Smart Aerial Plant Classification System

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***Abstract*—The rapid advancement of machine learning (ML) and unmanned aerial vehicles, commonly known as drones, has opened new possibilities for plant monitoring. This paper presents a novel approach for the detection of plant names using ML-based drone technology. The system leverages high resolution aerial imagery captured by drones and employs advanced machine learning algorithms to identify and classify various plant names in real-time. To facilitate efficient and effective plant name monitoring, a camera equipped will be deployed to take aerial photographs. An edge computing paradigm of Machine Learning is employed to process this image in order to make decisions with the least amount of latency possible.**

This Research presents a drone-based plant recognition system that helps identify specific plants from an aerial view using machine learning. A small drone is used to capture images of plants while flying over the area, and the images are transmitted to a server for further analysis. The system is trained using a dataset of selected plants so that it can recognize and display the plant name from the captured images. By combining aerial monitoring with intelligent image analysis, the system aims to make plant identification quicker and more convenient. This approach can help reduce the effort involved in manual inspection and support more efficient monitoring of plants in agricultural or green environments.

***Index Terms*—Machine Learning (ML), Drone-Based Plant Recognition System, Dataset, Plant Name, Image Analysis.**

I. INTRODUCTION

Agriculture is gradually adopting modern technologies to improve the way crops and plants are monitored in large farming areas. Identifying plant types through manual observation can be slow and sometimes inaccurate, especially when the field is wide or difficult to access. With the development of aerial imaging and machine learning, it has become possible to observe plants from above and analyze them automatically. A drone-based plant recognition system offers a practical way to capture plant images and process them using intelligent algorithms that can recognize specific plants from a trained dataset. By combining aerial monitoring with automated image analysis, this approach helps make plant identification faster, more convenient, and more efficient for agricultural observation and management.

II. LITERATURE REVIEW

Sabab Ali Shah et al., in his research proposes an automatic plant identification process based on a synthetic neural network with the ability to detect images of plant leaves. The trained model EfficientNet-B3 was used to achieve a high success rate of 98.80% in identifying the corresponding combination of plant and disease. To make the system user-friendly, an Android application and website were developed, which allowed farmers and users to easily detect diseases from the leaves. In addition, the paper discusses the transfer method for studying various plant diseases, and images were captured using a drone or a smartphone camera. The ultimate goal is to create a user-friendly leaf disease product that can work with mobile and drone cameras. The proposed system provides a powerful tool for rapid and efficient plant disease identification, which can aid farmers of all levels of experience in making informed decisions about the use of chemical pesticides and optimizing plant health.

Dr. Naseer R et al., in his research investigates the use of drones with artificial intelligence (AI) to identify crop diseases in precision agriculture. The suggested approach gives farmers precise and timely tools for regulating crop health by combining machine learning algorithms, remote sensing technology, and real-time monitoring. This method seeks to maximize harvest yields and minimize production losses by detecting diseases early on through the use of comprehensive disease databases and high-resolution imaging. This strategy is important because it can help with issues like food safety, agricultural production, and revenue loss—all of which are major concerns in poor countries. For big farms, traditional techniques of visual inspection by specialists are impractical due to their high cost and time requirements. Thus, using AI-powered drones to automate disease detection presents a workable way to improve agricultural sustainability and guarantee world food security.

Prayaga Siddappa et al., in his research discusses the system architecture, including the drone hardware, imaging sensors, and the AI algorithms used for image processing. It also addresses implementation challenges such as varying environmental conditions and the need for large annotated datasets for training the AI models. Preliminary field trials demonstrate the system's effectiveness in detecting common plant diseases, with promising results that suggest significant potential for improving crop management and yield. Future work will focus on expanding the range of detectable diseases, enhancing the robustness of the AI models, and integrating the system with existing agricultural management platforms

Prof. Daund R. P. et al., in his research discusses as Plant diseases are one of the major threats to global food production. Efficient monitoring and detection of plant pathogens are instrumental in restricting and effectively managing the spread of the disease and reducing the cost of pesticides. Traditional, molecular, and serological methods that are widely used for plant disease detection are often ineffective if not applied during the initial stages of pathogenesis, when no or very weak symptoms appear. The advantages of drone technology include high spatial resolution (as several sensors are carried aboard), high efficiency, usage flexibility, and more significantly, quick detection of plant diseases across a large area with low cost, reliability, and provision of high-resolution data. Drone technology employs an automated procedure that begins with gathering images of diseased plants using various sensors and cameras. After extracting features, image processing approaches use the appropriate traditional machine learning or deep learning algorithms. Features are extracted from images of leaves using edge detection and histogram equalization methods. Drones have many potential uses in agriculture, including reducing manual labor and increasing productivity. Drones may be able to provide early warning of plant diseases, allowing farmers to prevent costly crop failures

