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SMART AGRICULTURE: ENHANCING PLANT DISEASE DETECTION WITH DRONE TECHNOLOGY

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Abstract

This technology transforms farm management by optimizing resource consumption and improving crop health through the integration of AI-driven disease diagnosis and targeted watering. A quadcopter drone equipped with a GPS and high-resolution camera captures geo-referenced images for aerial surveys, which are processed in real-time by an onboard edge intelligence unit. Advanced AI technologies locate and map affected areas, instantly linking diseases to precise locations. Only the affected areas may receive precise water and nutrient supplies if this data is wirelessly transmitted to intelligent irrigation systems. The technique reduces unnecessary fertilizer and pesticide use, eliminates water waste, and boosts yields while promoting sustainability. Early disease diagnosis helps prevent large-scale epidemics and supports proactive management. This method combines drone-based remote sensing, AI-powered analysis, and precision irrigation to boost agricultural yield while conserving resources.

Key Words – GPS Navigation, Smart Irrigation, Drone,Geo Referenced Imaging, Leaf Disease Detection, Wireless Communication.

1. Introduction

Making wise investment decisions in today's volatile financial markets requires accurate stock price forecasting. We Crop diseases influence crop quality and yields, which in turn reduce farmers' income, and therefore represent a serious threat to global food security. For small-scale farmers in particular, the traditional disease diagnostic techniques, which depend on laboratory testing and physical inspections, may be expensive, time-consuming, and labor-intensive. Agricultural losses could be exacerbated by infections that spread as a result of delayed diagnosis. This study presents a drone-based crop disease detection system that uses cutting-edge precision agricultural technology to address these issues. The exact GPS locates hazardous areas, machine learning automatically analyzes images, and IoT-based connectivity transmits real-time data to farmers. This strategy facilitates early detection, focused intervention, and improved disease management by lowering crop losses and encouraging sustainable farming methods. Using actionable insights, farmers may apply early and accurate treatments, reducing disease spread and increasing overall output. This technology-driven approach lowers costs and increases productivity while promoting a more robust and sustainable food production system.

2. Literature Review

Shahi et al (2023) the existing research covered by our review questions. First, the different UAV platforms, sensors, used in the studies we reviewed also examine how these platforms affect the performance of methods for estimating crop diseases and highlight the most effective vegetation indices and their success in detecting specific crop diseases. Additionally, the performance of advanced data-driven methods, and the various features used, including vegetation indices.

Yamamoto S et al (2023) To track the changes in *soybean root rot* damage over time, researchers used drones to capture multispectral images of the same field across two years. Field studies confirmed that the disease reduced soybean yields in both years. By analyzing the images with supervised classification, they were able to map how the damage spread over time and calculate how quickly the affected areas grew. The results showed differences between the two years, indicating that various factors, beyond just the disease itself, play a role in the extent of the damage.

Md. Jobayer Rahman et al (2023) using data-driven methods in agriculture has the potential to greatly improve in farming. By using technology and expert knowledge, farmers can make smarter, more profitable decisions, which boosts productivity and promotes sustainability. Working closely with farmers has helped us fine-tune our approach, making it practical, affordable, and beneficial for their livelihoods. To create lasting change, it's crucial to use data-driven strategies, get continuous feedback, and adapt to evolving conditions. In the future, plan to analyze more crop data using GPS-based IoT and sensors from different regions, with machine-learning algorithms for analysis.

Muhammad Suleman Memon et al (2020) The Deep Learning, IoT, and other technologies can be used for smart farming. Various methods and techniques are covered for managing crops using Machine Learning, Deep Learning, and IoT. These approaches offer insights into how technology can be applied to monitor crops, identify issues like leaf diseases, and predict crop yields. The chapter also emphasizes the importance of techniques like CNN, SVM.

Ruben Chin et al (2023) using aerial drones, medical professionals can improve their effectiveness and efficiency, potentially saving more lives. In agriculture, research shows that blight and wilt are the most commonly studied plant diseases. To better understand how drones are used for disease detection, the diseases were grouped into five categories, with results showing that fungus-related diseases usage. Virus and abiotic diseases were studied in only 10% of the research. This suggests that while more research is needed for these less-studied diseases, drones can already be effectively used to detect fungus-related diseases due to the strong scientific backing.

