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Forced Seeding Drone for Agriculture and Reforestation: Design, Development and Performance Evaluation

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Abstract

The increasing demand for precision agriculture and rapid reforestation has created a need for efficient and economical seed dispersal systems. This paper presents the design, development, and testing of a forced seeding drone based on a carbon-fiber hexacopter platform integrated with an iris-based seed dispensing mechanism. The proposed system utilizes GPS-guided navigation, a Pixhawk flight controller, brushless motors, and a lightweight carbon-fiber structure to achieve efficient aerial seeding operations. The iris mechanism enables controlled and accurate release of seeds during flight. Experimental testing demonstrated successful flight operations and seed dispersal with an average flight endurance of approximately six minutes using a 4200 mAh Li-ion battery. The developed prototype offers a cost-effective solution for agricultural sowing and large-scale reforestation while reducing labor requirements and improving operational efficiency.

Keywords: UAV, Hexacopter, Forced Seeding, Precision Agriculture, Reforestation, Iris Mechanism, Agricultural Drone.

1. Introduction

Unmanned Aerial Vehicles (UAVs) have emerged as transformative tools in agriculture, environmental monitoring, and forestry applications. Modern agricultural practices increasingly rely on UAVs for crop monitoring, spraying, mapping, and precision farming operations. Seed sowing remains one of the most labor-intensive agricultural activities, particularly for small and medium-scale farmers.

Conventional seeding methods require significant manpower and time. Similarly, reforestation efforts demand extensive resources for planting seeds across large and inaccessible areas. The development of UAV-based seeding systems offers an innovative solution by enabling rapid, accurate, and cost-effective seed deployment.

The present work focuses on the development of a forced seeding drone capable of performing aerial sowing in agricultural fields and reforestation zones. The proposed drone incorporates an iris mechanism for controlled seed release and utilizes lightweight materials and commercially available components to maintain affordability.

2. Literature Review

Recent studies have demonstrated the growing importance of UAV-based seeding systems in agriculture and forestry. Existing research indicates that drone-assisted seeding can improve planting efficiency, reduce labor requirements, and enhance seed placement accuracy. Researchers have investigated various seed dispensing mechanisms, autonomous navigation systems, and environmental monitoring techniques for aerial seeding applications.

Studies on reforestation drones have highlighted the importance of precise seed placement and optimized seed survival rates. Open-source flight control systems and autonomous waypoint navigation have further expanded the feasibility of drone-based seeding technologies.

Despite these advancements, challenges remain in achieving low-cost implementation, precise seed delivery, improved endurance, and adaptability to diverse agricultural conditions.

3. System Design and Methodology

3.1 Hexacopter Platform

The developed UAV is based on a ZD-850 carbon-fiber hexacopter frame. A six-rotor configuration was selected due to its superior stability, payload capability, and fault tolerance compared with conventional quadcopters.

3.2 Forced Seeding Mechanism

The core innovation of the system is the iris-based seed dispensing mechanism. The mechanism consists of:

- Fitter housing
- Rotator plate
- Gear system
- Pallets

A servo motor actuates the iris mechanism, enabling controlled opening and closing of the seed outlet. This arrangement allows accurate seed dispensing while minimizing wastage.

3.3 Flight Control System

The drone utilizes:

- Pixhawk 2.4.8 flight controller
- NEO-M8N GPS module
- FlySky FS-i6 transmitter and receiver
- Telemetry communication system

The integrated system supports manual operation and future autonomous missions.

4. Hardware Configuration

The major hardware components employed in the prototype include:

Component	Specification
Frame	ZD-850 Carbon Fiber Hexacopter
Motors	5010-360KV Brushless Motors
ESC	40A OPTO ESC
Flight Controller	Pixhawk 2.4.8
GPS	NEO-M8N GPS with Compass
Propellers	14 × 5.5 inch Carbon Fiber
Battery	4200 mAh Li-ion

The carbon-fiber frame significantly reduces structural weight while maintaining mechanical strength.

5. Performance Analysis

5.1 Static Thrust

The theoretical static thrust generated by the propulsion system was calculated using aerodynamic power relations. The calculated thrust value was approximately 5169.96 g.

5.2 Thrust-to-Weight Ratio

The total thrust generated by six motors was estimated at 10,338.79 g, while the overall drone weight was approximately 6000 g. This resulted in a thrust-to-weight ratio of 2.38, indicating adequate lifting capability for payload operations.

5.3 Flight Endurance

With a 4200 mAh Li-ion battery, the estimated flight endurance was 6.42 minutes under operational conditions.

5.4 Flight Range

The theoretical flight range was calculated to be approximately 10.14 km under ideal operating conditions.

6. Experimental Results

Field testing was conducted to validate flight stability and seed dispensing performance. Initial tests revealed synchronization issues among Electronic Speed Controllers (ESCs), resulting in instability. After calibration, stable flight performance was achieved.

The drone successfully performed:

- Takeoff and hovering operations
- Controlled maneuvering
- Seed dispensing using the iris mechanism
- Payload activation through remote control

An average flight duration of approximately six minutes was achieved, closely matching theoretical predictions.

7. Applications

Agriculture

- Seed sowing in large agricultural fields
- Precision farming operations
- Reduced labor requirements
- Increased operational efficiency

Reforestation

- Large-scale afforestation programs
- Seed dispersal in inaccessible terrains
- Rapid ecological restoration
- Environmental conservation initiatives

8. Conclusion

This work demonstrates the successful design and implementation of a forced seeding drone for agricultural and reforestation applications. The integration of a lightweight carbon-fiber hexacopter with an iris-based seed dispensing mechanism provides an economical and effective aerial seeding solution. Experimental testing confirmed stable flight characteristics and reliable seed release operations. The developed system has significant potential to reduce labor dependency, improve seeding efficiency, and support sustainable agricultural and environmental practices.

Future Scope

Future developments may focus on:

1. Fully autonomous seeding missions.
2. AI-based route optimization.

3. Real-time soil and crop analysis.
4. Variable-rate seed dispensing.
5. Enhanced flight endurance.
6. Large-scale reforestation deployment.
7. Integration with precision agriculture platforms.

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