Adoption of Drone Technology for Agricultural Monitoring

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***Abstract*- The world's population is growing at a fast pace and is projected to reach 9.6 billion by 2050, leading to a significant rise in food demand. To address this challenge, agricultural productivity must be enhanced through modernization. Traditional farming methods alone may not be sufficient to meet future food requirements. Factors such as climate change, water scarcity, and declining soil fertility further complicate agricultural production. Therefore, integrating advanced technologies into farming practices has become essential for sustainable growth. One effective solution to improve crop yield is the adoption of drone technology in farming. This paper examines the impact of drones on agriculture over the past decade, particularly in areas such as crop monitoring and precision agriculture, including pesticide application. It also discusses drone design, advancements in sensor technologies, and innovations in targeted spraying techniques. Additionally, the role of artificial intelligence and deep learning in enabling efficient remote crop monitoring is explored.**

Keywords - Unmanned aerial vehicle, agricultural drone, crop monitoring, precision agriculture, remote sensing, drone, deep learning, machine learning, deep learning, vegetation index.

I. INTRODUCTION

The exponential growth of the global population has resulted in significant challenges in maintaining food security. The Food and Agriculture Organization of the United Nations (FAO) reports that over 1 billion people are chronically malnourished, with 64% residing in Asia. To meet the demands of a growing population, food production needs to increase by 50% by 2050. However, the availability of resources such as land and water for agriculture is dwindling. Studies have shown that 9.2% of the world's population is suffering from extreme food scarcity, while a further 17.2% experience moderate food insecurity. These issues have been exacerbated by the COVID-19 pandemic, which has had a significant impact on the agricultural industry, leading to reduced crop yields and food shortages.

Developing countries in Asia, including India, are particularly vulnerable to these challenges due to outdated farming technology, power shortages, and unskilled farmers. Traditional farming methods, such as the manual application of pesticides and fungicides, are time-consuming and less effective. Hence, there is a need for technological advancements in this field, particularly in light of the difficulties presented by the COVID-19 pandemic.

Drone technology can be a game-changer for the agricultural industry, particularly for precision agriculture (PA) and smart farming. With drone monitoring systems, farmers can obtain detailed aerial footage of their crops, providing valuable information on soil quality, water management, and pests or fungal infestations. The high-resolution images collected by drones can also provide detailed data on plant health, which may not be visible to the naked eye. This information is updated regularly, allowing farmers to take timely and appropriate action for improved crop management.

Drones can also be used for payload devices, including plant health monitoring and pesticide spraying, which can significantly improve crop yield and reduce environmental impact. Compared to traditional methods of crop monitoring using manned aircraft or satellites, drone technology is more cost-effective and time-efficient. Additionally, drones can capture high-resolution images in a non-destructive manner, providing a more accurate picture of crop health and yield potential.

In conclusion, the use of drone technology in agriculture has enormous potential for addressing the challenges posed by the growing global population and resource scarcity. By providing farmers with detailed and timely information on their crops, drones can improve productivity, reduce waste, and ensure food security.

Fig. 1: Taking flight with cutting-edge drone technology

II. AGRICULTURAL DRONE

There are two main categories of agricultural drones: those used for plant health monitoring and those used for pesticide spraying. Plant health monitoring drones are equipped with sensors that can detect early signs of crop stress, nutrient deficiencies, and disease, allowing farmers to take corrective action before the issue becomes widespread. Pesticide spraying drones, on the other hand, can accurately and efficiently spray crops with pesticides, reducing the need for manual labor and minimizing exposure to harmful chemicals. Overall, agricultural drones have the potential to revolutionize the way farmers manage their crops, increase yields, and improve food security.

Agricultural drones are drones used in agriculture to increase crop production and monitor plant growth. The information gathered by these devices can prove useful in improving crop yields and farming efficiency. Agricultural drones are a relief for modern farmers. Drone technology can reduce labour and resource requirements. Farmers can also use drones to take aerial photos of their fields. Realizing the potential of drones, the Japanese government first used drones in 1986 to track down the cause of rice farmers' decline. About 35% of Japan's rice fields are now controlled by drones. Now the Ministry of Agriculture, Forestry, and Fisheries is focusing vigorously on the use of drones in agriculture. Agricultural drones are a relief for the modern farmer. They help increase productivity and reduce costs by reducing the need for human labour and other inputs.