El Mehdi Raouhi et al (2023) Drones are transforming agriculture by enabling smarter and more efficient farming practices. With technologies like AI, IoT, and cloud computing, they help farmers monitor crops, collect data, and make better decisions for improved productivity and sustainability. A systematic review using the PRISMA method highlights how drones are valuable for precision farming, offering accurate monitoring and management of large-scale farming operations. These advancements make farming more sustainable and efficient, paving the way for smarter agriculture.

Gregorio Z et al (2023) Recent research on using UAVs (drones) for crop disease detection focuses on the platforms, sensors, and settings, such as flight height, that influence how accurately these drones can estimate crop health. The studies look at how different UAV configurations impact the performance of various disease detection methods. They also identify which vegetation indices—like specific formulas based on plant reflectance—work best for detecting different crop diseases. Furthermore, the research explores the effectiveness of advanced data analysis techniques, to improve detection, using features like vegetation indices to enhance accuracy.

Mohamed Emimi et al (2023) In 2018 and 2020, UAVs were used to take multispectral images of soybean fields to study how red crown rot (RCR) damage changed over time. Field studies revealed that *soybean root rot* led to a noticeable decrease in soybean yields in both years. Researchers used image analysis to track how the disease spread and how much the affected areas grew over time. The differences in how much the damage grew between the two years suggest that other factors, besides the spread of the pathogen, also play a role in the extent of the damage.

Zhihong Zhang et al (2023) In a study on soybean fields, drones were used to take multispectral images in 2018 and 2020 to examine the effects of *soybean root rot*. The field research showed that the disease caused a decrease in soybean yields in both years. By analyzing the images, the researchers could track how the damage spread and how it changed over time.The data showed that the extent of the damage increased in both years, but the rate of increase varied between the two. This suggests that factors other than just the spread of the pathogen, like environmental conditions or management practices, may also play a role in how the damage develops.

Wei Zhao et al (2023) The "Deep Learning and IoT: Enabling Technologies Towards Smart Farming" explores various methods and techniques for managing agricultural crops using Machine Learning, Deep Learning, and IoT. It provides detailed insights into implementing these technologies for crop monitoring, identifying crop health issues such as leaf diseases, and predicting crop production.

Zhang, T et al (2021) Different techniques like deep learning models, decision trees, and machine learning algorithms are becoming increasingly important in modern agriculture. These methods help farmers by providing better tools to manage crops and improve yields. CNNs are great for analyzing images, making them useful for detecting crop diseases or pests from aerial photos. SVMs are used for classifying different types of crops or predicting their growth patterns, while Random Forest Models help in making decisions based on multiple factors, such as weather or soil conditions, to optimize farming practices. Overall, these techniques support more efficient and sustainable farming by helping farmers make data-driven decisions that reduce waste and increase productivity.

By harnessing aerial drones, medical professionals can significantly enhance their effectiveness and efficiency, ultimately saving more lives. Additionally, the military can ethically employ drones in their operations while ensuring the utmost care to safeguard civilian lives, Hu G. et al (2022).

Sumathadas et al (2024) Research and development play a key role in improving the use of drones for detecting crop diseases. Blight and wilt are the most commonly studied diseases, but some studies have covered more than 10 different types of diseases. For a better understanding, these diseases were grouped into five categories. The findings show that fungi are the most common cause of disease detected by drones, making up 64% of the cases, while viruses, nematodes, and environmental factors were only explored in 10% of the studies. This suggests that there is potential for researchers to focus more on the less studied disease types.

Ravi Ray Chaudhary et al (2023) Drones, also known as UAVs, have revolutionized modern agriculture by integrating advanced technologies like AI, IoT, and cloud computing. A systematic review using the PRISMA method has shown the great potential of UAVs in precision farming. These technologies enable drones to carry out important tasks such as gathering data, closely monitoring crops, and helping farmers make informed decisions. As a result, UAVs play a crucial role in boosting agricultural productivity and promoting sustainability.

Agarwal M et al (2022) Technology is becoming more essential in farming today. Drones and other advanced tools help farmers make better choices, use resources wisely, and increase crop yields.Various techniques have been explored to monitor crops, spot problems like leaf diseases, and even predict crop yields. We had planned to develop another model to improve this further, but we had to put the idea on hold due to time limitations.

