FACULTY RESEARCH OVERVIEW

Engineering intelligent systems for specialty-crop agriculture

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Integrated research program

My research connects perception, biological understanding, decision-making, and robotic action. The current program develops an AI-driven, vision-guided precision herbicide spraying system for sustainable weed management in apple orchards. Each study resolves one part of a complete field pipeline, while the combined work establishes a platform for broader specialty-crop automation.

84.9% SEGMENTATION MAP@0.5	83.6% LOCALIZATION MAP@0.5	0.82 MULTIPLE-OBJECT TRACKING ACCURACY	93.7% DYNAMIC SPRAY HIT RATE AT 0 DEGREES

Four connected studies

01 Orchard weed perception
YOLOv7-CBAM segmentation, modified DeepSORT tracking, persistent weed identities, localization, and pixel-grid density estimation in cluttered apple rows.

02 Vision-guided multi-servo spot spraying
Pixel-to-ground calibration, target-to-nozzle assignment, independent servo steering, timing compensation, and coordinated spray scheduling.

03 Weed morphology and adaptive dosing
Repeatable top- and side-view greenhouse imaging connects plant size and growth habit to deposition and treatment decisions.

04 Autonomous field integration
A Farm-ng Amiga platform integrates stereo vision, LiDAR, GNSS, onboard computing, ROS 2, navigation, perception, and precision application.

Selected contributions and measured evidence

Perception that remains spatially actionable

The first-author journal study combines attention-enhanced segmentation, identity-preserving tracking, and spatial density mapping. The contribution is not only to identify weeds, but to preserve target continuity and convert image evidence into information that a mobile field system can use.

- Published in Computers and Electronics in Agriculture 239 (2025), article 111071.
- Segmentation mAP@0.5: 84.9%; localization mAP@0.5: 83.6%; MOTA: 0.82.
- DOI: 10.1016/j.compag.2025.111071.

Precision actuation and coordinated spray delivery

The three-nozzle prototype converts weed locations into steering angles and timed spray commands. Controlled testing measured less than 1 degree of steady-state servo error, observed settling times from 108 to 265 ms, a 93.7% dynamic hit rate at 0 degrees, and complete direct and sequenced scheduling in the evaluated trials.

Biologically informed treatment decisions

Controlled greenhouse experiments evaluate two contrasting weed species across three size classes and 18 treatments per plant, producing 324 plant-level deposition records. The design links measurable morphology to treatment volume, nozzle angle, travel speed, and canopy-ground deposition rather than relying on a binary spray/no-spray decision.

Field integration and validation

The Farm-ng Amiga research platform brings sensing, autonomous navigation, onboard inference, target selection, and precision spraying into one field system. Current validation focuses on orchard-row operation, field clearance, timing, reliability, and recovery under variable conditions.

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