Fig. 2: Aerial technology transforming modern agriculture

Fig. 3: Agricultural drones spraying crops for efficient and precise farming

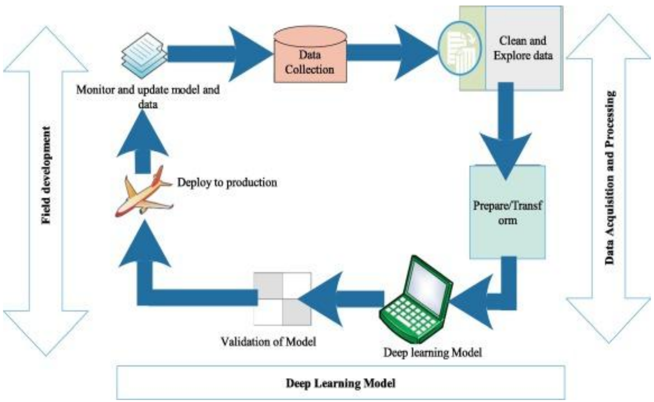


Fig. 4: End-to-end deep learning workflow

Fig. 5: Drone-based precision agriculture platform used for crop monitoring and real-time field data collection

III. COMPONENTS

The BLDC motor powers the propeller, which is controlled via the ESC and is powered by means of a battery linked thru a battery connector, while communication is done through the transceiver and the frame holds the whole thing collectively; wires connect the whole lot to the flight controller and drone PCB board, with battery protection and GPS module making sure secure and accurate flights, and the LiPo battery charger maintains the battery charged; extra features like a radio digicam and multispectral sensor are added for extra advanced functionality.

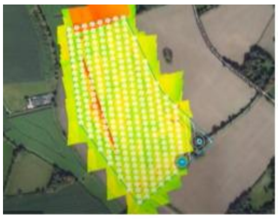
IV. WORKING

Unmanned Aerial Vehicles (UAVs), commonly known as drones, are typically constructed using lightweight composite materials to enhance maneuverability and reduce weight. Military drones, specifically, can operate at very high altitudes thanks to the strength of these materials. UAVs are equipped with advanced technologies such as GPS, infrared cameras (for military purposes), and lasers (also for military purposes). They can be operated using a remote control system or a ground cockpit, and come in various sizes ranging from hand-launched drones to larger military ones like the Predator drone, which require short runways for takeoff and landing. The system of an UAV comprises the drone itself and the control system, with the front of the drone housing all the sensors and navigation systems. The body of the drone is an innovative design that maximizes space and minimizes weight, making use of complex composites that absorb vibrations to reduce noise. The diagram above shows how UAVs can operate in any environment without creating noise or requiring a human pilot, which is why they are often referred to as unmanned aerial vehicles. To operate the drone, the user marks the desired area on their computer or mobile device, after which the drone captures images of the target area using multispectral camera sensors. The images are then analyzed using software to obtain accurate information. The cameras, sensors, and software are the main agents of surveillance, providing detailed information about the target area.

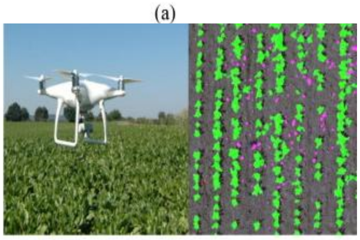
V. CROP HEALTH MONITORING

Daily crop monitoring by farmers involves detecting potential threats such as diseases, pests, and slow growth. Traditional monitoring methods include visual inspections and manual soil sample collections from random locations.

