technologies to provide actionable insights to farmers. By combining hardware components such as A2212 BLDC Motors, ESP32 CAM modules, and Lithium Polymer (LiPo) batteries with sophisticated software functionalities for object detection using TensorFlow, the project seeks to empower farmers with real-time monitoring and analysis of crop health. The system's software aspect includes the development of a user-friendly web interface and integration with Robo Flow for seamless feedback delivery to farmers. By detecting common crop diseases such as black fungus pod, early and late leaf spot, fungus leaf, and rust leaf, the project aims to provide targeted feedback to farmers, enabling them to take proactive measures to protect their crops and maximize yield.

Keywords: Smart Irrigation, Internet of Things, Artificial Intelligence.

INTRODUCTION

In the realm of modern agriculture, there is a growing demand for innovative solutions that harness the power of technology to address challenges related to crop health and productivity. This project responds to this need by developing an integrated drone system that combines cutting-edge hardware components with advanced software functionalities. By integrating A2212 BLDC Motors, ESP32 CAM modules, and other hardware elements, along with TensorFlow-based object detection algorithms, the project aims to provide farmers with a comprehensive tool for crop monitoring and disease detection. The system's ability to analyze captured images for common crop diseases such as black fungus pod, early and late leaf spot, fungus leaf, and rust leaf, underscores its potential to revolutionize agricultural practices and empower farmers with actionable insights.

Smart Irrigation is a modern methodology that makes making very easy and reduces time consumption and manpower. Already more people worked on Smart Irrigation on various methodologies for specific functions like capturing images, detecting pests, etc. We are newly implementing the existing projects by combining a few different functionalities. We think one step forward and we are using drones in the project for various uses like capturing the crop or plant images and detecting pests that occurred to the plant. In this project, we can operate the drone by using a mobile and also we will get the pictures in our mobile captured by the drone. By using this project we can collect the data easily and accurately and also we can make farming efficient without burdening the former. Smart Irrigation in agriculture is significantly growing and gaining immense importance both among industrialists as well as farmers.

The definition of Smart Irrigation concerning agriculture can be defined as the wide use of sensors, the latest cameras, drones, and new pedagogical devices which will bring transformation to the traditional method of farming These innovations hold immense promise for addressing longstanding challenges in crop management, including the optimization of irrigation practices and the early detection of plant diseases. By leveraging the capabilities of drones equipped with sophisticated sensors and AI-powered algorithms, farmers can gain unprecedented insights into crop health and environmental conditions, thereby enabling more informed decision-making and resource allocation. By harnessing drone technology coupled with AI and ML algorithms, it becomes feasible to monitor crop water stress levels in real time and optimize irrigation schedules.

The detection and management of plant diseases are paramount for ensuring crop health and minimizing yield losses. However, conventional disease monitoring methods often rely on manual inspection, which is labour-intensive, time-consuming, and prone to human error. In contrast, the integration of drones equipped with high-resolution cameras and TensorFlow AI and ML algorithms offers a revolutionary approach to disease detection and diagnosis.

If we observe traditional farming and smart irrigation, there are several changes occurred in irrigation. We mentioned down changes, that occurred in irrigation from traditional forming to Smart irrigation.

Criteria	Traditional method	Smart Irrigation
Data Collection	Farmers	Drone
Data Transmission	None	Wi-Fi/ Bluetooth
Data Analysis	Formers	System
Maintenance	Manual	Mobile

Efficiency	Low	High
Accuracy	Moderate	High
Man Power	High	Less
Time Consumption	High	Less
Cost	Low	High

We aim to contribute to the advancement of precision agriculture practices by providing farmers and agricultural stakeholders with innovative tools and techniques for sustainable crop management. By harnessing the synergies between drone technology, AI, and ML, we envision a future where farming becomes more efficient, resilient, and environmentally conscious, ultimately ensuring food security and prosperity for generations to come.

