A review of Implementation of drone technology for farm monitoring & pesticide spraying

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Introduction:

An **Efficiency Misting Sprayer Drone** is an advanced agricultural or industrial tool designed for the precise and even distribution of liquids, such as pesticides, herbicides, fertilizers, or water. These drones are equipped with misting systems that spray liquids in fine droplets, ensuring efficient coverage over large areas. The use of drones offers several benefits:

1. **Even Distribution**: The misting system ensures uniform coverage, reducing waste and preventing over-saturation in certain areas.
2. **Automation and Precision**: GPS and sensors allow the drone to follow precise flight paths and adjust the spray rate based on environmental conditions, leading to more efficient resource use.
3. **Time and Labor Efficiency**: Drones can cover large areas quickly, reducing the need for manual labor and minimizing human exposure to chemicals.
4. **Accessibility**: They can reach areas that may be difficult or dangerous for ground-based equipment, such as steep terrain or dense crops.

These drones are particularly useful in precision agriculture, where optimizing resource use and minimizing environmental impact are key objectives.

Agriculture faces significant challenges, including labor shortages, increasing costs, and the need for sustainable practices. Innovative technologies like autonomous drones offer solutions to enhance efficiency and crop yield. This report presents a fully automatic farming drone designed for precision spraying, equipped with advanced features for optimal agricultural practices.

Agricultural drone

Aircraft in farming

Aircraft have long been used in agriculture, but this has been accompanied by heavy controversy, especially in connection with spraying. The European Union has banned all aerial spray applications since 2009, mostly for ecological reasons. Switzerland, in contrast, adopted a more liberalist approach, aiming to limit the use of helicopters to the spraying of specific terrains and crops. In 2019, the country was the first European nation to allow the use of sprayer drones. The relevant regulatory framework treats sprayer drones in the same way as ground-based equipment for the application of pesticides, unlike helicopters. Hereby, the key argument was that drones produce less spray drift than helicopters and as such resemble more precise and thus ecological technologies deployed on the ground. The company Agro-Drone, i.e. the object of the present case study, has contributed in differing ways to this legal arrangement, as shown below.

On April 15, 2019, the company's sprayer drone obtained the first certification in Switzerland for a ‘ground application system’.

Thus, applying pesticides from the air is not new, but sprayer drones bring the air ever closer to the agricultural everyday, both in spatial terms, because they fly lower than helicopters, and in legal terms, because of the simplified regulatory procedures. Furthermore, sprayer drones also make it cheaper, technically simpler and, thus, much easier to farm through the air than does the use of helicopters. For example, Agro-Drone's sprayer drone can be bought for 49,500 Swiss francs and used after a 2-h training course .

Initially, the drone was originated as a military tool and was given different names such as Unmanned Aerial Vehicle (UAV), Miniature Pilotless Aircraft, or Flying Mini Robots. Nowadays it is being utilized in the business sector, infrastructure sector, farming, security, insurance claims, mining, entertainment, telecommunication, and transport sector, etc. The drone has a powerful market opportunity as is evident from the data given in Table 1. Such a broad application of drones has resulted in a very fast improvement in drone technology, thereby making it more user-friendly day by day. Nowadays, the application of small unmanned aerial vehicles (UAVs) is growing at a very fast rate in agribusiness. Drones are semi-automatic devices that are continuously shifting toward fully automatic devices. These devices have an enormous potential for agricultural planning and related spatial information collection. In spite of some innate barriers, this technology can be utilized for productive data analysis . Initially, UAVs were radio-controlled devices operated by a pilot from the ground, however, modern drones are GPSbased autopilot aerial vehicles. The type of cameras, sensors, controlling devices depends on the application of a drone. The three main types of UAVs platforms are Fixed-wing, Helicopter, and Multi-copter. Fixed-wing UAV: These UAVs have stationary wings in the shape of an aerofoil which creates the lift needed when the vehicle reaches a certain speed. Helicopters: It has a single set of horizontally rotating blades attached with a central mast for producing lift and thrust. A helicopter is capable of vertically take off and land, fly forward, fly backward, and hover at a particular place. These features allow the use of helicopters in congested and remote areas where fixed-wing aircraft are unable to operate. Multi-copters: Rotorcraft with multiple sets of horizontally rotating blades (typically 4–8) have the capability to provide lift and control movements of UAV. In the past decade, the unmanned aerial vehicle (UAV) market was captured by fixed-wing and helicopters. Nowadays, the use of small drones in precision agriculture has shifted focus towards multi-copters that at present covers almost 50% of the available UAV model. Performance of tiny sensors (accelerometers, magnetometers, gyros, and pressure sensors, etc.), used in drone technology, is continuously increasing and their size is reducing day by day . Moreover, the development of powerful processors, GPS modules, and increment in the range of digital radios is a continuous process, and thus drone technology is also improving. New innovations in embedded systems and motors have made it possible to reduce the size of UAVs and improved their payload capability. This further leads to a better controlling of the drone for monitoring of remote fields .

