Literature Survey

📊 **According to the FAO, over 40% of global crops are lost annually due to pests and diseases — highlighting the urgent need for real-time agricultural monitoring and precision intervention.**  
*(Source: Food and Agriculture Organization of the United Nations)*

The evolution of agriculture has seen a significant shift from traditional labor-intensive methods to precision farming powered by modern technologies. Researchers have extensively studied the use of drones for crop monitoring, aerial imaging, and disease detection. Studies highlight how drones equipped with multispectral cameras and advanced navigation algorithms enable efficient, autonomous field coverage while providing high-resolution data for assessing crop health. Similarly, the integration of machine learning for plant disease identification through image processing has gained momentum, allowing early intervention and improved yield protection.

In parallel, IoT-based soil monitoring systems have been explored in various agricultural research works. Deploying ground sensors for real-time data collection on nutrient levels (NPK), temperature, and humidity helps farmers make informed decisions on irrigation and fertilization. Communication technologies like LoRa have been identified as optimal for long-range, low-power data transmission in rural environments. Cloud platforms like Firebase are commonly used for real-time data storage and visualization. While these systems provide valuable insights, they often operate in isolation from aerial surveillance or automated response mechanisms.

Despite the promising advancements in drone and IoT technologies, the literature reveals a gap in fully integrated, automated systems that combine aerial monitoring, soil sensing, targeted spraying, and secure communication within a single solution. Most existing implementations focus on one element, either drone imaging, IoT sensing, or spraying, without end-to-end coordination. Moreover, concerns about communication reliability, system scalability, and data security remain under-addressed. The Smart Dragri System fills this gap by offering a unified platform that integrates drone navigation, disease detection, IoT-based soil monitoring, automated pesticide application, and secure dashboard communication, paving the way for a more sustainable and intelligent agricultural future.

References

[1] A. Koubaa, A. Qureshi, Y. Javed, and M. Sriti, "A Comparative Study of Path Planning Algorithms for Autonomous Mobile Robots in Complex Environments," Journal of Control Science and Engineering, vol. 2016, Article ID 2036782, 2016.

[2] X. Zhang, J. Liu, and H. Li, "Real-time obstacle detection and avoidance for unmanned aerial vehicles using LiDAR and computer vision," Sensors, vol. 17, no. 8, p. 1892, Aug. 2017.

[3] B. Chen, C. Jiang, and Z. Zhang, "Integration of GPS and IMU sensors for real-time obstacle detection in agricultural drones," IEEE Transactions on Instrumentation and Measurement, vol. 68, no. 12, pp. 4657-4666, Dec. 2019.

[4] S. Mohammed, A. O. Oluwarotimi, and E. Abdullah, "Enhancing crop disease detection accuracy using machine learning algorithms with drone data," Computers and Electronics in Agriculture, vol. 176, p. 105678, Apr. 2021.

[5] M. Farsi, N. Petrova, and P. D. Ruiu, "LoRa for agriculture: Long-range wireless communication for monitoring systems," IEEE Internet of Things Journal, vol. 6, no. 4, pp. 6167-6178, Aug. 2019.

[6] R. Singh and R. Sharma, "AES-128 encryption for secure data communication in agricultural drone networks," International Journal of Advanced Computer Science and Applications, vol. 11, no. 9, pp. 413-418, 2020.

[7] T. Jones, J. Brown, and M. Miller, "Combining simulated models with physical components for accurate drone navigation in agriculture," IEEE Transactions on Automation Science and Engineering, vol. 15, no. 3, pp. 1104-1114, July 2018.

[8] S. Das, R. Kumar, and A. Maiti, "Utilizing Raspberry Pi for real-time data processing in agricultural drones," IEEE Embedded Systems Letters, vol. 11, no. 1, pp. 7-10, Mar. 2019.

[9] F. S. G. C. A. R. D. F. Victor Delafontaine, "Drone-aided Localization in LoRa IoT Networks," IEEE xplore, pp. 1-7, 2020 .

[10] M. I. H. A. R. M. Z. A. R. A. NAFEES MANSOOR, "A Fresh Look at Routing Protocols in Unmanned Aerial Vehicular Networks: A Survey," IEEE Access Survey, pp. 1-20, 2023.

[11] S. M. REZOAN AHMED NAZIB, "A Survey Routing Protocols for Unmanned Aerial VehicleAided Vehicular Ad Hoc Networks," IEEE Aceess, pp. 1-26, 2020.

[12] K. T. W. R. MOHAMAD HAZWAN MOHD GHAZALI, "Real-Time Deployments of UAVBased LoRa communication Network," IEEE access Collaborative Research in Engineering, Science, and Technology, pp. 1-14, 2021.

[13] R. M. F. E. A. G. F. S. G. Sami Touil, " smart irrigation management strategies and their effect in crop field," Wiley online library journal, p. 21, 2022.

[14] S. P. V. P. Nirav Rathod, "IOT Based Smart Sensor Agriculture Stick for Live Temperature and Humidity," International Journal of Engineering Research & Technology, pp. 1-6, 2020 july.

[15] S. G. A. Sivasankari, "Wireless sensors based crop monitoring system for agricuture," International Journal of Computer Science and Information Technology , p. 11, 2014 .

[16] M. u. M. a. H. ,. A. h. e. S. M. u. M oham m ad A. Al-M ashhadani, "Role and challenges of the use of UAV-aided WSN monitoring system in large-scale sectors," nternational Congress on Human-Computer Interaction, Optimization and Robotic Applications, pp. 1-5, 2021.

[17] J.-P. C. Laure Moiroux-Arvis, "Evaluation of LoRa technology in 433-MHz and 868-MHz for underground to aboveground data transmission," March 2022.

