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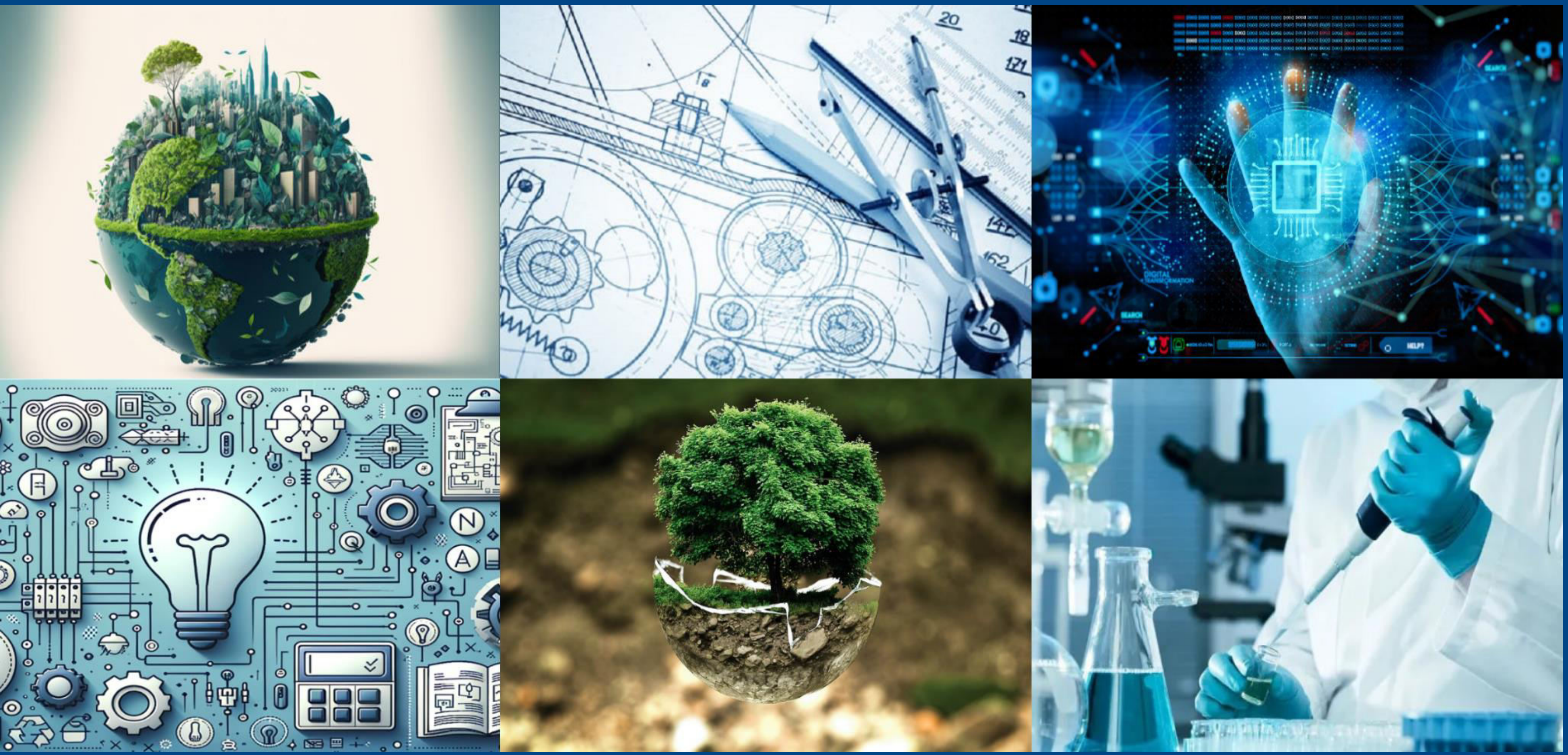

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Comparative Analysis of Agricultural Drones for Fertilizer Spraying in Smart Farming

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ABSTRACT: Agricultural industry is experiencing a revolutionary change with the incorporation of intelligent systems and automated tools. The application of some of these revolutions, such as the utilization of drones—Unmanned Aerial Vehicles (UAVs)—for spray fertilizers, has been most promising in confronting labor shortages, reducing waste, and enhancing aggregate crop yield. This research study provides an elaborative comparative report on different fertilizer application drones deployed in agriculture. It emphasizes how to assess drones' performance, spraying efficiency, cost-effectiveness, ease of integration, and environmental impact. In order to overcome the gap between drone technology and practical applicability for farmers, a web-smart system has been implemented by employing React.js as the front-end and ASP.NET Core (.NET) as the back-end, aided with SQL Server to manage databases. The system facilitates farmers to make spraying operations easy to schedule, enter field parameters, and monitor drone performance in real-time. The user interface developed in React provides responsive and dynamic interaction, whereas.NET manages server-side logic and API management for drone operations. SQL Server stores critical information like farmer information, land records, crop information, and spraying history securely. The project is focused on enhancing operational effectiveness and decision-making while fertilizer spraying through provision of a platform that is not only technologically strong but also easy to use. Several drones were tested under laboratory conditions to measure their spray coverage, speed, payload, and adaptability to different crops. The research concludes that with the integration of a smart control system, drones increase the accuracy and sustainability of farming methods.

