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Title: Use of drones and RFID as the next generation of nursery inventory

Principal Investigators:

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Key Collaborators: Avery Dennison and R.A. Dudley Nurseries

Project Background

Plant inventory data collection is very time-consuming, costly, and inaccurate. Accurate inventory allows for better forecasting, profit projections, and precise delivery to customers. Increasing labor costs and shortages are just one of the pressing problems in the nursery industry. There is an increased need for automated technologies to address these problems, especially in the unstructured environment of nurseries.

Drones have been used to read Radio-Frequency Identification (RFID) tags for inventory of vehicles and boxes in warehouses but to date they have limited use in nurseries. One advantage of drones is their ability to execute complex low altitude flights and carry various sensing payloads. RFID tags offer a major advantage over barcodes for inventory since they do not rely on line of sight to capture data. Merging RFID tags with a drone is suggested as a plausible method to automate the inventory process in nurseries.

Since 2021 a collaborative team has been working on developing solutions using drones and RFID tags to automate inventory in nurseries. Funded in part by a grant from the Horticultural Research Institute (HRI), the team has made significant progress in evaluating several key factors (e.g., drone speed & number of passes, distance and orientation of RFID tags relative the reader). In early 2022, using the same grant funds, the team deployed more than 9,000 RFID tags to four crops (Osmanthus, boxwood, holly, and maple) at Dudley Nurseries at Thomson, GA. Three different label types (peel-n-stick on stake, peel-n-stick on container, and looplock) with five different antennas (web, dogbone, miniweb, longbow, and squarewave) were evaluated. Starting in February 2022, and every two months since, the team has collected tag reading counts. To date three of the nine tag designs in combination with the current drone RFID reader configuration have delivered 88%+ tag counts. While preliminary results are very promising the experiment has identified the need for a smaller targeted experiment to further refine the inventory system including a better adhesive for peel-n-stick tags. A key reason for the success of this early work was the close collaboration with two companies (William Frick; Avery Dennison) with expertise in RFID tag development.

Benefit to Nursery Industry

Adoption of appropriate technologies will result in significant economic, environmental, and social benefits to the nursery industry. The ultimate goal is to foster the development of technology-based systems for nursery growers that commercial companies (e.g. sUAS: DJI, HSE,

Autel, Skydio; RFID: William Frick, Arbre Technologies, Avery Dennison) can easily adopt and further develop.
The use of RFID will allow traceability of production information to crops from the moment they are tagged until they leave the production facility and beyond (Barge et al., 2010). This system will improve inventory data accuracy, quality control, and may be used for irrigation management and pesticide application.

Project Objectives and Outcomes
The narrow objectives of this proposal are based on foundational results from our HRI funded research. We anticipate ***three outcomes*** will be achieved from this project including: 1) recommendation for an RFID reader/drone system, 2) final design for two types of RFID tags (peel-n-stick; loop lock) for nursery use, and 3) dashboard to graphically view inventory data. For this proposal, we will focus our efforts on the following ***two objectives***:

- *RFID tag refinement: Evaluate two tag antennas (dogbone and square wave) for peel-n-stick and loop lock tags*
- *Peel-n-stick Adhesive: Evaluate three different adhesives for the peel-n-stick tags*

Overview of methods

- Tag/antenna refinement. Four tag treatments (2x tag types; 2x antenna) will be attached to container-grown plants of two types (low & medium canopy density). The drone/RFID reader will be flown over blocks of labeled plants starting at planting at bi-monthly following to capture any effects of canopy development on tag counts.
- Peel-n-stick adhesive. This very simple experiment is designed to evaluate three adhesive strengths on peel-n-stick tag retention over 12 months under nursery conditions.

Outline of how the project will be carried out over 12 months:
We will follow the same successful protocol used in 2022 whereby two container-grown plants will be tagged at canning and then placed in nursery blocks. Every other month the team will collect tag count information (i.e. for adhesive objective, how many tags fall off; for RFID, plant counts).

Budget summary

Description	Amount
Student Helper Salary	9,600.00
Travel	
Nursery	
Dr. Maja and Student helper	9,421.00
Fringe	179.00
Conference	
PIs to present results to conference	13,000.00
Materials and Supplies	4,500.00
TOTAL	**27,100.00**