Smart Monitoring of Vegetable crop by Drone: A Cyber-Physical System Model in the Arena of Accuracy Agriculture

Kunal Kanti Maity, Aritra Das, Arya Paul, Rupanwita Das Mahapatra, Nav Kumar Mahato
Department of Mathematics. Department of Electrical and Electronics Engineering.
Adamas University, Barasat-700126, West Bengal, India

ABSTRACT:

Cyber Physical System is showing a very important part in the arena of accuracy agriculture and it is predictable to progress productivity in order to provide food to all and prevent hunger. To accelerate the consciousness of CPS in the arena of accuracy agriculture it is essential to grow some devices, software tools and hardware components depend upon interdisciplinary methods, along with authentication of the ideologies through prototype. In this framework this paper offerings a precision agricultural supervision model through drone based on CPS design technology. Accuracy agriculture means to include the cleverness in the production of the harvest, by real-time identifying technique, optimization for improving health of soil-crop, as well as most efficient cyber-occupied tools for computerization and adeptness. Combined analysis of agricultural and ecosystem of soil is in promising stages, but increasing progressively with enhancements in sensing skills and data-influenced decision making. Our target to grow an adaptive Sensor based -Drone-Satellite system for endorsing agricultural operations and sustainability through matching often-conflicting purposes (e.g. price ecological or environmental and commercial). This integrated system is a theoretical prototype constructed on a cyber-physical interface to enable real multi-scale manual decision making by coupling innumerable existing and yet-to-be implemented data resources with AI techniques (e.g. artificial neural networks). The planned flexible system search for best solutions that can efficiently support fundamental, improve agriculture reliability and finally food safety.

Keywords: Microcontroller, Smart Agriculture, Sensors, Drone, Pesticide, Motors, Container.

I. INTRODUCTION:

BACKGROUND

Agriculture has always been the backbone of many economies worldwide, playing a crucial role in sustaining populations and driving economic growth. However, modern agriculture faces several challenges, including climate change, pest infestations, and the need for increased productivity to feed a growing global population. Traditional methods of crop monitoring and management are often labor-intensive, time-consuming, and can be inefficient, leading to substantial losses and decreased crop yields [1].

THE ROLE OF TECHNOLOGY IN AGRICULTURE:

Advancement in technology offer promising solutions to these challenges. Precision agriculture, in particular, leverages technology to enhance farming practices. Among these technological innovations, drones have emerged as a powerful tool in modern agriculture. Equipped with advanced sensors and cameras, drones provide farmers with high-resolution images and real-time data, enabling them to monitor crops more efficiently and make informed decisions. Some sensors for soil and crop monitoring are made by chalcogenide glasses like some infrared sensors are made by chalcogenide glasses that are sensitive to a wide range of wavelengths. Chalcogenide materials can be used to create hyperspectral imaging sensors. These sensors capture data across many spectral bands and can provide detailed information about crop conditions. Drones equipped with chalcogenide-based thermal cameras can monitor temperature variations in fields. Chalcogenide semiconductors offer a range of functionalities that can be harnessed to improve the capabilities of agriculture drones, leading to better monitoring, efficient resource use, and enhanced productivity in farming [2].

II. PROJECT OVERVIEW

This project, "Smart Monitoring of Vegetable Crop by Drone," aims to utilize drone technology to improve the monitoring and management of vegetable crops. By integrating drones with smart sensors and data analytics, we seek to provide a comprehensive solution for real-time crop monitoring, early detection of issues, and precise interventions [3]. This approach will help farmers increase crop yields, reduce resource usage, and promote sustainable farming practices.

OBJECTIVES

The primary objectives of this project are:

i. Enhanced Crop Monitoring: Utilize drones to capture high-resolution images and videos of vegetable crops, providing detailed insights into crop health and growth patterns.
ii. Early Detection of Issues: Implement advanced image processing and machine learning algorithms to identify potential issues such as pest infestations, diseases, and nutrient deficiencies at an early stage.
iii. Data-Driven Decision Making: Analyze the collected data to provide actionable insights and recommendations for farmers, enabling them to make informed decisions regarding irrigation, fertilization, and pest control.
iv. Resource Optimization: Help farmers optimize the use of water, fertilizers, and pesticides, reducing costs and minimizing environmental impact [4].
v. Increase Crop Yield and Quality: Ultimately, the project aims to enhance the yield and quality of vegetable crops, contributing to food security and the economic well-being of farmers. In Fig.1,we mentioned advantage of Drone in agriculture through diagram.

III. METHODOLOGY

1.Drone Technology

Drones equipped with multispectral and thermal cameras will be used to capture high-resolution images of vegetable crops. These images will provide information on various crop health indicators, including plant vigor, chlorophyll levels, and canopy temperature.

2.Image Processing and Analysis

Advanced image processing techniques will be employed to analyze the captured images. Machine learning algorithms will be developed to detect and classify various crop issues such as diseases, pest infestations, and nutrient deficiencies [5].