3. System Methods

The majority of crop disease detection techniques used today depend on farmers and agricultural specialists doing in-person inspections, which is a labor-intensive and time-consuming procedure. Farmers inspect their crops for disease symptoms like discolouration, lesions, or abnormal growth patterns. Because samples must be sent to a lab for a formal diagnosis, treatment may not begin for days or even weeks in many suspected cases. Aerial and satellite images are examples of remote sensing technologies that can detect agricultural stress, although their application is usually constrained by poor weather and resolution issues. Furthermore, because the existing system is reactive, remedies like the use of chemical pesticides or fungicides are sometimes applied after serious damage has already been done, which exacerbates environmental and health issues.

This proposed system utilizes a drone equipped with a GPS, high-resolution camera, and an Internet of Things (IoT) module for real-time crop disease identification. The drone takes images of the crops while hovering over the field, and the GPS module provides the position of each image. These images are transferred to a server through an Internet of Things module for the purpose of identifying and classifying crop diseases. They are examined there using machine learning methods, namely a convolutional neural network (CNN). The outcomes and location information are stored in a database that may be accessed through a mobile application or website. By giving farmers and agricultural experts location-specific disease detection information and treatment advice, this facilitates timely intervention to halt disease spread and reduce crop losses.

A drone equipped with a GPS module, high-resolution camera, and an Internet of Things-based communication system is used in the proposed system. The drone flies over the field by itself and takes images of the crops. Real-time processing of these images and the corresponding GPS coordinates is done by an integrated machine learning model. Following processing, the information is transmitted via the Internet of Things to a cloud-based server or edge computer system for further examination. In addition to categorizing the discovered disorders, the machine learning model recommends treatments. By employing a smartphone application or web gateway to obtain this information, farmers can take immediate action. In rural agricultural areas, the Internet of Things increases system accessibility and efficiency by eliminating the need for cellular networks and ensuring a reliable, low-latency connection.

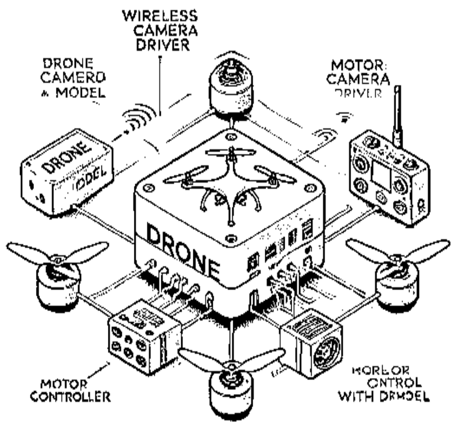

Fig.1. Block diagram for a drone with a wireless camera

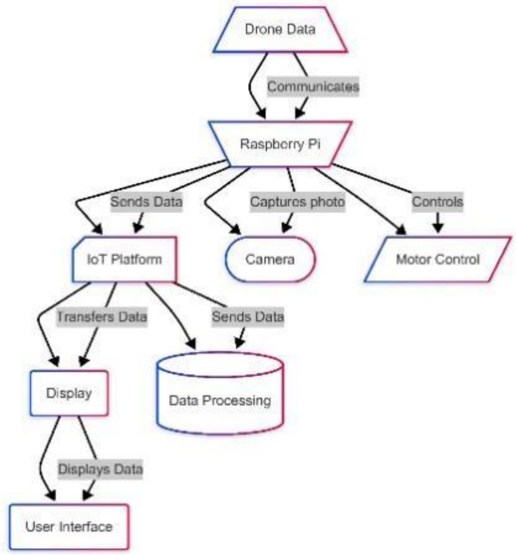

Fig. 2. Drone Data Processing and Lead Detection System Block Diagram

This diagram shows the basic parts and how a wireless camera-equipped drone system works. The Drone Controller and Model, situated on the drone, is the central processing unit that integrates flight control, camera operation, and data transmission, and it communicates in both directions with the Drone Control Remote, which allows the operator to control the drone and initiate actions like taking pictures or videos. The Wireless Camera, which is mounted on the drone, records aerial views and wirelessly sends the footage back to the operator or a designated receiver.

In order to propel and steer the drone, Motor with Driver units are used. These units are positioned strategically and managed by the Drone Controller and Model. By controlling the propellers' rotational speed in conjunction with electrical drivers, these motors allow the drone to hover, climb, descend, and move in various directions. By highlighting the link between the motors and the central controller, the figure draws attention to the synchronized operation necessary for accurate and stable flight. The term Drone Model emphasizes the system's components' cohesive design and integration, and it is repeated on the controller module and the physical structure.