Table 1 – Utilization of drone in different sectors

S.No.	Industry	Drone application	Budget (Source: PwC (2016))
1	Infrastructure	Investment monitoring, Maintenance, Asset inventory	$45.2 bn
2	Agriculture	Analysis of soils and drainage, Crop health monitoring, Yield prediction, Pesticides and fertilizer spot spraying	$32.4 bn
3	Transport	Delivery of goods, Medical Logistic	$13.0 bn
4	Security	Monitoring lines and sites, Proactive response	$10.5 bn
5	Entertainment and Media	Advertising, Entertainment, Aerial Photography, Shows and Special Effect	$8.8 bn
6	Insurance	Support in claims settlement process, Fraud detection	$6.8 bn
7	Telecommunication	Tower maintenance, Signal broadcasting	$6.3 bn
8	Mining	Planning, Exploration, Environmental impact assessment	$4.3 bn

The integration of Artificial Intelligence (AI) has revolutionized the use of semi-controlled drones for farm monitoring . The decision of a semi-controlled drone was purely based upon the sensor output. AI system has its own decision-making power, which has made it a useful tool for real-time data analysis. This decisionmaking power of AI is based upon previous training. Realtime data analysis has improved farm productivity through mapping spatial variability in the field. The crude data (of crops in agricultural fields) collected using drones are fed to the analytical models for analysis and further remedial actions are taken to improve the yield. Drones can perform soil health scans, assistance in irrigation, fertilizers application, crops health monitoring. Moreover, it provides useful data analysis to estimate farming yield . Satellite image utilization for data analysis has its limitation in the case of small plants. Moreover, the availability of satellite images depends upon weather and light conditions. Unmanned Aerial Vehicle (UAV) provides a better solution for image data collection since they can capture desired location images from the desired height and at the desired frequency automatically. Moreover, drone-based technologies can analyze the data instantaneously and can be used as a fully automatic device for pesticide, and weed.

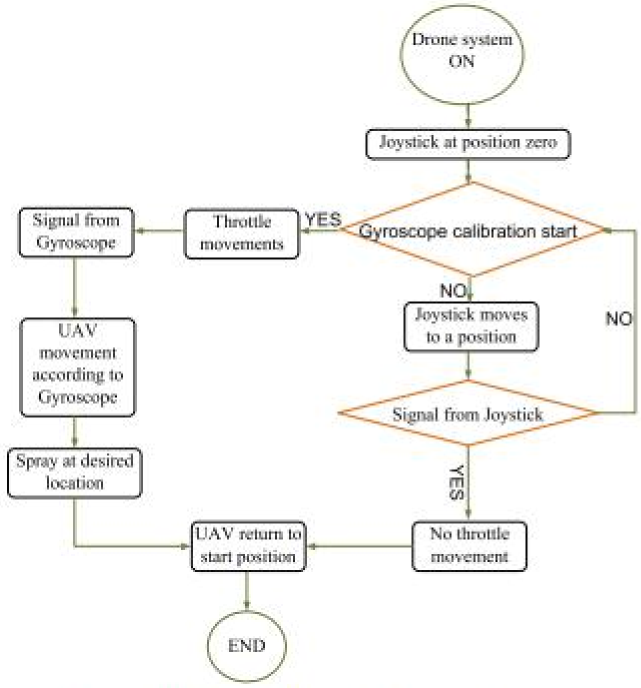


Fig. 2 – Workflow diagram of sprayer drone.