For over 50 years, color and infrared photographs have been used to monitor crop growth from various platforms. Drone technology has enabled advanced image data analysis tools to identify plants with diseases or defects. Drones are primarily used for field mapping and crop monitoring in agriculture. This section analyzes the use of drones for crop monitoring, which includes creating a map with vegetation indices based on images captured by the drone camera. These indices help estimate plant information such as their health status, nutrient requirements, and water stress. The selection of sensors used with drones is critical for effective crop monitoring and depends on their applications, such as disease detection, nutrient detection, and water status identification. In 2010, a digital color infrared camera system for field monitoring of wheat was developed, and in 2012, an autonomous hexacopter called VIPtero was developed for site-specific vineyard management. In 2015, AggieAir, a remote sensing technology, was proposed for agricultural applications, capable of capturing high-quality multispectral image data for crop health monitoring. In 2016, a drone system was used to study water status in vineyard crops using aerial thermal images, and in 2017, a simple multispectral imaging system for UAV-based agricultural applications was proposed. However, these systems have limitations due to factors such as flight altitude and camera resolution.



(a)



(b)

Fig. 6: (a) Flight planning and aerial image acquisition for agricultural field mapping.
(b) Deep learning-based crop detection and localization from UAV-acquired imagery.

A. Study area:

The study was conducted in Ghaziabad, a city located in the northwestern region of the Indian state of Uttar Pradesh. Uttar Pradesh is situated between latitudes 23°52'N and 31°28'N and longitudes 77°3' and 84°39'E and is divided into three Agro-climatic zones. The sub-zone covering numerous districts, namely Shahjahanpur, Bareilly Rampur, Moradabad, Bijnor, Saharanpur, Muzaffarnagar, Meerut, Baghpat, Ghaziabad, and Bulandshahar, encompasses the study area. This region is known for its high agricultural productivity, with approximately 70% of the land used for farming and 5% under forest cover. Irrigation is mainly done through tube wells, and around 76% of the land is irrigated. The climate in the area is dry sub-humid to semi-arid, with an average rainfall of 907 mm, and the soil is predominantly loamy to sandy loam.

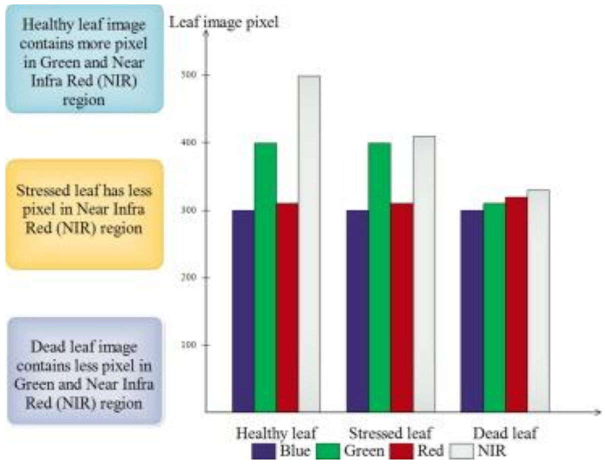


Fig. 7: Spectral reflectance comparison of healthy, stressed, and dead leaves using RGB and Near-Infrared (NIR) bands, demonstrating the effectiveness of multispectral imaging for crop health assessment and stress detection.

B. Data set:

Fig. 8:

C. Data processing:

We will use library 'os' to read the file name from folder, and library 'cv2' (opencv) to do image processing. The individual dataset data will be stored in the list 'imgs' and the name of the data will be stored in the list 'labels'. Then find the GLCM matrix and the texture metric of the entire image. Next, we change the glcm_features data format from list to data frame using the library.

VI. Conclusion And Future Scope

Drones have increasingly been used in agriculture over the past decade, but their adoption is hindered by several key constraints, including high initial costs, limited sensor capabilities, strict aviation regulations, and lack of farmer interest. While the application of drones in agriculture is still in its infancy, there is significant potential for further development in both technology and various applications. Advancements in drone technology are expected to lead to improved image processing techniques, lower costs, and the ability for drones to hover like tractors in agriculture in the future. The Indian drone industry offers enormous opportunities for skill development and job creation, with potential applications in agriculture, healthcare, tourism, media, and other industries. With many players in the market for drone devices and innovative solutions, a customized plan is needed to address everyday problems. Different types of drones, such as surveillance drones, drone delivery services, internet-connected drones, pesticide-spraying drones, and heavy-duty construction drones, can be developed and utilized to their fullest potential. The corporate world has also recognized the value of drones, and the potential for India to become a global drone hub is significant.

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