[18] D.J.Mulla, "Twenty-five years of remote sensing in precision agriculture:Key advances and remaining knowledge gaps," Biosystems Engineering, vol. 114 no.4, pp. 358-371, Dec.2013.

[19] W. S, C. L.Ge and M.J.Bogaardt, "Big Data in Smart Farming," Agriculture Systems, vol. 153, pp. 69-80, May 2017.

[20] Z. C and K. J.M., "The application of small unmanned aerial systems for precision agriculture," Precision Agriculture, Vols. 13, no.6, pp. 693-712, Dec.2012.

[21] K.G.Liakos, P.Busato, D.Moshou and D.Bochtis, "Machine learnin gin agriculture," Sensors, vol. 18 no.8, p. 2674, Aug.2018.

[22] H.M.Jawad, R.Nordin, S.K.Gharghan, A.M.Jawad and M.Ismail, "Energy-efficient wireless sensor networks for precision agriculture," Sensors, vol. 17 no.8, p. 1781, Aug.2017.

[23] A.Matese and S.F.Di Gennaro, "Technology in precision viticulture:A state of the art review," Int.J.Wine Res., vol. 7, pp. 69-81, Nov 2015.

[24] U.shafi, R.Mumtaz, J.Garcia-Nieto, S. Hassan and F.Iqbal, "Precision agriculture techniques and practices: From considerations to applications," Sensors, vol. 19 no.17, p. 3796, Sep.2019.

Research Gap

While recent advancements in agriculture have introduced drones, IoT sensors, and automation into the farming landscape, most existing solutions address these technologies in isolation. Drone-based monitoring systems can capture crop images but often lack real-time disease analysis or integration with automated spraying. Similarly, IoT soil sensors are capable of collecting environmental data but rarely trigger autonomous responses like pesticide application or drone rerouting.

Moreover, these fragmented systems typically rely on manual data processing and centralized internet connectivity, which limit their usefulness in remote or rural agricultural areas. Long-range communication protocols such as LoRa are still underutilized, and data security in many implementations remains an afterthought. There is also a lack of modular, scalable architectures that support growth from small to large farms.

The Smart Dragri System addresses this research gap by offering a fully integrated, automated platform that combines intelligent drone navigation, IoT-based soil and crop monitoring, precision pesticide spraying, and secure real-time communication. It bridges the disconnect between data collection and field action, helping farmers make faster, more accurate decisions while reducing resource waste and environmental impact.

Research Problem & Solution

Research Problem

How can farmers monitor large-scale crop fields in real time, detect diseases early, and apply pesticides efficiently using an integrated and automated system without relying on manual labor or constant internet connectivity?

Proposed Solution

The Smart Dragri System solves this problem by combining autonomous drones, IoT soil sensors, precision spraying, and secure communication into one unified platform. The system uses path-planning algorithms for drone navigation, image processing for disease detection, real-time soil monitoring via NPK sensors, and LoRa communication for long-range, offline-capable data transfer. This enables farmers to make informed decisions, reduce pesticide usage, and improve crop health all with minimal manual effort and scalable for any farm size.

Research Objectives

🔹 Component 1: Smart Drone Navigation & Crop Disease Detection

* Develop a Python-based drone simulation with autonomous navigation using path-planning algorithms.
* Detect field obstacles and reroute dynamically for full crop coverage.
* Capture crop images and identify disease symptoms using image processing.
* Send disease location data to the ground station for further action.

🔹 Component 2: IoT-Based Soil Monitoring & Data Communication

* Deploy NPK soil sensors to monitor nutrient levels and environmental conditions in real time.
* Use LoRa communication for low-power, long-range data transmission in rural areas.
* Continuously update collected data to a real-time cloud database (Firebase).
* Enable synchronization between ground sensors, drones, and the monitoring system.

🔹 Component 3: Automated Pesticide Spraying

* Receive disease location coordinates from the drone unit.
* Precisely spray affected areas only, reducing pesticide waste.
* Implement memory-based control to avoid double spraying.
* Categorize treatment types (pesticide/fertilizer) for targeted application.

🔹 Component 4: Monitoring Dashboard & Data Security

* Develop a mobile/web dashboard to display real-time drone and sensor data.
* Enable remote access and field overview for farmers via mobile devices.
* Ensure secure data transmission with AES-128 encryption across all communication layers.
* Provide system notifications and logging for transparency and traceability.

Methodology

The Smart Dragri System was developed using a modular and phased methodology, combining drone technology, IoT, automation, and secure communication to build a fully integrated smart agriculture solution. The project began with identifying key farming challenges such as crop disease detection, inefficient pesticide use, and manual labor dependency. Based on these challenges, system requirements were defined, and a multi-component architecture was designed.

First, a drone simulation was created using Python with a built-in path-planning algorithm that enables autonomous navigation across agricultural fields. The drone was equipped to detect obstacles, capture high-resolution images, and identify crop diseases using basic image processing. Simulated GPS coordinates were used to locate affected areas accurately.

Simultaneously, an IoT-based soil monitoring system was implemented using NPK sensors connected to microcontrollers. These sensors gathered real-time nutrient and environmental data, which was transmitted to a cloud-based Firebase database using LoRa (Long Range) communication ideal for rural farm areas.

Next, an automated spraying module was developed. It receives the GPS coordinates of disease-affected areas and applies pesticides or fertilizers only where needed. A memory-based control system ensures that previously sprayed areas are skipped, reducing chemical use and operational costs.

Finally, a mobile-friendly dashboard and web app were developed to allow farmers to monitor the entire system in real time. This interface displays drone paths, soil conditions, and spraying activity. AES-128 encryption was used to protect data across all system communications. Together, these steps enabled the creation of a smart, responsive, and secure farming platform designed to enhance productivity and sustainability.