How artificial intelligence can enhance the citrus industry

Figure 1. Example of an Agroview fertility map for nitrogen. (Nitrogen ranges based on UF/IFAS recommendations).

By Yiannis Ampatzidis

Artificial intelligence (AI) is a promising area in computer science, automation, robotics and agriculture. AI describes the capability of a machine to imitate intelligent human behavior and mimic cognitive functions such as learning and problem-solving.

Machine learning, which is an application of AI, is based on the idea that a machine, such as a computer or microcontroller, can "learn" from data and identify patterns in it. A machine can learn without being programmed and adjust to new inputs to accomplish specific tasks (e.g., self-driving cars, phase/voice detection and classification). This process can eliminate human intervention and errors.

In citrus, recent advances in AI and machine learning with the latest technological developments in remote sensing, automation and robotics can improve production management, optimize agrochemical applications, increase profit and reduce negative environmental impact. This article presents several applications of AI as examples in citrus.

FIELD SCOUTING

Traditional techniques for plant pest and disease detection in the field rely on manual sampling, which is labor-intensive, expensive and time-consuming. Artificial intelligence can be used to develop cost-effective scouting systems that optimize pest and disease identification and management.

Smartphone App

Arnold Schumann, professor at the University of Florida Institute of Food and Agricultural Sciences (UF/IFAS) Citrus Research and Education Center, developed an AI-based app for smartphones to identify unique leaf symptom expressions (e.g., nutrient deficiencies and HLB symptoms). This diagnostic tool can help citrus growers and gardeners rapidly identify common citrus pests and diseases from foliage symptoms. Visit www.makecitrusgreatagain.com/SmartphoneApp.htm to download the app.

Automated Tap Sampling

My team at the Southwest Florida Research and Education Center (SWFREC) automated the tap-sample method, a commonly used method for insect scouting. This new automated system (patent #16/505927) utilizes machine vision and AI to monitor Asian citrus psyllid (ACP) populations in groves and determines the need to spray.

This smart, low-cost system can detect, distinguish, count and geolocate ACP populations in citrus groves. It includes a tapping mechanism that strikes tree branches.

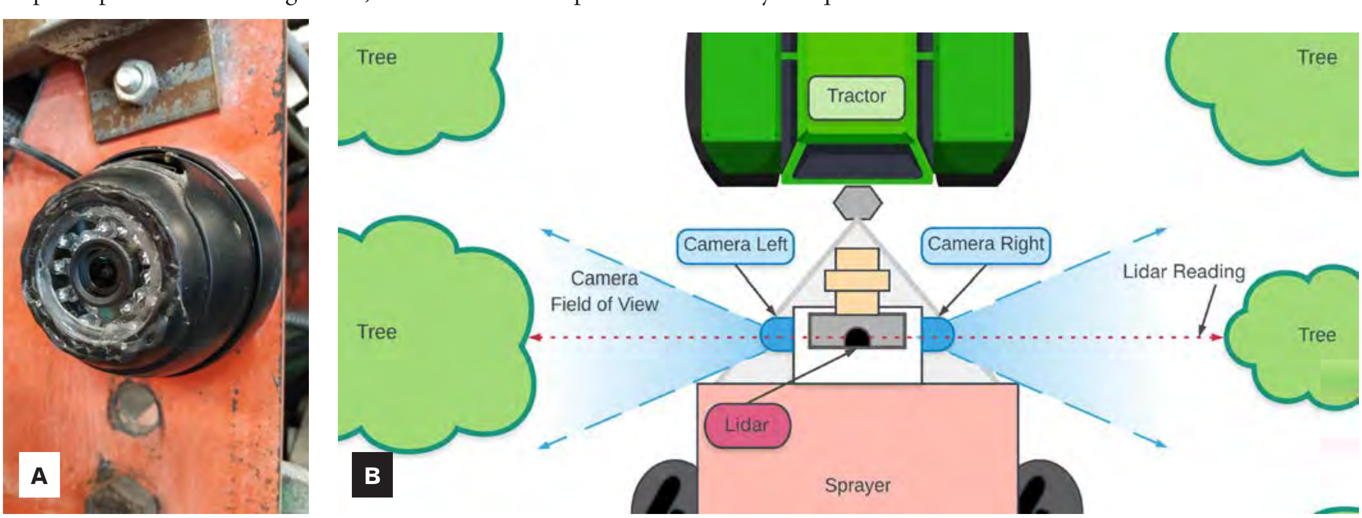

Figure 2. SmartSense for variable-rate sprayers: A) RGB camera installed on the sprayer and B) top view of the schematic of the positioning of cameras and lidar on the sprayer.