Danila Donskoy et al., This paper presents the possibility of applying a modern ESP32 microcontroller platform in the agro industrial sector to create intelligent devices based on the Internet of Things. CNN models are implemented based on the TensorFlow architecture in hardware and software solutions based on the ESP32 microcontroller from Espress if company to classify objects in crop fields. The purpose of this work is to create a hardware–software complex for local energy-efficient classification of images with support for IoT protocols. The results of this research allow for the automatic classification of field surfaces with the presence of "high attention" and optimal growth zones. This paper shows that classification accuracy exceeding 87% can be achieved in small, energy-efficient systems, even for low-resolution images, depending on the CNN architecture and its quantization algorithm. The application of such technologies and methods of their optimization for energy-efficient devices, such as ESP32, will allow us to create an Intelligent Internet of Things network.

Gouri D Malgi et al., This paper is driven by the imperative need to address a critical challenge faced by farmers worldwide: Leaf disease. This paper outlines the development of a comprehensive solution for precision agriculture aimed at enhancing crop health management through drone-based leaf disease detection and classification and pesticide spraying. Leveraging advanced imaging technology and machine learning algorithms, our system enables real-time identification of leaf diseases. By integrating with pesticide spraying systems, our solution offers precise treatment, minimizing environmental impact and optimizing resource utilization. Additionally, considerations such as cost-effectiveness, scalability, and user-friendliness are addressed to ensure practical feasibility and adoption by farmers and agricultural stakeholders. Through the integration of drone technology, machine learning, and precision agriculture techniques, this paper showcases a promising solution for combating leaf diseases and optimizing pesticide application in crop management, ultimately contributing to increased crop yields, reduced environmental impact, and enhanced food security.

P.M. Benson Mansingh et al., These days a large number of the ranchers and agro help focus and utilize the distinctive new innovation to upgrade the agribusiness creation. Plants have become significant wellsprings of energy. Yield development assumes a fundamental part in the rural field. There are a few illnesses that influence plants which reflexively diminishes the creation rate. In the event that the illness isn't distinguished from the outset stage then it is more mischief full to creation. The primary test is to decrease the labor and significant stretch of time for distinguishing the illnesses. To defeat this test an automated elevated vehicle (UAV) is utilized to catch the influenced plants pictures and an improved k-mean grouping calculation to anticipate the tainted zone of the leaves. A shading-based division model is characterized by sectioning the contaminated locale and putting it to its pertinent classes. Test examinations are done on example pictures utilizing picture preparation strategies. MATLAB programming. Sickness identification measures include different advances like picture securing, picture pre-preparing, picture division, highlight extraction and characterization. Our venture is utilized to distinguish the plant illnesses and give answers for recuperation from the infection. It shows the influence part of the leaf in rate.

Swapna Choudhary et al., the Detection of Plant Leaf Diseases using the Internet of Things and a Machine Learning Drone System is developed. Convolutional neural network (CNN) architecture is used to detect objects. ESP32 Cam captures images of plants from the field. A computer system is trained to recognize plant diseases using a plant disease dataset obtained from Kaggle. The algorithm is trained to overcome the existing limitations and to enhance the performance.

Rodica Gabriela Dawod et al., Recent studies have approached the identification of foliar plant diseases using artificial intelligence, but in these works, classification is achieved using only one side of the leaf. Phytopathology specifies that there are diseases that show similar symptoms on the upper part of the leaf, but different ones on the lower side. An improvement in accuracy can be achieved if the symptoms of both sides of the leaf are considered when classifying plant diseases. In this context, it is necessary to establish whether the captured image represents the leaf on its upper or lower side. A second feature is the thickness of the primary and secondary veins. The veins of a leaf are more prominent on the lower side, compared to the upper side. A third feature corresponds to the concave shape of the leaf on its upper part and its convex shape on the lower part. In this paper, they aim to achieve upper and lower leaf side classification using both deep learning methods and machine learning models.