Design Specifications-

Drone Type and Size:

Type: Multi-rotor drone for stability and maneuverability.

Dimensions: Approximately 355 mm in wingspan and wing size approximately 379.50mm, weight around 3136 grams.

Material: Lightweight carbon fiber for durability and reduced weight.

Battery and Power Management

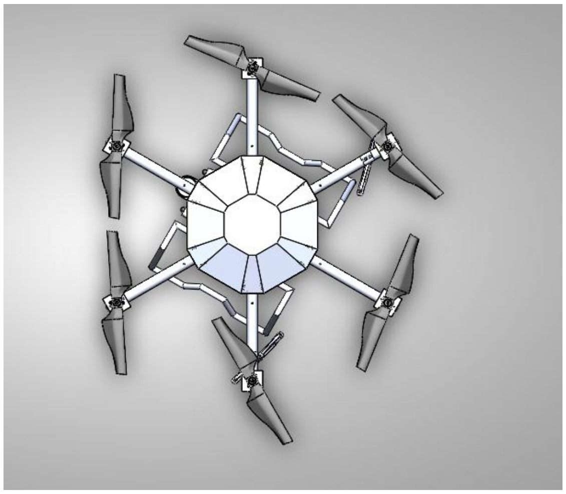
Battery Type: High-capacity lithium-polymer (LiPo) battery with 12,000 mAh capacity.

User Interface

Control Software: Intuitive app interface for route programming, real-time monitoring, and data analysis.

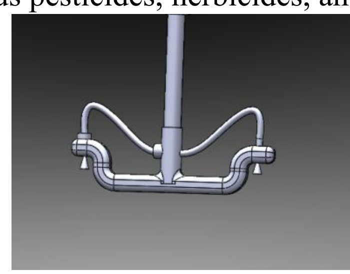
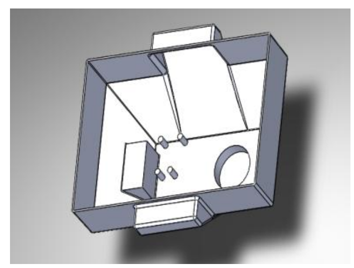
Automatic Return Feature: The drone continuously monitors battery levels and initiates a return-to-home sequence if levels fall below a predetermined threshold. Also The system can detect when the spray tank is empty and automatically return to the launch point to refill, optimizing operational efficiency.

Data Collection: Logs flight data including area covered, spray rates, and operational efficiency.




Spraying Mechanism

Type: High-efficiency misting sprayer for even distribution.
Capacity: 10 liter spray tank for extended operation.
Compatibility: Can spray various pesticides, herbicides, and fertilizers.

Various herbicides are applied via Unmanned Aerial Vehicles (UAVs)-
A UAV equipped with diflufenican + isoproturon herbicide demonstrates a notable weed control efficacy, reducing over 98 % of weeds such as Japanese foxtail and bedstraw (Galium aparine) in wheat crops . Conversely, the application of Fluroxypyr-meptyl at a rate of 20 % EC, using a drone at 600 mL/ha results in a considerably diminished impact on weed growth and height .
In the research domain, current studies reveal that there is no significant divergence in weed control effectiveness when employing different herbicide rates (e.g., diflufenican + isoproturon at 180 + 1.800 kg a.i. ha^{-1} and 120 + 1.200 kg a.i. ha^{-1}) through various sprayers such as UAVs and knapsack sprayers. Similar observations are made with different herbicide combinations (diflufenican + isoproturon and flufenacet + diflufenican + flurtamone). The research asserts that low-rate herbicides exhibit less efficacy compared to high-rate herbicides, attributing this to the development of weed resistance in the area .
The application of isoproturon + clodinafop-propargyl + mesosulfuron herbicides via UAV demonstrates comparable weed control effectiveness to that achieved with a knapsack sprayer. However, for Japanese foxtail weed, the knapsack sprayer application of mesosulfuron + isoproturon + clodinafop-propargyl proves more effective than its UAV counterpart. Simultaneously, UAV application of diflufenican + isoproturon reduces Japanese