During operation, the Drone Control Remote is used by the user to communicate with the Drone Controller and Model. This starts a series of steps, with the controller first modifying the Motor with Driver units to reach the desired altitude or flight route. Concurrently, the controller can turn on the Wireless Camera to take pictures or record videos, sending the information wirelessly to a recipient device. The Drone Model physically embodies these movements by moving in accordance with motor changes and serving as the camera's platform. The figure shows how these components are coupled and how a contemporary wireless drone system operates.

This block diagram shows a system that combines lead detection skills with drone data, probably for surveillance or environmental monitoring. The RASPBERRY PICO, the central processing unit, is powered by a POWER source and serves as the focal point for communication and data processing. DRONE DATAS (CONTROL ROOM) provides the Raspberry Pi Pico with data, possibly such as pictures or sensor readings. An algorithm, most likely for lead detection, is then used to process this data on a DISPLAY (PC) device that is connected to the Pico. Through an IoT (Internet of Things) module that is also connected to the Pico, the analysis's findings can be shown on the PC and possibly initiate actions. Furthermore, the device has GPS capabilities, which are probably going to geotag the drone data for precise location mapping and analysis.

Receiving, processing, and transmitting data is the core of the Raspberry Pi Pico's operation. The Pico receives and processes the drone data that was recorded and sent from the control room. The Pico then sends this information to the PC that is connected, where the lead detection algorithm is run. This PC-based algorithm examines the data to determine whether lead is present in samples of soil, water, or air (based on the drone's collecting method). Important information is presented to human operators on the PC screen as a result of this study. The Pico can simultaneously provide the IoT module with pertinent information or notifications. Based on lead concentration, this permits remote monitoring and possible automatic reactions, such as notifying users or initiating additional samples.

The system essentially uses drone technology to gather information from potentially dangerous areas and send it to a central processing unit, where a specialized algorithm detects the presence of lead and perhaps measures its quantity. Data transmission between the drone data source, the processing PC, the display, the GPS module for location tagging, and the IoT module for remote monitoring and control is managed by the Raspberry Pi Pico, which serves as the primary interface. Real-time monitoring and quick reactions to environmental threats are made possible by this integrated method, which enables effective and possibly automated lead detection. The figure does a good job of showing how information flows and how the various parts of the system are related.

4. Implementation

4.1 Hardware Employed

Drone kit: DroneKit is an open-source SDK that enables Python to be used for autonomous drone control. It works with ArduPilot and PX4 firmware and has features including telemetry, waypoint navigation, and real-time control. It is ideal for automation and research since it allows for seamless communication with companion computers and ground control stations.

Raspberry Pi PICO: The affordable Raspberry Pi Pico microcontroller board is based on the RP2040 microprocessor. In addition to a dual-core ARM Cortex-M0+ processor with support for C/C++ and MicroPython, it includes 264KB of RAM. With 26 GPIO pins, it is perfect for embedded systems and Internet of Things projects.

Fig.3. Drone Kit

Fig.4. Raspberry Pi PICO

Fig.5. GPS

Fig.6. LCD

GPS: The Global Positioning System (GPS), a satellite-based navigation system, can tell you the time and location of any location on Earth. It uses a network of satellites to precisely determine a receiver's position, making it essential for applications like tracking, mapping, and navigation.

LCD: The 16x2 LCD is a popular display module for applications that show text and data. It is ideal for basic output in projects requiring Arduino, Raspberry Pi, or embedded devices where status updates or real-time data must be displayed because of its 16 columns and 2 rows

IoT: The Internet of Things (IoT) is a network of interconnected items that, thanks to sensors, software, and network connectivity, are able to collect and exchange data

4.2 Software Employed

For embedded systems, Python and embedded C are two widely used programming languages. While Python, which is commonly used with microcontrollers, facilitates programming, embedded C works well for low-level hardware control. Mostly used for Python programming on microcontrollers like Raspberry Pi Pico, the Thonny IDE is an easy-to-use environment for novices.

5. Result and Discussions

Wide-ranging agricultural surveillance is made possible by a drone equipped with a high-resolution camera, which can efficiently capture images of plants from various heights and perspectives. Fig. 7. Using advanced image processing techniques, these images are utilized to detect plant diseases, assess crop health, and identify insect infestations. The drone's portability allows it to swiftly collect data over vast farmlands, reducing the expense of manual labor while improving accuracy. When paired with deep learning algorithms, the collected photos can yield real-time insights that assist farmers in making decisions that will increase productivity and support sustainable farming practices.