II. LITERATURE SURVEY

Recent studies have highlighted the potential of integrated drone systems in agriculture, particularly in the realm of crop health monitoring and disease detection. A2212 BLDC Motors have emerged as a key component in agricultural drones, offering reliability and efficiency in powering aerial platforms. Similarly, the integration of ESP32 CAM modules enables high-resolution image capture, facilitating detailed analysis of crop health parameters. The use of TensorFlow-based object detection algorithms enhances the system's capabilities, allowing for real-time identification of common crop diseases. By leveraging platforms such as Robo Flow for seamless feedback delivery to farmers, the project aims to bridge the gap between technology and agriculture, ultimately empowering farmers to make informed decisions and optimize crop yields. Previous research has demonstrated the effectiveness of integrated drone systems in providing timely and accurate information to farmers, highlighting the potential for widespread adoption and impact on agricultural practices.

As per the various research conducted from 2016-2022, it has been observed that with the help of IoT, the production of food has been significantly increased and it has also reduced the personnel efforts which has increased farmers' economy. There are many developed countries like the USA, Israel, Australia, and other European countries who has already adopted Smart Irrigation to practice increasing the productivity of crops and maintaining sustainable development in irrigation. It has been observed that in the USA 70% of the farms use IoT and AI in agriculture. Japan has also very efficiently applied IoT and AI to practice agriculture and it has been noticed that these devices have improved production and minimal resource wastage which further improved the livelihood of farmers. These countries are significantly contributing to establishing precision agriculture. Japan is one step forward to other countries by using robots in agriculture. By reducing the manpower they are using robots for every stage of irrigation like planting seeds, watering plants, weeding, cutting crops monitoring fields, etc. Our seniors had done some research on smart irrigation they came up with new methodologies like Farming by using wireless Sensors, Crop monitoring Systems, Automated irrigation systems and more. But we are coming up with a new methodology, that Smart Irrigation by using the drone. Here we are including some existing projects and implementing them by drone**.**

III. PROJECT DESCRIPTION

The project has two major requirements which are Hardware and Software as mentioned below.

Hardware Requirements:

i. Motor

A2212 BLDC Motor is a 3-phase out-runner type popular brushless DC motor commonly used in Drones and other multirotor applications. It is a 1000 KV motor. It provides high performance, superpower, and brilliant efficiency. These motors are perfect for medium-sized quadcopters with our 10-inch propellers. The Higher torque value motors are required for larger propellers and will draw more current than lower-torque motors.

ii. ESP32 CAM

The ESP32(Espressif32)-CAM is a small camera module from Ai-Thinker that can be used in IoT applications such as wireless monitoring, industrial wireless control, and home smart devices. ESP32 CAM Wi-Fi Module Bluetooth with OV2640 Camera Module 2MP.The OV5640 is a 5MP camera module with a focus that can be attached to an ESP32-CAM AI-Thinker board. It has a focus range of 100mm to infinity and can support 2.4 GHz Wi-Fi and Bluetooth.

iii. Lithium Polymer (LiPo) Battery

Lithium polymer (LiPo) battery is used for drones to give the power supply to all hardware devices that run on the power. The LiPo battery offers the advantage of high energy density of their size and weight, with a higher voltage per cell, so they can power the drone's onboard systems with fewer cells than other rechargeables. LiPo batteries are lightweight and have a high power-to-weight ratio.

iv. Node MCU ESP8266:

The Node MCU (Node Micro Controller Unit) is an open-source software and hardware development environment built around an inexpensive System-on-a-Chip (SoC) called the ESP8266. The Node MCU ESP8266 provides a cost-effective approach to connecting devices to the internet. It features built-in Wi-Fi capabilities, allowing seamless communication with other devices and cloud services. The Node MCU board simplifies rapid prototyping for IoT projects. It combines an ESP8266 microprocessor with Wi-Fi support, making it ideal for creating Wi-Fi-enabled products without deep networking knowledge.