foxtail seedlings by 60 % and shepherd's purse by 50 %, while the knapsack sprayer treatment achieves approximately 75 % reduction in Japanese foxtails and 80 % in shepherd's purses in another experimental area. Additionally, UAV application of flufenacet + diflufenican + flurtamone controls 70 % of Japanese foxtail and 80 % of shepherd's purse, whereas the knapsack sprayer application results in less than 85 % reduction in Japanese foxtail and 80 % in shepherd's purse .
Herbicide application through a combination of knapsack sprayer (PE) and drone (PoE) yields a lower weed index compared to PE herbicide application by a knapsack sprayer with metribuzin 70 % at a rate of 0.175 kg a.i ha^{-1} .

Spraying Mechanism of an Efficient Misting Sprayer Drone:
Misting sprayer drones are innovative agricultural tools designed to enhance the efficiency of pesticide and nutrient application. Their spraying mechanisms utilize advanced technology to optimize droplet size, coverage, and operational efficiency.

Key Components

1. Spraying System:
Rotary Disc Atomizers: These devices are positioned under the drone's propellers and use rotational speed to create spray droplets. Higher speeds produce smaller droplets, while lower speeds yield larger ones. This flexibility allows for customization based on the specific requirements of the sprayed material.

Centrifugal Nozzles: These nozzles utilize centrifugal force to atomize the liquid as it is ejected from radial grooves in the disc. This design promotes uniform droplet size and minimizes clogging issues common with traditional hydraulic nozzles.

2.Control Systems:
Drones are equipped with GNSS receivers and multiple sensors for precise navigation and collision avoidance. This technology ensures accurate flight paths and effective coverage of the target area.
Intelligent Flight Control Systems: These systems integrate various sensors to monitor flight parameters, allowing for real-time adjustments to maintain optimal spraying conditions.

3. Tank and Pump :
The drones have integrated tanks that can hold varying amounts of liquid (e.g., 5 gallons), with pumps that facilitate consistent flow rates during operation. Some models include sensors that indicate liquid levels and can automatically return to base when refills are needed.