Drone-captured images Fig. 8 using a wireless camera revealed many visual indicators of disease in tomato, rice, and apple plants. Tomatoes showed potential signs of disease or malnutrition through darkened leaves, whereas rice plants showed symptoms suggestive of blight. Apple trees had changes that could be connected to fungal or pest issues. These images demonstrate how drone technology may be applied to early disease detection in a range of agricultural settings, enabling timely intervention and crop management.

Fig.7 Photographing plants with a drone

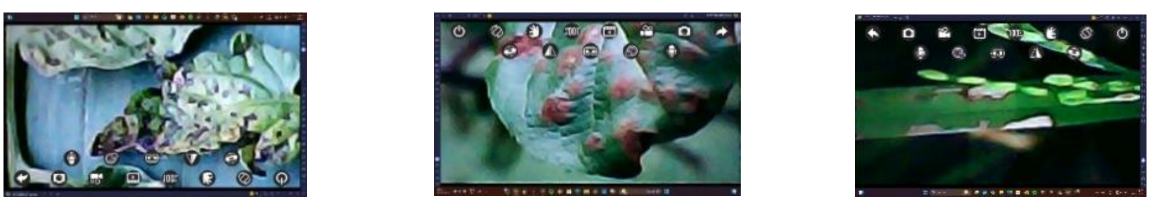

Fig.8(a). Tomato plant **Fig.8(b).**Apple plant **Fig.8(c).**Paddy Plant

Fig.8. Plants with various diseases being photographed by a drone

The system searches for indications of disease by analyzing the gathered plant pictures (Fig. 9). When a potential issue is detected, the information is displayed on the LCD screen, making it clear which plant species is affected and which disease was discovered. This real-time data facilitates timely action and customized treatment, assisting in efficient crop management and potentially preventing significant harm. Upon identifying a plant disease, the system presents pertinent details on the Internet of Things output interface, including the name of the disease and recommended pesticides for its management (Fig. 10). With the help of the web interface's extensive information, users can take timely, appropriate action to save their crops by gaining the knowledge they need for targeted intervention

With the help of the proposed UAV-based plant disease diagnosis system, deficiencies and illnesses might be accurately identified by taking high-resolution images of a range of crops. Figure 7 illustrates how the drone efficiently traversed vast agricultural fields, decreasing manual labor and improving data-collecting accuracy. The photographs in Fig. 8 were used to identify various symptoms, such as browning of tomato leaves, blight in paddy fields, and fungal or pest-related issues in apple trees. By accurately identifying the types of plants affected and presenting disease-related data on an LCD panel, the real-time processing system (Fig. 9) allowed for swift diagnosis. Better crop management and timely response were also made possible by the IoT-based interface (Fig. 10), which offered relevant disease information and recommended herbicides. These results show how the system can reduce crop loss, detect diseases early, and encourage sustainable agricultural methods.

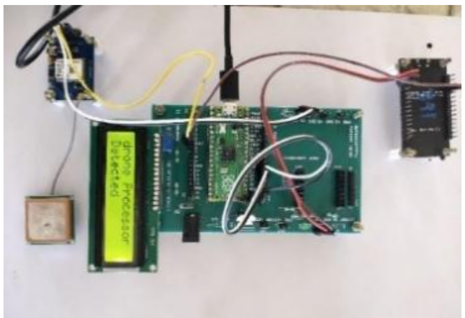

Fig.9. Once the camera has captured plants, the detected LCD display

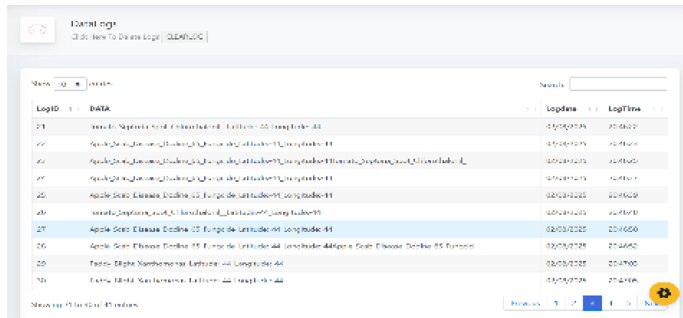

Fig.10. After the plant was identified, it provided the specific plant disease and pesticides in the IoT output

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6. Conclusion

This agricultural disease detection system combines drone-based photography, machine learning, GPS, and Internet of Things connectivity to provide a promising approach for accurate and real-time disease identification. The technology's ability to automate the detection process, provide precise location data, and enable timely interventions might significantly reduce crop losses and boost agricultural productivity. It is a vital tool for farmers, agricultural specialists, and scholars due to its inherent simplicity, affordability, and scalability. Subsequent studies may focus on integrating increasingly sophisticated machine learning techniques, expanding the range of diseases that may be detected, and exploring applications in more extensive precision farming initiatives. This technology is a big step toward transforming agricultural practices and increasing food security.