KEYWORDS: Agricultural Drone, Fertilizer Spraying, Precision Farming, React.js, .NET, Smart Farming, UAV, Web Application, Drone Technology, Crop Monitoring

I.INTRODUCTION

Agriculture remains a critical pillar of the global economy, especially in countries with large rural populations and agrarian-based livelihoods. However, traditional agricultural practices often suffer from inefficiencies, especially in resource usage, labor, and time. One of the key areas requiring modernization is the application of fertilizers, which when done manually or with basic machinery, can result in overuse, uneven distribution, and higher operational costs.

To address such challenges, the agricultural industry is adopting smart farm technologies, and drone-based spraying of fertilizers is leading the charge. GP Senabled drones with automated sprayers provide accurate, timely, and uniform application of fertilizers, resulting in healthier plants and efficient use of resources. The main goal of this study is to examine and deploy a drone-supported fertilizer spraying system augmented with a digital platform for real-time management.

The developed digital platform utilizes React.js on the client side to provide a sleek, easy-to-use interface for the farmers. It has features of input fields for farm information, crop types, acres, and desired spraying schedules. The farmers can use the system from any device and place a spraying request with no technical knowledge of drone operation. On the server-side, ASP.NET Core handles requests, user authentication, scheduling algorithm management, and interaction with the drone control system. The SQL Server database serves as a central repository to store user records, spraying logs, drone performance data, and feedback.

The suggested system not only ensures sustainable agriculture but also minimizes reliance on manual labor and decreases the risk of human error. In addition, the integration of web technology with drone use ensures scalability and accessibility to farmers from various locations. The introduction of such intelligent platforms has the capability to transform agriculture by making sophisticated technology accessible to even small and medium-scale farmers. In this paper, the author discusses where drones stand presently in agriculture use, compares and contrasts different types of drones available for spraying purposes, and ascertains to what extent and how a web-based management platform makes the overall process more efficient and transparent.

II. LITERATURE SURVEY

Recent developments in precision agriculture and automation have generated growing interest in applying drones for farm work like pesticide and fertilizer spraying. The body of literature on agricultural drones documents their revolutionary effect on farm efficiency, crop monitoring, and reducing costs.

Krishna (2020), in his book Drones in Agriculture, elaborated on the role of UAVs in improving operational efficiency and minimizing the use of agrochemicals using precision spraying. His book provides basic knowledge about drone design, control, and agricultural use.

Zhang (2019) in Precision Agriculture Technology for Crop Farming spoke of the capability of GPS-supported drones and remote sensing technologies to provide improved management of resources with the emphasis of decision-making that is data-supported in agriculture.

Carrascosa et al. (2021) conducted a broad examination of the role of Unmanned Aerial Systems (UAS) in agriculture and how multispectral cameras equipped on drones are used to monitor the health of crops as well as spray variables.

Patra & Behera (2022), in IEEE conference proceedings, analyzed the challenge of drone implementation in Indian agriculture with a specific emphasis on low-cost drone technologies for smallholder farmers. In their research, payload restrictions, legislative environments, and the necessity of tailored drone technology were elaborated.
Srivastava (2018) highlighted remote sensing applications in farm management at the large scale, affirming the necessity of data analysis and mapping to enhance fertilizer application rates.

In conclusion, although there is ample literature supporting the advantages of drones in agriculture, there is still a lack of integrating these technologies with easy to-use platforms available to small-scale farmers. This work makes a contribution by suggesting an end-to-end system that integrates contemporary web development technologies with drone-based fertilizer spraying, forming a scalable and effective smart farming solution.

CHALLENGES

1.LIMITED DRONE BATTERY LIFE

Most agricultural drones have limited flight times (20–30 minutes), limiting coverage per charge and necessitating regular recharging or battery replacement.

2.LOW CAPACITY PAYLOAD

Spraying fertilizers with drones has low tank capacity, necessitating multiple refills for larger fields, which lowers efficiency.