v. Electronic Speed Controller

Electronic speed controllers (ESCs) are devices that allow drone flight controllers to control and adjust the speed of the drone's electric motors. A signal from the flight controller causes the drone ESC to raise or lower the voltage to the motor as required, thus changing the speed of the propeller. ESC is an integral part of a drone's propulsion system that is critical to the performance and safe flight of the aircraft.

vi. MPU 6050 6-dof

The MPU-6050 is a six-axis motion tracking device (6 Degrees of Freedom) that combines an accelerometer and a gyroscope. It's also known as an inertial measurement unit (IMU), and it can be used in drones to control orientation and measure a craft's velocity, orientation, and gravitational forces. The IMU is a key component of the drone's flight control system, allowing the drone to fly with maximum stability and control. The MPU-6050 has three accelerometer outputs and three gyroscope outputs. The gyroscope measures angular velocity, while the accelerometer measures acceleration. Accelerometers and gyroscopes to measure acceleration and rotation, which can be used to provide position data.

vii. Arduino Uno

The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analogue inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started.

viii. Quadcopter Drone Frame

F450 quadcopter drone is highly stable and the most compatible drone frame for making 4-propeller drones. It is built from high-quality glass fibre and ultra-durable polyamide nylon. Arms are reinforced and much stronger to prevent and reduce breakage. Integrated PCB connections for direct soldering ESCs. Large mounting tabs on the main frame bottom plate for easy camera or other accessories mounting. Pre-threaded brass sleeves for all of the frame bolts and easy assembly. The purpose of the drone frame is to provide adequate protection to the components that operate the drone. It simply protects the delicate electrical components from harm. The level of protection a frame provides to the drone depends upon its stiffness, material, and strength of the arms.

ix. Propellers

Propellers are devices that transform rotary motion into linear thrust. Drone propellers provide lift for the aircraft by spinning and creating an airflow, which results in a pressure difference between the top and bottom surfaces of the propeller. 1045(10×4.5) SF Propellers have high-quality propellers specially designed for multi-copters. 1045(10×4.5) SF Props has a 15° angle design at the end of the propeller to avoid whirlpool multi-copter flying. These Props are lightweight and high-strength. Two propellers must be rotated clockwise and two propellers must be rotated counterclockwise. The clockwise rotation propellers must be in opposite corners and also counterclockwise rotation propellers must be in opposite corners to balance the drone in the air.

x. Solar Panel

The drone's motors and sensors can be powered by solar panels on its torso or wings, which can transform sunlight into electricity. This means that compared to drones powered by batteries, solar-powered drones can fly for extended periods and cover more ground. solar-powered drones offer exciting possibilities for extended flight durations, reduced environmental impact, and innovative applications.

Software Requirements:

In these software requirements, we employ website design for both frontend and backend technology to create the user interface. We utilize AI & ML algorithms, specifically TensorFlow, to analyse images captured by drones. The analysed images are then presented in the user interface of the website design for AI & ML object detection. The software requirements consist of three parts:

1. Website Development (Frontend & Backend)
2. TensorFlow Object Detection Datasets and Algorithm
3. Drone Software

1. Website Development (Frontend & Backend):

Frontend: The front end of the website is responsible for creating an appealing and user-friendly interface. It's what users interact with directly.

- **HTML** (Hypertext Markup Language): Used to structure the content of web pages. HTML defines the layout, headings, paragraphs, images, and links.
- **CSS** (Cascading Style Sheets): Used to style the HTML elements. CSS controls the visual presentation, including fonts, colours, spacing, and layout.
- **JavaScript:** Enhances user interactivity by adding dynamic behaviour to web pages. It allows you to create responsive forms, handle user input, and perform client-side validation.

Backend: The backend handles server-side logic, data processing, and communication with databases and external services.