References

1. Shahi, T.B.; Xu, C.-Y.; Neupane, A.; Guo, W. Recent, "Advances in Crop Disease Detection Using UAV and Deep Learning Techniques". Remote Sens. 15, 2450., 2023.
2. Yamamoto, S.; Nomoto, S.; Hashimoto, N.; Maki, M.; Hongo, C.; Shiraiwa, T. , "Monitoring spatial and time-series variations in red crown rot damage of soybean in farmer fields based on UAV remote sensing." Plant Prod. Sci. 26, pp.36–47. 2023.

3. Md. Jobayer Rahman, Md. Shakil Ahmed, Swapnil Biswas, Anika Tabassum Orchi, Raiyan Rahman, and A.K.M. Muzahidul Islam , “CropCare: Advanced Crop Management System with Intelligent Advisory and Machine Learning Techniques”. 2024.
4. Muhammad Suleman Memon, Pardeep Kumar, Azeem Ayaz Mirani, “Deep Learning and IoT: The Enabling Technologies Towards Smart Farming”., pp.47-60. 2020.
5. Ruben Chin, Cagatay Catal & Ayalew Kassahun , “Plant disease detection using drones in precision agriculture Revie”, Open accessPublished: Vol. 24, pp.1663–1682, 2023.
6. El Mehdi Raouhi, Mohamed Lachgar, Hamid Hrimech, Ali Kartit, LTI Laboratory, ENSA, El Jadida, Morocco1,2,4 LAMSAD Laboratory, ENSA, University Settat, Berrechid, Morocco3 Unmanned Aerial Vehicle-based Applications in Smart Farming., Vol.14, No.6.2023
7. Gregorio Z. Gamboa Jr., Analyn S. Morite, Robert R. Bacarro, Rowena A. Plando, VrianJayYlaya, elieson john serna, “Rice field health monitoring system using a drone with ai interface”.,Sci. Int.(Lahore),35(3),181-184. 2023.
8. Mohamed Emimi , Mohamed Khaleel , Abobakr Alkrash, “The Current Opportunities and Challenges in Drone Technology”, ISSN:2959-9229, pp.74-89. 2023.
9. Zhihong Zhang et al., “Precision Variable-rate Control System for MiniUAV-based Pesticide Application”, To cite this article: J. Phys.: Conf. Ser. 2557 012006. 2023.
10. Wei Zhao, Meini Wan, and V. T. Pham. , “Unmanned Aerial Vehicle and Geospatial Analysis in Smart Irrigation and Crop Monitoring on IoT Platform”, 1/4213645. 2023.
11. Zhang, T.; Xu, Z.; Su, J.; Yang, Z.; Liu, C.; Chen, W.-H.; Li, J., “Ir-unet: Irregular segmentation u-shape network for wheat yellow rust detection by UAV multispectral imagery”. Remote Sens., 13, 3892. 2021.
12. Hu, G.; Zhu, Y.; Wan, M.; Bao, W.; Zhang, Y.; Liang, D.; Yin, C. “Detection of diseased pine trees in unmanned aerial vehicle images by using deep convolutional neural networks”. Geocarto Int., 37, 3520–3539. 2023.
13. Sumathadas, Arindam gosh, sarit pal, “Internet-of-Things-Enabled Precision Agriculture for Sustainable Rural Development, Classification: LCC”, S494.5.P73 P74 2024 | DDC 630.285—dc23. 2024.
14. Ravi Ray Chaudhary, Kalyan Devappa, Himanshi Agrawal P. Malathi, Aarti S. Gaikwad, Abhijit Janardan Patankar , “A critical analysis of crop management using Machine Learning towards smart and precise farming.” 2023
15. Agarwal, M., Singh, A., Arjaria, S., Sinha, A., and Gupta, S. “ToLeD: tomato leaf disease detection using convolution neural network.” Proc. Comput. Sci. 167, 293–301. 2022.