Artificial Intelligence for Precision Agriculture

Yiannis Ampatzidis

Associate Professor, Agricultural Engineer

UF/IFAS SWFREC

Phone: 239.658.3451

Email: i.ampatzidis@ufl.edu

@PrecAgSWFREC

4th Agricultural Revolution

1900 1950 1990 Now

Digital Farming / Big Data / Internet of Things (IoT)

Robotics / Artificial Intelligence (AI) /Automation

Smart Farming / Smart-Intelligence Machinery

Google Mineral crop-inspecting robots

Azure FarmBeats by Microsoft

Artificial Intelligence for Robotic Harvesting

Robotic Apple Harvester
Abundant Robotics

https://www.youtube.com/watch?v=mS0coCmXiYU

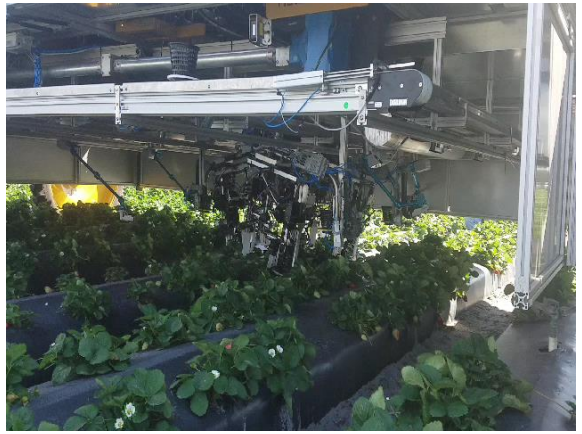
Automatic fruit picker
FF Robotics

https://www.youtube.com/watch?v=UaL3UxUclKY

Agrobot Strawberry Harvester
Human vs Machine

https://www.youtube.com/watch?v=mlpu-XFZjno

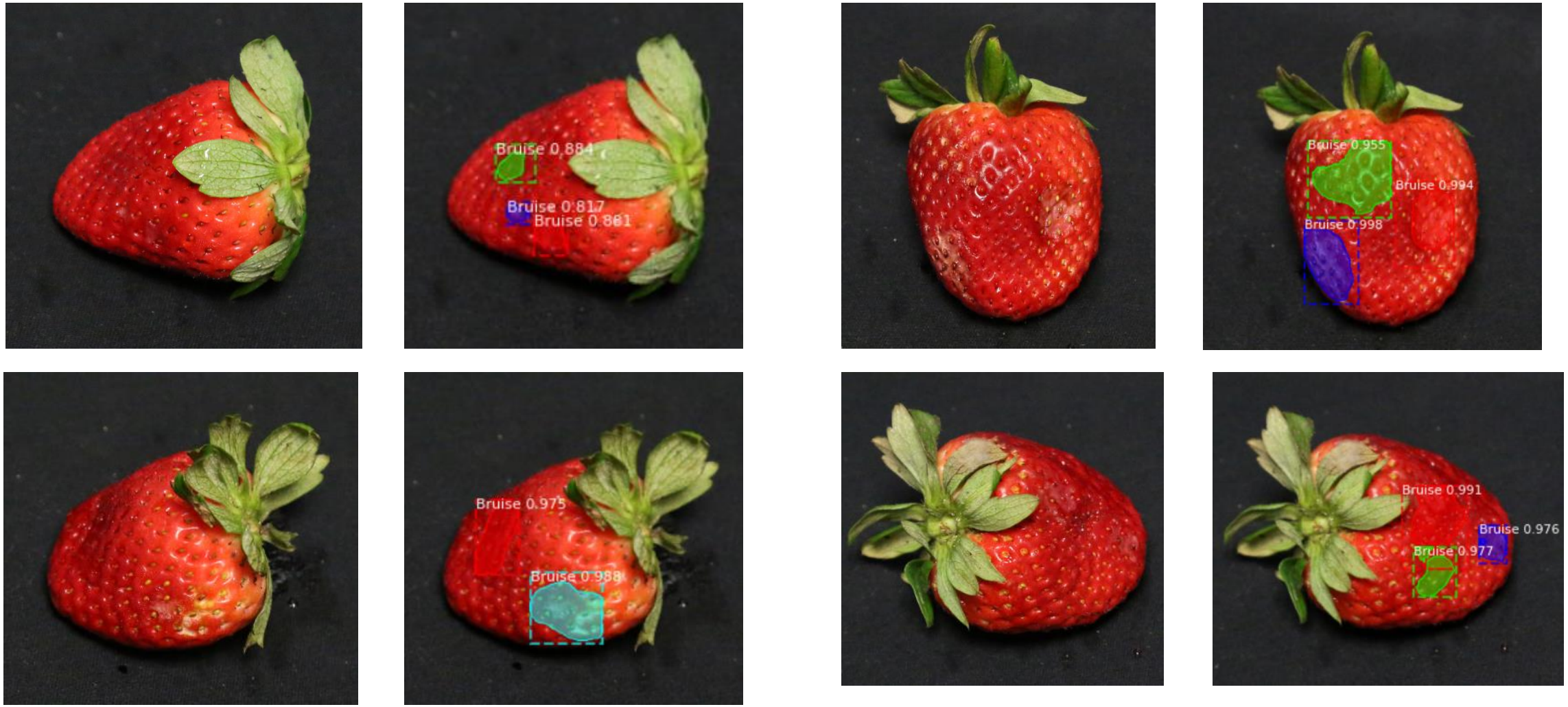
Harvest Croo Robotic: Strawberry Harvester