- **JavaScript (Node.js):** Commonly used for backend development. Node.js allows you to build scalable and efficient server applications.
- **Firebase:** A cloud-based platform that provides authentication, real-time databases, storage, and hosting. Firebase simplifies backend development by offering ready-to-use services.

2.1. TensorFlow Object Detection Datasets:

Collecting and Curating Images:

Gather a diverse dataset of images relevant to your object detection task. These images should cover various scenarios, backgrounds, lighting conditions, and object orientations. Ensure that the dataset includes positive examples (images containing the objects of interest) and negative examples (images without those objects).

Data Annotation:

Annotate the dataset by labelling the objects of interest within each image. Common annotation formats include bounding boxes, polygons, or masks. Tools like Robo Flow allow you to annotate images efficiently by drawing bounding boxes around objects.

Splitting the Dataset:

Divide the dataset into three subsets:

- Training Set: Used to train the object detection model.
- Validation Set: Used to fine-tune hyperparameters and monitor model performance during training.
- Test Set: Used to evaluate the model's performance after training.
- Data Augmentation:
- Apply data augmentation techniques (such as rotation, scaling, flipping, and brightness adjustments) to increase the dataset's diversity and improve model generalization.

2.2. TensorFlow Object Detection Algorithm:

Pre-Trained Models:

TensorFlow provides pre-trained object detection models (e.g., Faster R-CNN, YOLO, SSD) that are trained on large datasets (e.g., COCO, Pascal VOC). These models serve as a starting point for transfer learning.

Fine-Tuning:

Fine-tune the pre-trained model using your annotated dataset. Retrain the model's top layers while keeping the lower layers frozen. Adjust hyperparameters (learning rate, batch size, etc.) during fine-tuning.

Model Evaluation:

Evaluate the model's performance on the validation set using metrics like mean Average Precision (MAP) or Intersection over Union (IOU). Tweak the model architecture or hyperparameters based on evaluation results.

Inference:

After training, use the model for inference (object detection) on new images. The model predicts bounding boxes and class labels for detected objects. Post-process the predictions (e.g., non-maximum suppression) to obtain the final object detections.

2.3. Robo Flow and Workflow:

Robo Flow:

Robo Flow is a platform that simplifies the process of creating, annotating, and managing object detection datasets. It provides tools for data augmentation, annotation, and dataset versioning.

Workflow:

- Upload your images to Robo Flow.
- Annotate the images by drawing bounding boxes around objects.
- Split the dataset into training, validation, and test sets.
- Export the dataset in a format compatible with TensorFlow (e.g., TFR record).
- Fine-tune a pre-trained model using TensorFlow, using the annotated dataset.
- Evaluate the model's performance and iterate as needed.

3. Drone Software:

Flight Controller:

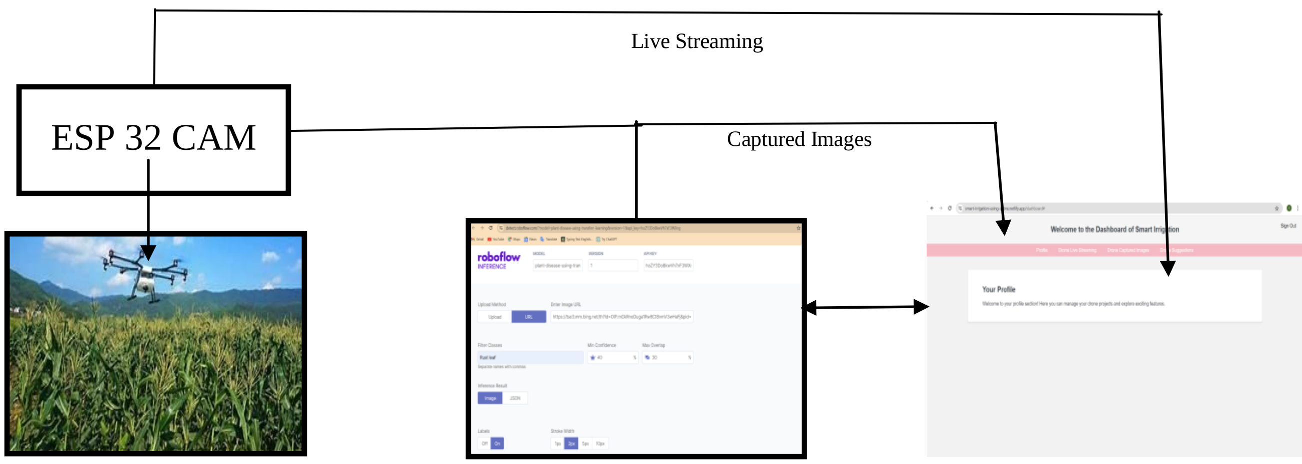
We are using MPU 6050 to make a flight controller