3. Data Integration and Analytics

The data collected from drone surveys will be integrated with other data sources such as weather data, soil data, and historical crop performance data. This integrated data will be analyzed using advanced analytics to generate actionable insights and recommendations for farmers.

4. Decision Support System

A user-friendly decision support system will be developed to present the insights and recommendations to farmers. This system will provide visualizations of crop health, alerts for detected issues, and suggestions for interventions. Agriculture drone prototype has been shown in Fig.2.

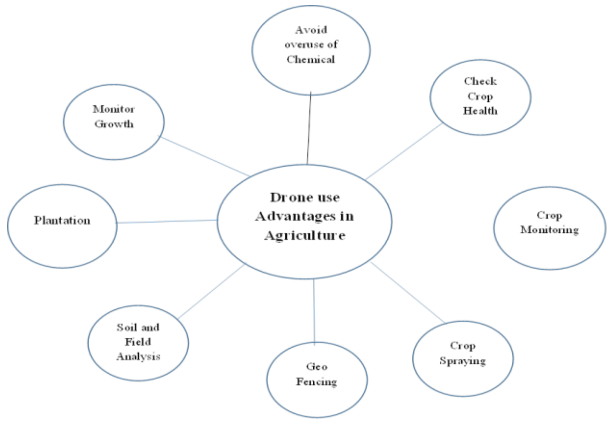

Fig.1. Drone use advantage in agriculture

Fig. 2. Agriculture Drone prototype

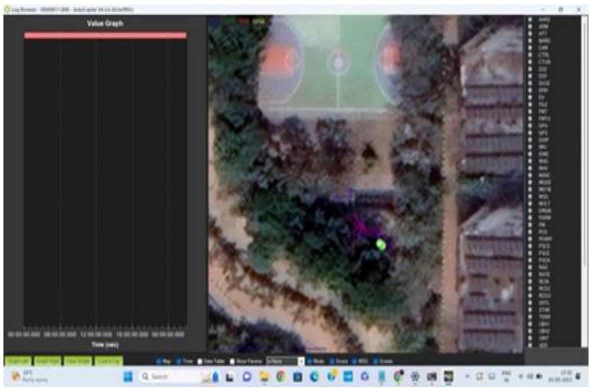

Fig.3 Agriculture drone project for precision agriculture

IV. RESULTS

The drone data revealed several critical insights:
Crop Health: We identified areas of the field affected by pests and diseases early, allowing for timely intervention.
Soil Conditions: Variations in soil moisture and nutrient levels were mapped, informing better irrigation and fertilization practices [6][7].
Growth and Yield: Regular monitoring enabled accurate tracking of crop growth and yield estimation, aiding in harvest planning. In fig.4 vibration of a drone in the X, Y, and Z axes has been shown through graph. Understanding the vibration of a drone in the X, Y, and Z axes can be crucial for maintaining its stability and performance. Here is an explanation of how such data might be represented and analyzed on a graph:

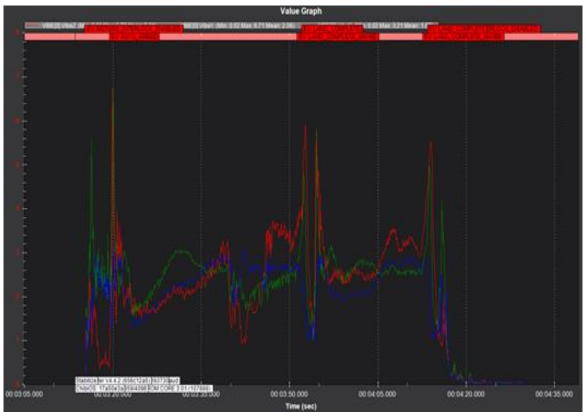

Fig. 4. Vibration of Drone in X,Y,Z

Axes Description:

1. X -axis (Roll): Represents the left-right tilt of the drone. Vibrations in this axis indicate lateral oscillations.
2. Y-axis (Pitch): Represents the forward-backward tilt. Vibrations here show longitudinal oscillations.
3. Z-axis (Yaw): Represents the rotational movement around the vertical axis. Vibrations in this axis indicate rotational oscillations.

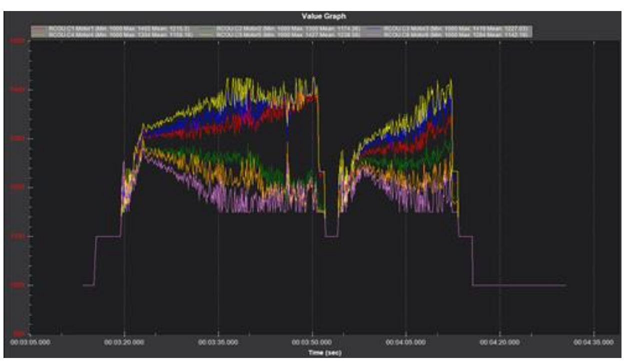

Fig. 5. RCOUT6 motor output

The RCOUT6 motor output of a drone from Fig.5 refers to the signal sent from the flight controller to the sixth motor (usually one of the motors in a multi-rotor drone setup).This output is typically measured in pulse-width modulation (PWM) values or in microseconds (µs), indicating how much thrust each motor should produce [8].