Insects fall onto a board with a grid of cameras used for image acquisition and processing. (See a video demonstration at twitter.com/i/status/1110151596770500608.)

This novel technology distinguishes and counts adult ACPs and visualizes the number of ACPs per sample tree on maps compatible with precision equipment for variable-rate applications. The system helps determine where to apply the right amount of pesticides.

PRECISION CROP MANAGEMENT

Almost all agricultural inputs (e.g., water, pesticides and fertilizers) are applied uniformly with conventional equipment despite field variability (e.g., non-uniformity in soil composition, variability in tree size and age within a field, etc.) and the variable distribution of spatial pathogens. Uniform applications result in overusing agrochemicals (e.g., applications where no disease or pests occur; over-application of fertilizers and water), which leads to increased costs, risk of crop damage, environmental pollution and contamination of the edible products.

Artificial intelligence and automation can be used to develop smart agricultural technologies for precision and timely management of inputs.

Agroview

A novel cloud-based technology named Agroview (http://agroview.farm) was recently developed by my team to process, analyze and visualize data collected from aerial (e.g., unmanned aerial vehicles and satellites) and ground-sensing platforms (patent pending). It comprises multiple AI models that detect and assess individual plants on aerial maps.

Agroview's user-friendly and interactive interface visualizes individual tree health and detects at-risk trees. It also shows plant nutrient concentration presented as fertility maps (Figure 1, page 10). In addition, Agroview visualizes tree inventory, including categories based on tree height and canopy size as well as detections/counts of tree gaps.

The fertility maps can be used for precision and variable-rate fertilizer applications. A UF/IFAS spinoff company, Agriculture Intelligence Inc. (www.agroview.ai/), was developed to license and commercialize this novel AI technology to save growers money and time while optimizing precision agriculture applications.

Smart Spray Technology

Technological advances in remote sensing, mechatronics and AI helped develop smart spraying technologies for tree crops. For example, a smart tree crop sprayer was developed by my program at SWFREC. The sprayer utilizes a low-cost and novel SmartSense sensor [a combination of lidar (laser imaging, detection, and ranging) and two RGB cameras; Figure 2, page 10] and AI-based data fusion to optimize agrochemical (e.g., pesticide, foliar fertilizers) applications.

This SmartSense sensor and variable-rate spraying technology (patent pending) detects tree canopy and estimates tree height and leaf density. Based on this information, it controls liquid flow and nozzle zones (or individual nozzles). The lidar estimates tree height and canopy size, and the cameras and AI verify if the detected object is a citrus tree. It will not spray if another object, human, other tree, etc. are detected.

Together, the lidar and cameras also are used to estimate leaf density with an AI-based data fusion algorithm and to vary the quantity of agrochemicals (based on tree height and canopy leaf density) applied. This SmartSense technology can detect at-risk trees and does not spray on dead trees or gaps. While spraying, it detects and counts fruit and estimates fruit size (see the video demonstration at www.youtube.com/watch?v=qRd4g44b2lk&feature=youtu.be).

The smart sprayer can also "read" fertility maps, such as those developed by Agroview as described above, and vary the amount of the foliar fertilizer based on the management zones. At the end of each application, it develops spraying and fruit heat-maps (visualized by Agroview, Figure 3). Chemical Containers Inc. licensed this smart sprayer technology from UF/IFAS and plans to commercialize it soon.

Figure 3. Agroview: Example of A) spray path and spraying heat-map and B) fruit detection and fruit heat-map in an experimental grove at the Southwest Florida Research and Education Center.

Yield Prediction and Harvest Management

Harvest costs are generally the single greatest expense for citrus producers. Predicting harvest date and yield in advance can help with efficiency and significantly optimize the harvest, which are essential steps toward reducing costs and maintaining product quality and quantity. Currently, growers use time-consuming, expensive and destructive sampling methods to predict yield and collect other fruit information (e.g., fruit quality).

Agroview integrates data from aerial images (e.g., tree canopy volume, leaf density and tree health/stress) and data from ground-based smart sensing systems (e.g., fruit counts and fruit size collected by the SmartSense sensor of the variable-rate sprayer) to predict fruit load (Figure 3B) and yield. These results can be combined with weather and soil data to increase yield prediction accuracy.

CONCLUSIONS

AI can provide growers with low-cost tools and smart technologies to continually monitor crop health/stress status, determine plant needs, and optimize pest and disease identification and management. These technologies have real potential to deliver more productive and sustainable agriculture through a precise and cost-efficient approach, especially in the face of farming labor shortages and climate change.

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