1. **Arduino Programming:**
- Write firmware for the Arduino Uno to interface with control motors, and handle communication with the web interface.
- Implement communication protocols to send telemetry data from the drone to the website and receive commands from the website to control the drone.

2. **Web Interface Development:**
- Develop a web interface using HTML, CSS, and JavaScript for users to interact with the drone remotely. This interface could include features like:
- A dashboard to display real-time telemetry data such as altitude, speed, GPS coordinates, battery level, etc.
- Controls for sending commands to the drone, such as take-off, landing, altitude adjustments, and directional control.
- Implement WebSocket or web server communication to establish a bidirectional connection between the web interface and the Arduino Uno for real-time updates.

IV. METHODOLOGY

i. Block Diagram:



ii. Working:

Working Steps:

1. **Drone Initialization:**
- The drone system initializes upon powering on, initializing all hardware components and software modules.

2. **Take-off and Flight:**
- The drone takes off and begins its flight mission over the agricultural field.

3. **Image Capture:**
- The ESP32 CAM module captures images of the agricultural field at regular intervals.

4. **Image Transmission:**
- Captured images are transmitted to the onboard processing unit or directly to the ground station via wireless communication (Wi-Fi or cellular).

5. **Object Detection:**
- The TensorFlow object detection algorithm analyses the captured images to detect common crop diseases such as black fungus pod, early and late leaf spot, fungus leaf, and rust leaf.

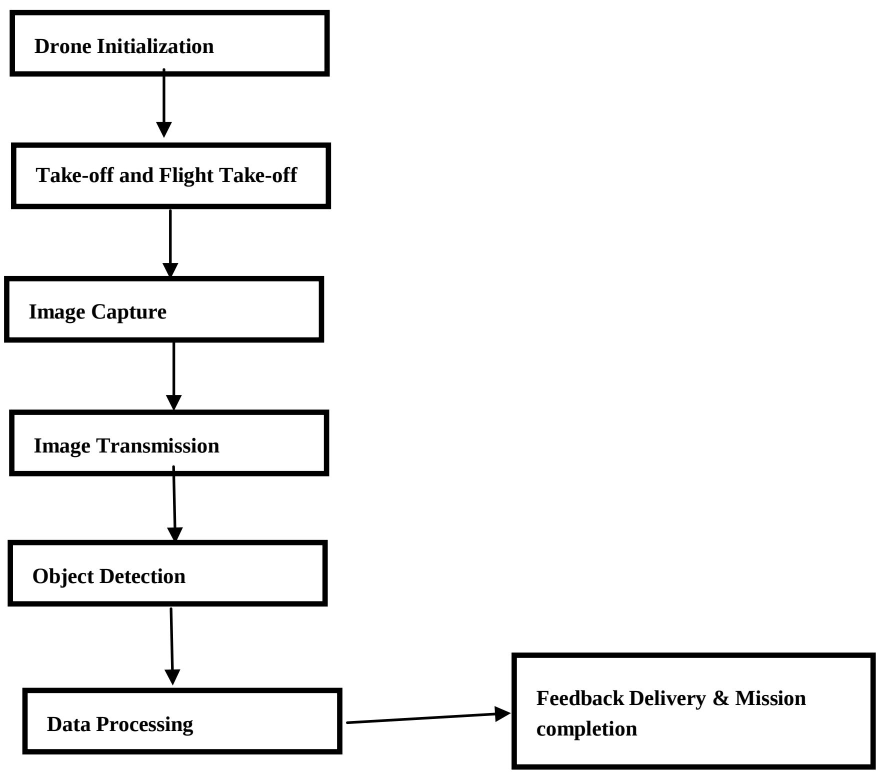
6. **Data Processing:**
- Detected diseases are processed and categorized using data processing algorithms to generate actionable insights.

