DroneBloom: Enhancing Orchard Efficiency through Agricultural Robotics

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***Abstract*—This paper presents a research initiative focused on the integration of drones, machine learning, artificial intelligence, and robotic technologies into apple orchards to enhance operational efficiency and promote sustainable agricultural practices.**

We introduce a suite of technological concepts, culminating in a drone-based system capable of generating geospatial maps of orchard tree locations.

The system is designed to support two distinct pathways: (1) retrofitting existing farms with advanced technologies, and (2) establishing new farms with automation and data-driven practices as a foundational framework.

The overarching objective is to demonstrate how current technologies can improve the efficiency, sustainability, and economic viability of modern orchard management.

***Index Terms*—Drones, Robotics, Precision Agriculture, Orchard Mapping, Geospatial Analysis, Sustainability, Apple Orchards**

I. Introduction

There are always opportunities to improve the way we cultivate food. Today, farms across the United States use the pesticide Sevin to thin their apple orchards. Apple thinning is the practice of reducing the number of blooms on a stem to ensure larger, higher-quality fruit. As the cost of hiring labor has become increasingly high, farmers have turned to alternative methods—most commonly, spraying chemicals to promote thinning. The purpose of this research is to explore whether there is a cost-effective and sustainable alternative that reduces reliance on pesticides in apple orchards across the United States.

II. Related Work

A. Drone Applications in Precision Agriculture

The integration of robotics has become a critical factor in maintaining competitiveness within modern agriculture. A recent study in Germany estimated the cost of a commercial weeding robot to exceed $75,000 USD [4], with total investment varying based on regional labor costs and the availability of skilled agricultural workers.

Similarly, drones have emerged as a cornerstone of precision agriculture, enabling applications such as aerial imaging, crop monitoring, and yield forecasting. Although the economic benefits of drone adoption are increasingly recognized, detailed cost benefit analyses remain limited. Studies such as Rejeb et al. (2022) [5] highlight that unmanned aerial vehicles (UAVs) can reduce operational costs, improve efficiency, and enhance profitability. However, relatively few research efforts have focused on high resolution aerial mapping and tree level data acquisition in orchards representing a promising avenue for further investigation.

B. Orchard Monitoring and Mapping Techniques

A wide range of agricultural monitoring and mapping technologies are currently employed to improve orchard management. Most existing approaches rely on aerial imaging and remote sensing methods, including RGB (red-green-blue) imaging for high-resolution visual mapping and multispectral or hyperspectral imaging for assessing plant health, stress, and disease detection.

The integration of low-altitude drone imaging with Internet of Things (IoT) networks and neural network-based image processing represents the next generation of orchard monitoring. However, these advanced systems have yet to see widespread deployment in commercial orchard environments [6].

C. Robotics in Blossom Thinning and Crop Care

D. Drone applications in precision agriculture

III. Motivation and Goals

A. Motivation

- Reduce reliance on chemical thinners (e.g., Sevin)
- Improve data collection and yield prediction
- Enable automation in orchard management

B. Project Goals

- Build a drone-based system to map orchard tree locations
- Develop a robotic blossom thinning prototype
- Design orchard architecture optimized for automation (e.g., espalier systems)
- Establish industry partnerships to support research and deployment

IV. Drone-Based Orchard Mapping Demo

A. System Design

(in progress)

- Camera and GPS-equipped drone

- OpenCV and Open3D for vision and point cloud processing
- Geospatial libraries: GeoPandas, Rasterio, Shapely
- Output: Annotated orchard tree location map

B. Methodology

(in progress)

- Aerial image capture over orchard grid
- Tree detection and mapping

C. Preliminary Results

- Visual renderings of mapped tree layout (in progress)
- Accuracy benchmarks (in progress)

V. Future Work

(in progress)

VI. Conclusion

(in progress)

TABLE I
PARTS LIST

Component	Description
Frame	Lumenier QAV-S 2 Joshua Bardwell SE 5” — Carbon fiber 5” freestyle frame with X-Lock arms.
Motors	Xilo Stealth 2207 1800 KV (6S) — Matched to 5” props and 6S battery configuration.
Electronic Speed Controller	Xilo Stax V2 45A BLHeli_32 (3-6S) — 4-in-1 electronic speed controller.
Flight Controller	Xilo Stax V2 F4 — Pre-stacked flight controller with firmware compatibility.
Propellers	Gemfan Hurricane 51477 — 5” 3-blade props optimized for freestyle flight.
Battery	Compatible 6S LiPo battery recommended.
Radio Receiver & Controller	Requires a compatible receiver (e.g., Crossfire, ELRS) and radio transmitter.
Building Tools & Accessories	Soldering tools, charger, goggles, and assembly hardware required.

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