M Shunmuga Priyan et al., This paper presents an IoT-based medicinal plant identification system that integrates deep learning with robotics and wireless communication to automate the process of plant species recognition in real-world environments. Manual plant identification is time consuming and often error-prone, especially in inaccessible regions. With the advancement of IoT, automated plant classification systems can now be deployed in the field. The ESP32-CAM, a compact low-power module with onboard Wi-Fi and camera, offers an ideal platform for real-time image capture and cloud data transmission. Combining this with the Rocker-Bogie mechanism enables smooth traversal over rough terrain, making it suitable for field applications. The proposed system consists of a mobile robotic platform using the Rocker-Bogie mechanism for stable all-terrain navigation. Mounted on the robot is an ESP32-CAM module that captures high-resolution images of plants from multiple angles. A GPS module is integrated to tag each image with accurate geolocation data. The Rocker-Bogie platform provided stable movement across uneven surfaces, while the ESP32-CAM captured clear images for classification. The developed IoT-based medicinal plant identification system effectively combines to provide a reliable and scalable solution for automated plant monitoring in remote environments.

III. METHODOLOGY

The proposed system is designed to recognize selected plants using a drone-assisted monitoring approach combined with machine learning. In this system, a mini drone carries an ESP32 camera module that captures images of plants while flying over the target area. The captured images are transmitted to a server for further processing. A trained machine learning model then analyzes these images and compares them with a dataset containing selected plant samples. Based on the learned features, the system identifies the plant and displays its name. This method allows plant recognition to be performed more quickly and efficiently without relying on continuous manual observation. By integrating aerial image capture with intelligent analysis, the system provides a convenient way to monitor plants and organize plant-related information.

IV. BLOCK DIAGRAM

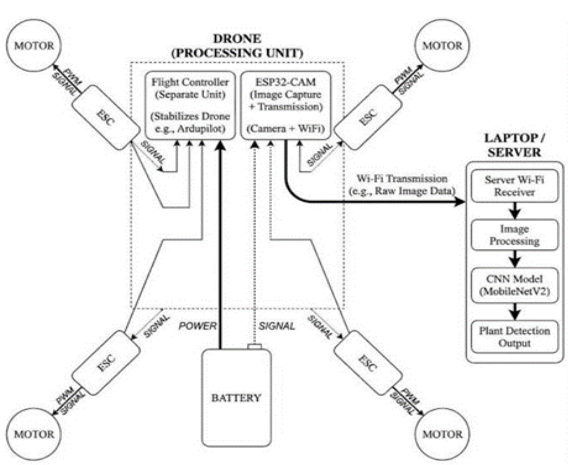


Fig. 1 Shows the Block Diagram of the Proposed System

The system architecture of the proposed Drone-Based Harmful Plant Detection System is designed to perform real-time monitoring and identification of harmful or illegal plant species in remote areas using a combination of drone technology and deep learning. The architecture consists of two major parts: the drone unit (image acquisition unit) and the processing unit (laptop/server). The drone is responsible for capturing images of the target area and transmitting them wirelessly, while the processing unit performs image analysis and classification using a trained Convolutional Neural Network (CNN) model.

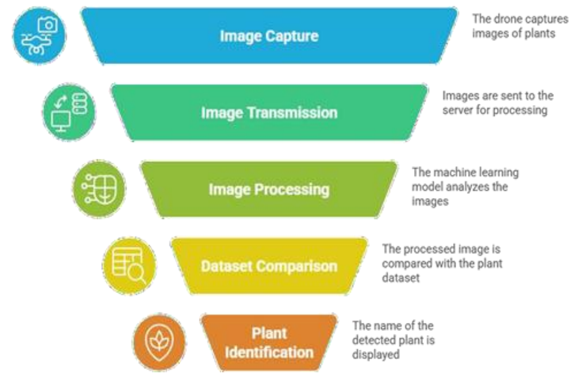


Fig. 2 Shows the Flowchart of the Proposed System

The working of this system begins when the mini drone is deployed over the area where plant monitoring is required. The drone is equipped with an ESP32 camera module that captures high-quality aerial images of plants from different heights and viewing angles, ensuring maximum field coverage and better visibility of plant features. These images are then transmitted to a connected server using a wireless communication method such as Wi-Fi.Upon receiving the images, the server performs essential preprocessing steps including resizing, noise reduction, and normalization to enhance image quality and maintain consistency for analysis. The processed images are then fed into a pre-trained machine learning model, such as a Convolutional Neural Network (CNN) or YOLO-based object detection algorithm. This model is trained on a dataset containing images of various plant species, enabling it to recognize different types of plants effectively.