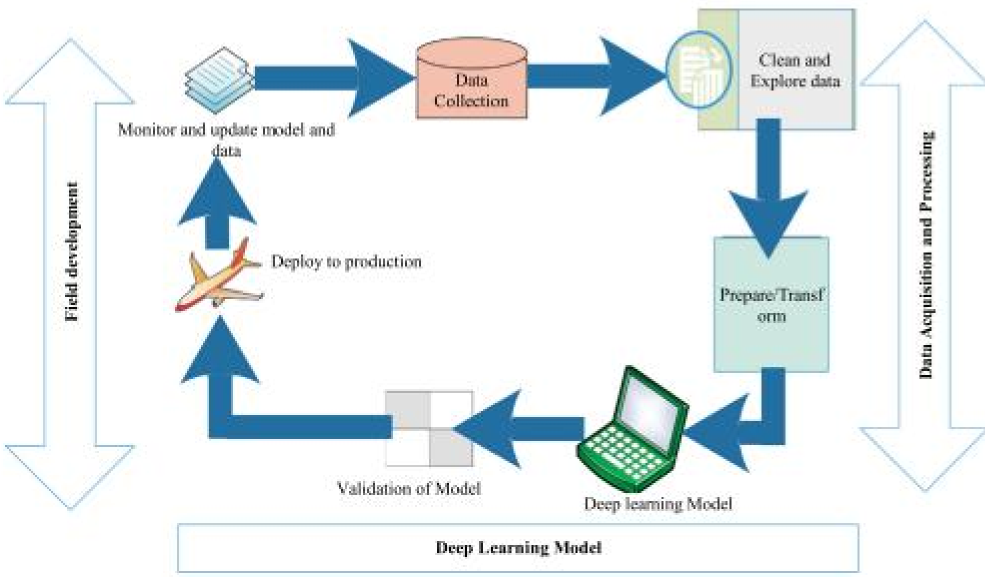
Operational Characteristics-

Droplet Size Control: The droplet spectrum can be adjusted by manipulating the rotational speed of the atomizers or nozzles, allowing operators to meet specific application needs without compromising effectiveness.

Coverage Efficiency : Drones can cover extensive areas quickly, with some capable of spraying up to 7 hectares per hour. This efficiency is enhanced by downwash airflow generated during flight, which helps droplets reach both the upper and lower surfaces of leaves.
Variable Application Rates: Typical application rates range from 1.5 to 2 gallons per acre, influenced by factors such as flying speed, spray width, and nozzle type.
Benefits Over Traditional Methods

Reduced Drift: The design minimizes drift issues associated with traditional spraying methods, ensuring more targeted application and reduced environmental impact.
Flexibility in Operation : Operators can easily adjust spraying parameters such as nozzle types and flow rates to adapt to different crops and conditions.
Autonomous Functionality: Many drones offer autonomous flight capabilities, allowing for pre-programmed routes that enhance operational efficiency while reducing labor costs.
Misting sprayer drones leverage advanced spraying mechanisms that combine rotary atomization technology with intelligent control systems to deliver efficient, precise, and environmentally friendly agricultural solutions.

Features:



Workflow Diagram of Deep Learning Based system used for precision agriculture

An Efficiency Misting Sprayer Drone comes with several key features that make it highly effective for tasks like agricultural spraying, industrial cooling, or pest control. Some of the main features include:
Precision Misting System
Fine Droplet Spray: The drone uses nozzles to create fine mist droplets, ensuring even coverage and reducing wastage.
Adjustable Flow Rates: The spray rate can be modified depending on the type of liquid and application area, ensuring optimal misting.

GPS and Navigation Systems
GPS and RTK Technology: Equipped with GPS systems to follow precise flight paths, allowing the drone to evenly cover large areas.
Terrain Following Sensors: These sensors enable the drone to maintain consistent altitude over uneven surfaces, ensuring even mist distribution.
Automated Flight Capabilities
Pre-programmed Routes: Operators can input flight paths and spraying schedules in advance for automated operation.
Obstacle Detection and Avoidance: Equipped with sensors to detect obstacles and prevent collisions during flight.
High-Capacity Tanks
Liquid Storage: The drone has a built-in tank with a capacity that varies depending on the model, typically ranging from a few liters to over 20 liters, minimizing the need for frequent refills.
Multi-functional Use
Versatility: Besides agricultural uses (fertilizers, pesticides), it can also be used for environmental management tasks such as dust control or mosquito control.
Efficient Power Systems
Rechargeable Batteries: Typically powered by high-capacity lithium-ion batteries, offering flight times of up to 20-30 minutes per charge.
Fast Charging Options: Some models offer fast battery charging or hot-swappable battery options to minimize downtime.
High Payload Capacity
Weight Handling: Designed to carry liquid loads without compromising flight stability, allowing efficient spraying over larger areas.
Weather Resistance
Durability: Many drones are built to withstand various weather conditions, including light rain or wind, ensuring uninterrupted operation.
Remote Control and Monitoring
Real-time Data and Monitoring: Operators can remotely control the drone via a mobile app or remote control, tracking its position, spray progress, and tank levels in real-time.
Live Video Feed: Some models come with cameras to provide a live view of the spray area for better accuracy and monitoring.
Environmental and Safety Features
Eco-friendly Spraying: Reduces the overuse of chemicals, preventing soil contamination and minimizing environmental impact.
Safety Protocols: The drone will automatically return to its home base if the battery is low or if there's a loss of signal.
These features make the drone highly effective for achieving precision in spraying while reducing operational costs, time, and environmental impact.