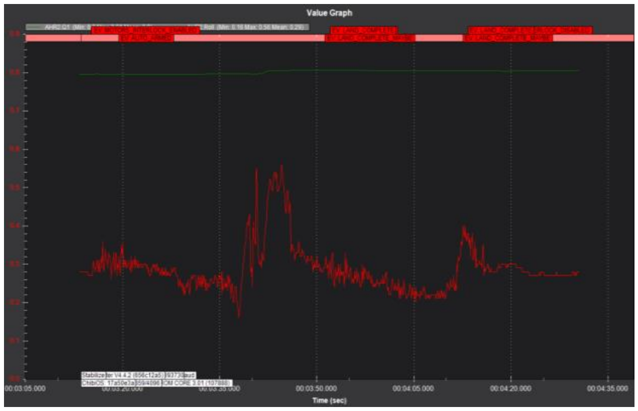

Fig. 6. Roll graph

A roll graph of a drone shows the roll angle over time, indicating how the drone tilts left or right during flight (Fig. 6). This data is critical for understanding the drone's stability and response to control inputs.

Understanding the Roll Graph:

Axes Description:

1. X-axis (Time):

Represents the time duration over which the roll data is collected. This could be in seconds, milliseconds, or any suitable time unit.

2. Y-axis (Roll Angle):

Represents the roll angle of the drone, typically measured in degrees. Positive values indicate a right tilt, while negative values indicate a left tilt.

Discussion

The use of drones resulted in a significant reduction in resource wastage and improved crop health. However, initial investment and technical expertise required posed challenges. Regulatory compliance also emerged as a critical factor for broader adoption. Despite these challenges, the benefits of drone technology in agriculture are substantial, particularly when integrated with other precision farming tools[9][10].

V. CONCLUSION

It is concluded that the adaptive Sensor based -Drone-Satellite system enables wide allocation of information from detecting towards decision making among farmers and agronomists. Technological inventions are vital in addressing agricultural trials, e.g. soil and crop health monitoring and efficiency. It is specious that latest progressions in performance calculation and accurate calculation can, in turn, bridge the gaps and provide chances for upcoming investigation and development. Developing technologies can be developed for speaking present limitations in farming practices that are not being happened; for instance, remote sensors for real time data collection, drones with high-quality cameras for 3-D image gathering and smart phone apps for real-time operation control. Such records and extracted information can alter present soil-crop investigation to the next-generation smart agricultural. Future research should focus on overcoming current challenges and exploring additional applications of drone technology in agriculture.

VI. REFERENCES

1. S. Ahirwar , R. Swarnkar, S. Bhukya and G. Namwade, “Application of Drone in Agriculture”. Int. J. Curr. Microbiol. App., 2019. Sci. 8(01): 2500-2505.
2. "Unmanned Aerial Vehicle Systems in Crop Production" by K. P. Sudheer.
3. "A Review of Remote Sensing for Precision Agriculture" by Mulla, D. J. (2013).
4. Adão, T., Hruška, J., Pádua, L., Bessa, J., Peres, E., Morais, R., & Sousa, J. J. Hyperspectral imaging: A review on UAV-based sensors, data processing and applications for agriculture and forestry. Remote sens. 9(11), 1110 (2017)
5. Furukawa, F., Maruyama, K., Saito, Y.K., Kaneko, M.: Corn height estimation using UAV for yield prediction and crop monitoring. In: Unmanned Aerial Vehicle: Applications in Agriculture and Environment, pp. 51–69. Springer, Cham (2020)
6. Jarman, M., Vesey, J., Febvre, P.: Unmanned Aerial Vehicles (UAVs) for UK Agriculture: Creating an Invisible Precision Farming Technology. White Paper (2016)
7. Milics, G.: Application of UAVs in precision agriculture. In: International Climate Protection, pp. 93–97. Springer (2019)
8. Radoglou-Grammatikis, P., Sarigiannidis, P., Lagkas, T., Moscholios, I.: A compilation of UAV applications for precision agriculture. Comput. Netw. **172**, 107148 (2020)
9. Toriyama, K.: Development of precision agriculture and ICT application thereof to manage spatial variability of crop growth. Soil Sci. Plant Nutr. **66**, 811–819 (2020)
10. Van der Merwe, D., Burchfield, D.R., Witt, T.D., Price, K.P., Sharda, A.: Drones in agriculture. In: Sparks, D.L. (ed.) Advances in Agronomy, pp. 1–30. Academic Press (2020)

AOI: 10.11234.2024.0001