The model analyzes important visual characteristics such as leaf shape, texture, color, and structural patterns. It compares these features with the trained dataset to identify the plant accurately. In cases where multiple plants are present in a single image, the system can detect and classify each plant individually. After identification, the system displays the plant name along with a confidence score indicating the accuracy of prediction. The results can be accessed through a web or mobile interface, and the data can be stored for further analysis. This system enables efficient, accurate, and automated plant identification, reducing manual effort and supporting modern smart agriculture practices.

V. IMPLEMENTATION

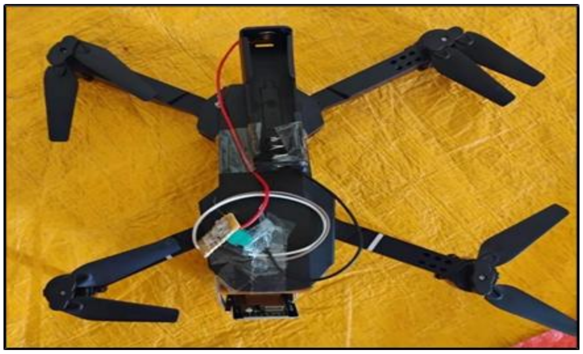


Fig. 3 Shows the Experimental Setup of the Proposed System

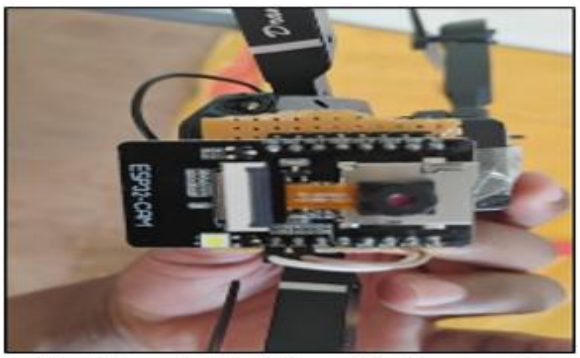
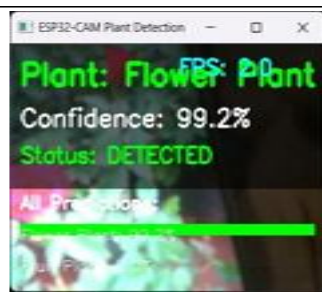


Fig. 4 Shows the Back View of the Experimental Setup

VI. RESULT

The developed system successfully demonstrates the ability to recognize selected plants using aerial image capture and machine learning analysis. During testing, the drone was able to capture clear images of plants, which were then transmitted to the server for processing. The trained model analyzed these images and identified the plant names from the prepared dataset with reliable results. The system showed that plant identification can be performed more quickly and conveniently compared to manual observation. Overall, the paper proves that combining drone-based monitoring with intelligent image recognition can provide an effective approach for observing and identifying plants in different environments.

Sr. No.	INPUT (Figure)	OUTPUT (Figure)	DESCRIPTION
1	 Fig. 5: Rose plant	 Fig. 6: Detection result	The image shows the output screen of a flower plant detection system where a camera-based model identifies the plant as a “Flower Plant” with a confidence score of 99.2%. The status is displayed as “Detected”. The interface shows the prediction result, confidence percentage, and detection status in real-time.
2	 Fig. 7: Mango Plant	 Fig. 8: Detection result	The image shows the output window of a fruit plant recognition system where a camera identifies the plant as a “Fruit Plant” with a confidence score of 92.7% and status as “Detected”.

3	 Fig. 9: Tulsi Plant	 Fig. 10: Detection result	The image shows the output window of a fruit plant recognition system where a camera identifies the plant as a "Medicinal Plant" with a confidence score of 97.9% and status as "Detected".
4	 Fig. 11: Cannabis Plant	 Fig. 12: Detection result	The image shows the output window of a fruit plant recognition system where a camera identifies the plant as a "Harmful Plant" with a confidence score of 99.8% and status as "Detected".
5	 Fig.13 Chrysanthenmu n Plant	 Fig.14 Detection result	The image shows the output window of a fruit plant recognition system where a camera identifies the plant as a "Flower Plant" with a confidence score of 99.8% and status as "Detected".

VII. CONCLUSION

The paper successfully demonstrates a practical and efficient way to identify selected plants using a drone-based system combined with machine learning. By capturing aerial images and analyzing them through a trained model, the system reduces the need for manual inspection while providing accurate and timely plant recognition. This approach not only saves time and effort but also supports better monitoring and management of agricultural or green areas. Overall, the paper highlights how integrating technology with plant observation can make plant identification simpler, faster, and more reliable.

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