7. **Feedback Generation:**
- Based on the detected diseases, feedback is generated to provide farmers with information on crop health and potential interventions.

8. **Feedback Delivery:**
- Feedback is delivered to farmers via the web interface and Robo Flow interface, accessible through web browsers or mobile applications.

9. **Mission Completion:**
- Once the flight mission is completed, the drone returns to base or continues monitoring as per the predefined mission parameters.

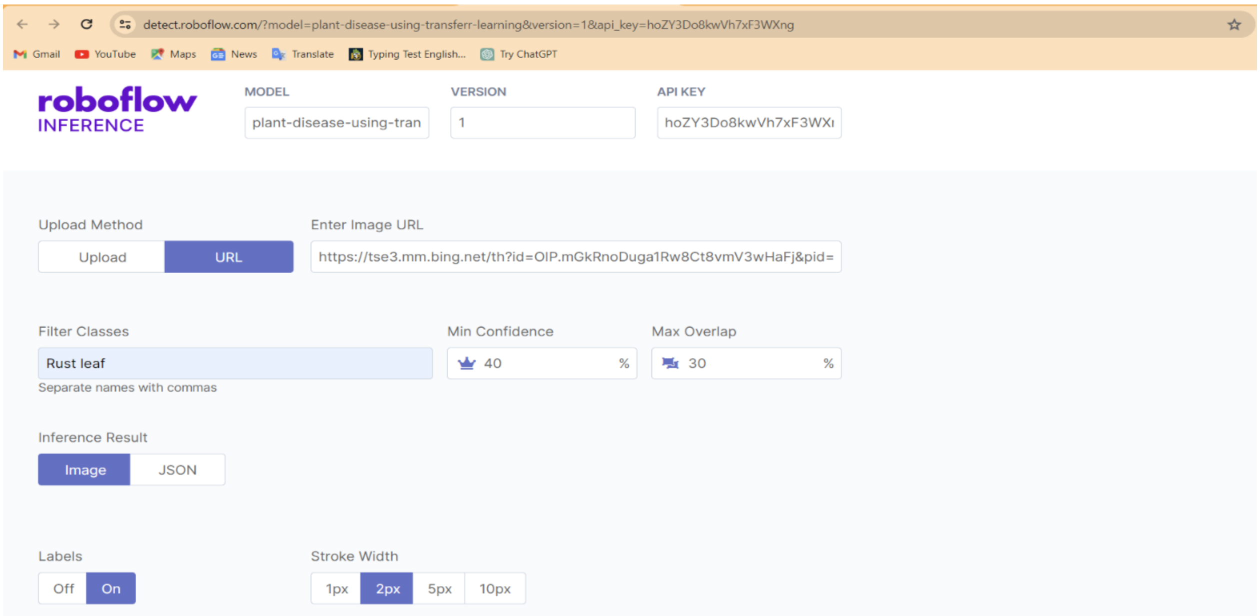
iii. FLOW CHART:



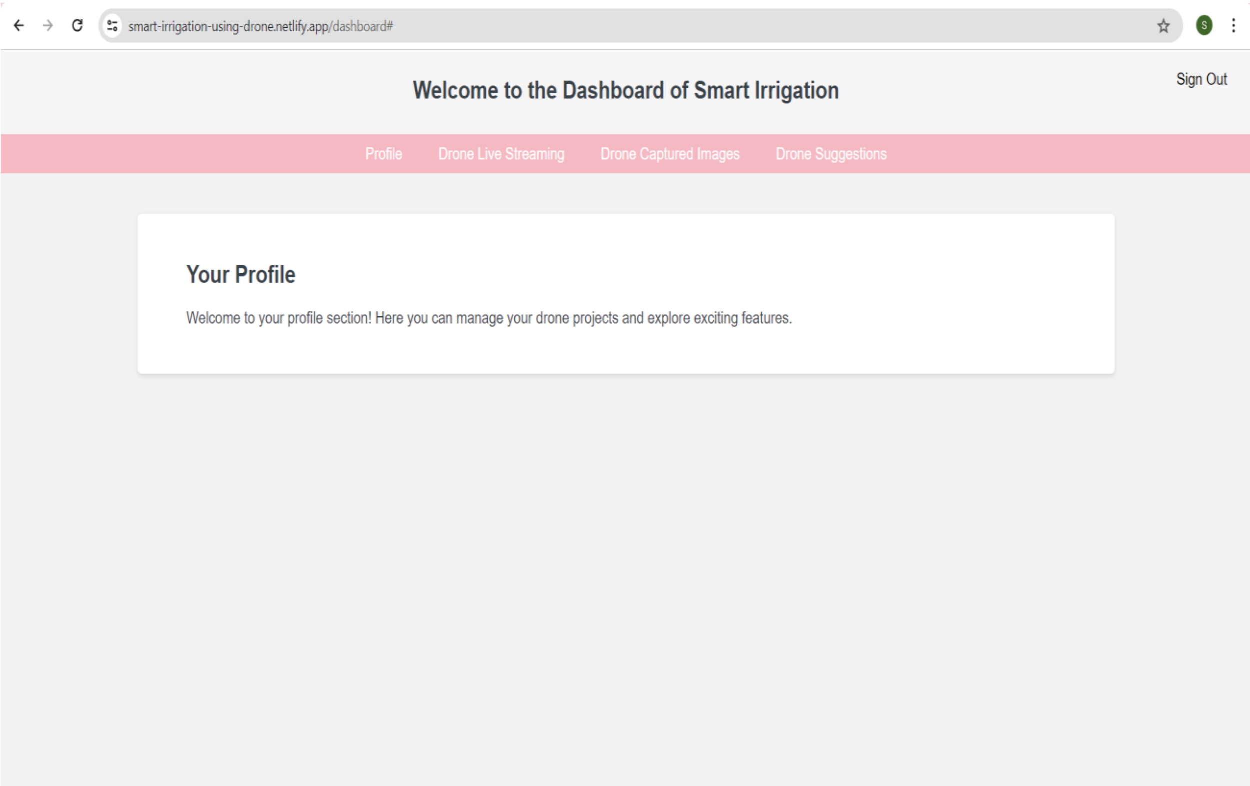
V. RESULTS

HARDWARE:

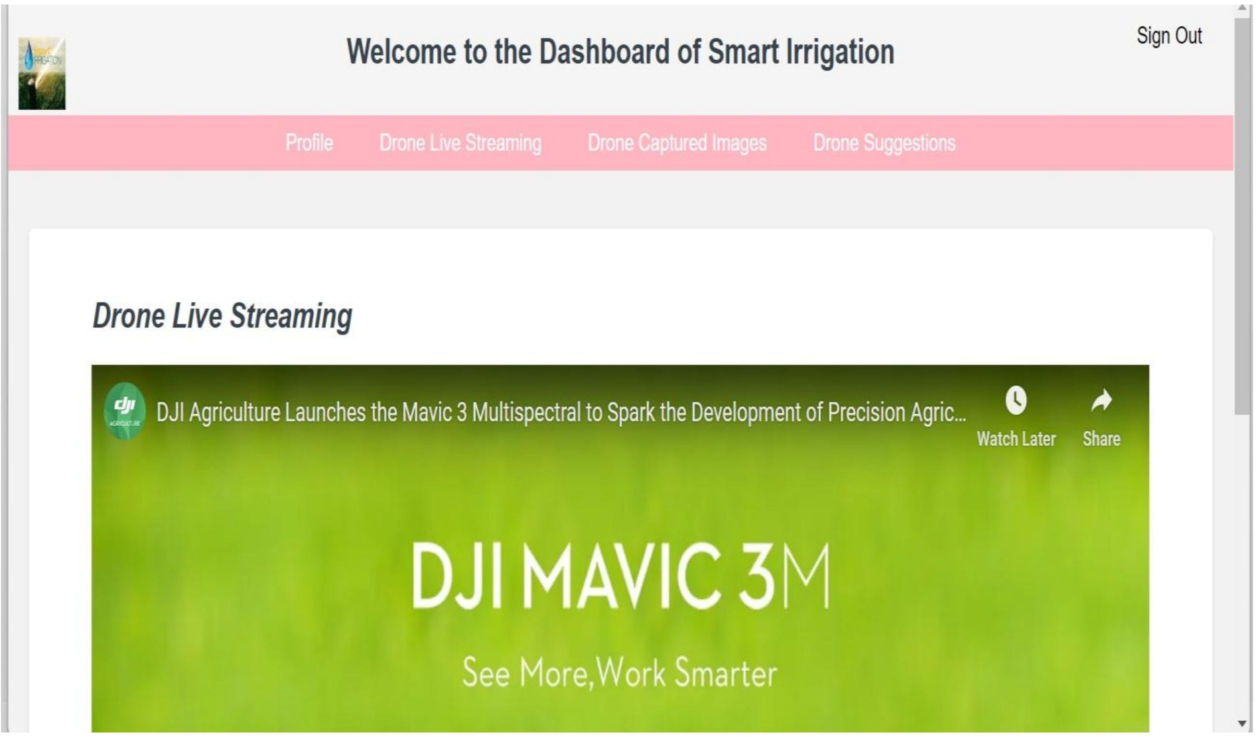
SOFTWARE:



https://detect.roboflow.com/?model=ground-nut-diseased-detection&version=1&api_key=hoZY3Do8kwVh7xF3WXng



https://smart-irrigation-drone.netlify.app/



VI. FUTURE SCOPE

Enhanced AI Algorithms: Continuous advancement in AI algorithms holds immense potential for revolutionizing disease detection and crop monitoring in agriculture. By integrating state-of-the-art techniques such as deep learning and reinforcement learning, the drone system can attain unprecedented levels of accuracy and efficiency. These enhanced algorithms will enable the system to not only detect common crop diseases with greater precision but also provide deeper insights into crop health parameters, paving the way for more informed decision-making by farmers.

Autonomous Operations: The evolution towards achieving full autonomy in drone operations signifies a pivotal step towards enhancing the scalability and efficiency of agricultural practices. Future iterations of the drone system can focus on implementing autonomous functionalities such as take-off, landing, navigation, and data collection. This autonomy will not only reduce the reliance on manual control but also enable drones to cover larger areas more efficiently, ultimately leading to improved productivity and resource management in agriculture.

VII. CONCLUSION

The integrated drone system showcased in this project represents a significant advancement in addressing the challenges faced by modern agriculture. By leveraging cutting-edge hardware components and sophisticated software algorithms, the system empowers farmers with actionable insights to optimize crop management practices and maximize yields. However, the journey towards realizing the full potential of precision agriculture requires continuous innovation and collaboration across interdisciplinary fields. By embracing emerging technologies, enhancing accessibility, and focusing on scalability, the vision of sustainable food production and economic prosperity for farming communities worldwide can be realized.

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