Automation and Control

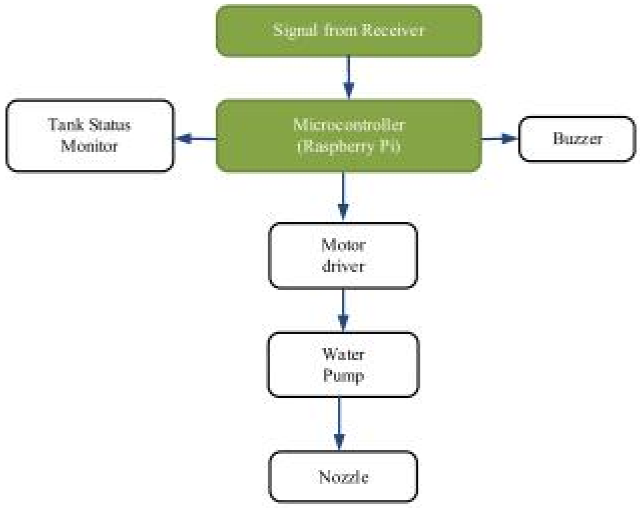
(a) (b) (c)

UAV based spraying system being used in different agriculture

Image classification methods are based upon supervised and unsupervised learning algorithms. These methods visualize the results effectively and are user-friendly. A continuous improvement in machine learning, computer vision, and AI technologies is making it more accurate and userfriendly. This technology needs good programming skills and latest equipment. Moreover, calibration is needed, for the classification model, in the case of real-time applications. IoT-based technology utilizes the different types of sensors for the collection of crop data and these data are analyzed using a simulation model. This technology is efficient in resource utilization, enhances data collection, needs less time, and minimizes human efforts. This technology has some drawbacks such as; complexity, security, and privacy.

The Automation and Control of an Efficiency Misting Sprayer Drone are advanced and designed to optimize performance, minimize human intervention, and ensure precision in spraying. Here are the main aspects of its automation and control:

This section is about research and developments in UAVbased pesticide spraying systems. Till date, mostly conventional methods for pesticides application are being used in various parts of the world. The manual mechanical sprayer is the most common tool for conventional pesticide application. Manual spraying of the pesticides affects human beings and may lead to diseases like cancer, hypersensitivity, asthma, and other disorders. Additionally, conventional methods have several other shortcomings such as extra chemicals use, farm labor shortage, lower spray uniformity, environmental pollution, and less area coverage. These conventional methods cause a higher cost of pesticide application and are less effective in controlling pests and diseases. To overcome these shortcomings, a drone-mounted sprayer is being employed. The application of drone-mounted sprayers in the field has enhanced the coverage ability, increased the chemical effectiveness, made the spraying job easier and faster. Nowadays, Drone is capable of carrying up to 40-liter pesticide tank and follow pre-mapped routes to spray crops according to the requirements. Drones are showing great potential in covering the fields with difficult access for tractors and aircraft.



Blocks of Fully automatic pesticide spraying system

Autonomous Flight Modes
Pre-programmed Flight Paths: Operators can plan and program flight paths in advance using mapping software. The drone can automatically follow these routes, ensuring uniform coverage.
Return-to-Home (RTH): If the battery level is low, or there's a loss of signal, the drone automatically returns to its starting point, ensuring safety and preventing crashes.
Waypoint Navigation: The drone can fly between specific GPS waypoints, spraying at designated intervals. This ensures targeted and accurate application of the mist.

GPS and RTK (Real-Time Kinematic) Precision
High-Precision Navigation: Equipped with GPS and RTK systems, the drone can maintain centimeter-level precision, ensuring consistent flight patterns even in large, complex fields. RTK improves positioning accuracy, reducing drift and ensuring the drone follows exact paths.
Geo-fencing: Operators can set virtual boundaries (geofences) around no-fly zones, preventing the drone from flying into restricted areas.