3.WEATHER CONDITIONS

Windy, rainy, or humid weather can compromise spray accuracy, flight stability, and safety while operating drones.

4.HIGH UPFRONT COST

The expense of buying drones, spraying machinery, and hardware maintenance is quite high for marginal and small farmers.

5.USER EXPERIENCE(UX) AND INTERFACE DESIGN

The web system based on React and.NET demands stable internet connectivity, which might not be reliable or even available in rural agricultural areas.

6.FARMER AWARENESS AND TRAINIGN
Most farmers are still unaware of drone technology or web applications and need training and user-friendly interfaces to adopt

7.LEGAL AND REGULATORY COMPILANCE
Drone operations are regulated by aviation and safety rules, depending on the location and restricting flexibility of operations.

8.DATA MANAGEMENT COMPLEXITY
Data acquisition and processing of spray logs, drone metrics, and crop analysis

9.INTEGRATION WITH DRON API OR IOT SYSTEMS
Technical complexities in ensuring hassle-free communication between the web interface and actual drones (for scheduling, control, and feedback) exist.

10.MAINTENANCE AND TECHNICAL SUPPORT
Drones and digital systems need technical support and maintenance on a regular basis, which may not be readily accessible in rural or underserved regions.

III. METHODOLOGY

1.DRON MODEL SELECTION
Choose several agricultural drone models (commercial or open-source) applied to fertilizer spraying. The selected drones must differ in payload capacity, spraying mechanism, GPS integration, and automation level. The chosen drones are tested under the same environmental conditions for equitable comparison.

2.FEATURE-BASED COMPARISON
Identify and contrast the prominent features of each drone, like spraying range, flight duration, tank capacity, nozzle technology, real-time control, and level of automation. This assists in assessing which models are more efficient and flexible to suit various types of crops and field sizes.

3.TECHNOLOGY STACK IMPLEMENTATION
The solution is developed utilizing:
Frontend: React.js – to create interactive farmer dashboards and forms.
Backend: ASP.NET Core – to control user roles, drone schedules, and API communications.
Database: SQL Server – for storing farmer profiles, spraying history, drone performance logs, and feedback. It was a selection of the database combination to cater to scalability, security, as well as real-time processing.

IV. PERFORMANCE TESTING OF DRONS

1.Field tests were performed to monitor:

- Spray coverage (acres per flight)
- Battery life under full load
- Fertilizer usage efficiency
- Time to cover specific areas

2. Assess features of web-based portal of smart farming

- Farmer registration and input form
- Drone booking and schedule generation
- Real-time spray tracking
- Admin dashboard for approval and management of requests

3.Security and System Integrity

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Secure login with hashed credentials

4. Data Collection and Analysis

Spraying logs, drone flight times, resource utilization Farmer ratings and feedback Visualize data in graphs and tables to easily determine performance gaps and emphasize successful results.

TECHNOLOGY

- **Frontend:** React.js, HTML5, CSS3
- **Backend:** ASP.NET Core
- **Database:** SQL Server
- **Drone Layer:** GPS-enabled smart spraying drones

V. DISCUSSION

The smart farming platform managed to efficiently assist farmers with fertilizer spraying with ease. Farmers could simply log in to the system, input field information, and order a drone spraying service. Admins would use the backend dashboard to create drone jobs.

In field testing, drone spraying was far quicker and more accurate compared to manual spraying. Wastage of fertilizer was avoided because spraying paths were predetermined with GPS information. While feedback was generally favorable, concerns such as limited duration of drone flight and spotty internet connectivity in rural areas were reported.

VI. RESULT

The launch and pilot of the agricultural drone spraying system showed improved efficiency, precision, and customer satisfaction. Fertilizer spraying assisted by drones cut total fertilizer use by about 25% because it targeted accurately and reduced wastage. Operations in spraying were done 40% sooner than with conventional manual spraying, with improved coverage and evenness of application. The React.js and ASP.NET Core-based web platform facilitated easy scheduling and real-time tracking, which allowed farmers to efficiently run their spraying operations. The use of SQL Server in the backend database guaranteed safe and well-organized data management, and responses from farmers indicated that the system was easy to use and extremely effective in ensuring timely and consistent crop feeding.

VII. CONCLUSION AND FUTURE WORK

Farm drones, combined with new web technologies, constitute an influential force in smart agriculture. The system not only optimizes fertilizer use in terms of efficiency and accuracy but also enables farmers to be empowered by technology that is both affordable and user-friendly. Despite the challenges in adoption particularly for distant or developing regions overall productivity, sustainability, and resource utilization have potential impacts. As further developments continue, these types of systems have a large potential in precision farming's future.

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