Terrain Following Technology
Altitude Control: The drone uses terrain-following sensors (such as LiDAR or ultrasonic sensors) to adjust its altitude automatically based on the topography. This ensures that the drone maintains a consistent height above the ground or crops, which is critical for even mist distribution.

Real-time Remote Control
Mobile and Tablet Interface: Drones are typically controlled via dedicated apps available on mobile devices or tablets. These interfaces offer intuitive controls for take-off, landing, and manual intervention.
Remote Monitoring: Operators can track the drone's location, speed, and spray progress in real time. Any changes in wind speed or direction can also be monitored, allowing adjustments during flight.

Adaptive Spraying Control

Automatic Adjustment: The drone can adjust its spray rate based on the speed, altitude, and environmental conditions (e.g., wind speed). This ensures uniform application and prevents over-spraying or under-spraying.

Variable Rate Application: Some advanced models feature the ability to apply different quantities of liquid in different areas, based on pre-programmed data such as crop health or soil moisture levels.

Obstacle Detection and Avoidance

Collision Avoidance: Drones are equipped with obstacle detection sensors such as radar, ultrasonic, or infrared systems. These sensors detect objects like trees, power lines, or other structures and allow the drone to change its flight path automatically to avoid them.

Safe Landing System: In case of an emergency, such as a sudden loss of power or system malfunction, the drone can land safely at the nearest clear area to avoid damage.

Automatic Refilling and Charging

Automated Refill Station: Some drones can autonomously return to a designated base station to refill their liquid tank or switch out a battery. This reduces downtime and allows for continuous operation over long periods.

Battery Swapping: Automated systems or ground personnel can swap batteries quickly, allowing the drone to resume its tasks immediately after charging or refueling.

AI and Data Integration

Artificial Intelligence: AI-powered drones use data from sensors and environmental factors to optimize flight and spray patterns. Some drones use AI to analyze crop health or field conditions and adjust the spraying accordingly.

Integration with Farm Management Systems: These drones can integrate with broader farm management software, using data from satellite imagery, weather forecasts, or soil sensors to refine their spray patterns.

Manual Override and Hybrid Control

Semi-autonomous Mode: Operators can switch to manual control at any time if real-time adjustments are needed or if the drone encounters unexpected challenges.

Manual Joystick Control: Traditional remote control systems are also available for operators to take over in case of specific requirements or for closer inspection of areas.

Benefits of Automation and Control:

Labor Reduction: With automation, the need for manual labor is drastically reduced.

Precision and Efficiency: Automated control systems ensure that the drone sprays only where needed, minimizing waste.

Safety: Automation reduces human exposure to chemicals and hazardous environments.

These features make the drone highly adaptable for different terrains and applications, providing precise and efficient operation with minimal supervision.

Line Mapping System-
GPS Integration: The drone uses high-precision GPS technology to define its operational area, enabling accurate positioning and navigation.
Computer Vision: Equipped with cameras and sensors, the drone can visually identify boundaries and obstacles in real-time, enhancing navigation accuracy.
Path Planning Algorithms: Advanced algorithms calculate optimal flight paths based on the field layout, minimizing overlap and ensuring complete coverage while reducing spray input.

Use of drones in weed detection

Drones are frequently utilized for crop condition assessment through the scanning of near-infrared and visible light . Their significant advantage lies in the reduced surveying or monitoring time required for identifying weed patches, a crucial aspect when navigating amidst crop rows . UAVs have the capacity to cover extensive hectares within minutes, generating photographic images for weed patch identification . Processing of these images involves the utilization of deep neural networks, convolutional neural networks, and object-based image analysis.

A comprehensive evaluation of research on UAV-based weed identification highlights three primary types of cameras: RGB, multispectral, and hyper spectral . However, the precision of these cameras in distinguishing weed patches depends on factors such as flying height, drone type, and camera resolution.

Prior to designing an automated weed management system, it is imperative to differentiate between crop seedlings and weeds . The quadcopter UAV model md4-1000, equipped with a global positioning system (GPS) and an RGB or multispectral camera, is employed for the detection and mapping of weeds, crop rows, and bare soil. This is achieved through an appropriate and automated object-based image analysis (OBIA) framework, facilitating the creation of accurate site-specific herbicide application maps .

A method involving color analysis for detecting green weeds like Cirsiumarvense in cereals before crop harvest has been implemented. Under various environmental circumstances, RGB cameras demonstrated correct categorization of 92–97 % of patches when *C.* arvense was dominant . Small consumer UAVs, including models like the Phantom 3 or 4, are capable of mapping 10 ha in 20 min at a flight altitude of 40 m. In a specific vineyard field, a quad copter UAV captured aerial red-green-blue (RGB) photos to map weed patches, optimizing site-specific weed control during the dormant stage of C. dactylon, utilizing an OBIA approach for early detection and mapping .

Conclusion:

The significance of drone applications in vegetable crops and the immense potential of these tools in enhancing cultivation efficiency. Drone applications in vegetable crops in the literature are increasing more and more, with the number of dedicated papers on this subject growing year by year.
The scientific knowledge in this field, combined with the array of information that drones can provide, will be employed by agronomists, agro technicians, and specialized consultants in precision agriculture. These professionals will be capable of offering farmers increasingly

informed and precise operational guidance, thereby contributing to the optimization of agricultural management practices and yielding economic and environmental benefits.
From an economic standpoint, drones can provide a dual advantage. Their utilization enables the reduction of input quantities such as herbicides, fertilizers, pesticides, and water but also the prevention of damages through early diagnosis of various stress types. Additionally, input savings can yield environmental benefits, positioning these technologies as potential solutions for the environmental sustainability of vegetable crops .
However, it is imperative to continue research and development to face technological challenges and make these tools increasingly accessible and effective for the agricultural sector where tradition is strong, and innovations are gradually accepted and adopted.

References:

1. Drones in agriculture: A review and bibliometric analysis
Abderahman Rejeb [a], Alireza Abdollahi [b], Karim Rejeb [c], Horst Treiblmaier [d]
2. Creation of a digital model of fields with application of DJI phantom 3 drone and the opportunities of its utilization in agriculture
T. Hovhannisyan, P. Efendyan, M. Vardanyan
3. Textural features for BLB disease damage assessment in paddy fields using drone data and machine learning: Enhancing disease detection accuracy
Arif K Wijayanto [a b c], Lilik B Prasetyo [a], Sahid A Hudjimartsu [d], Gunardi Sigit [e], Chiharu Hongo [f]
5. G. Wu, Y. Zhang, B. Wang, K. Li, Y. Lou, Y. Zhao, F. Liu
Proteomic and transcriptomic analyses provide novel insights into the crucial roles of host-induced carbohydrate metabolism enzymes in Xanthomonas Oryzae Pv. Oryzae virulence and rice-xoo interaction
6. J. Su, C. Liu, M. Coombes, X. Hu, C. Wang, X. Xu, Q. Li, L. Guo, W.-H. Chen
Wheat yellow rust monitoring by learning from multispectral UAV aerial imagery
7. Y. Su, X. Wang
Innovation of agricultural economic management in the process of constructing smart agriculture by big data
8. I.H. Syeda, M.M. Alam, U. Illahi, M.M. Su'ud
Advance control strategies using image processing, UAV and AI in agriculture: A review
9. N. Tantalaki, S. Souravlas, M. Roumeliotis
Data-driven decision making in precision agriculture: the rise of big data in agricultural systems
10. J. Torres-Sánchez, F. López-Granados, N. Serrano, O. Arquero, J.M. Peña, Q.K. Hassan
High-throughput 3-D monitoring of agricultural-tree plantations with Unmanned Aerial Vehicle (UAV) technology