Mechanization of Strawberry Harvesting
Harvest Croo Robotics

Strawberry bruise detection using deep learning

PhD student: Xue Zhou

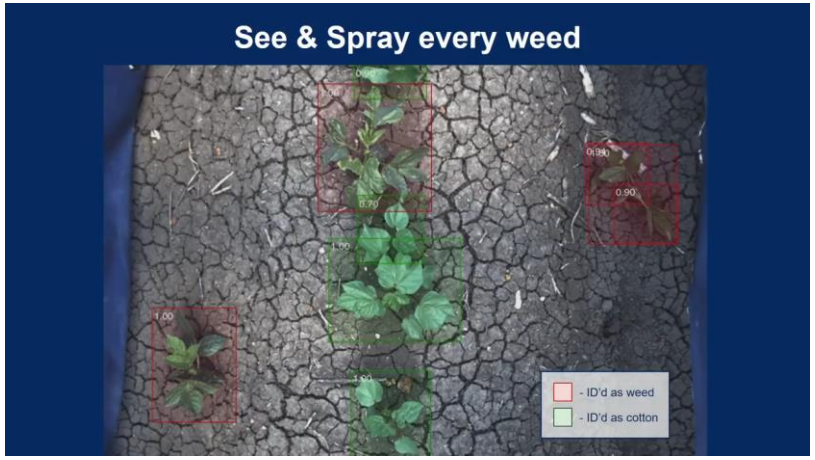


Zhou X., Lee W.S., Ampatzidis Y., Chen Y., Peres N., Fraisse C., 2021. Strawberry maturity classification from UAV and near-ground imaging using deep learning. Smart Agricultural Technology, 1, 100001, https://doi.org/10.1016/j.atech.2021.100001.

Nutrient and Pest Management

Artificial Intelligence for Precision Weed Management

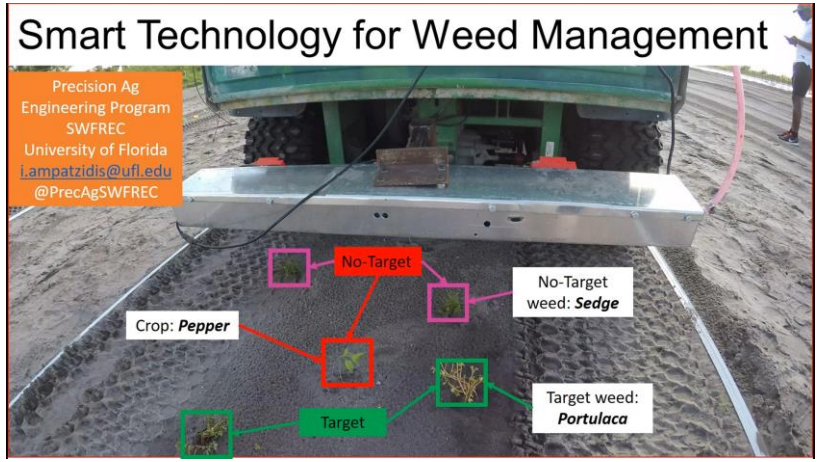
Precision Weeding
Blue River Technology



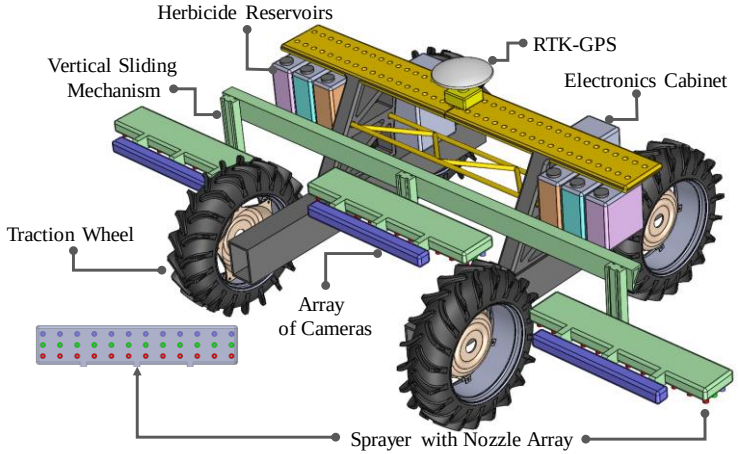
Carbon Robotics: Autonomous Laser-based weed elimination

https://www.youtube.com/watch?v=vSPhhw-2ShI

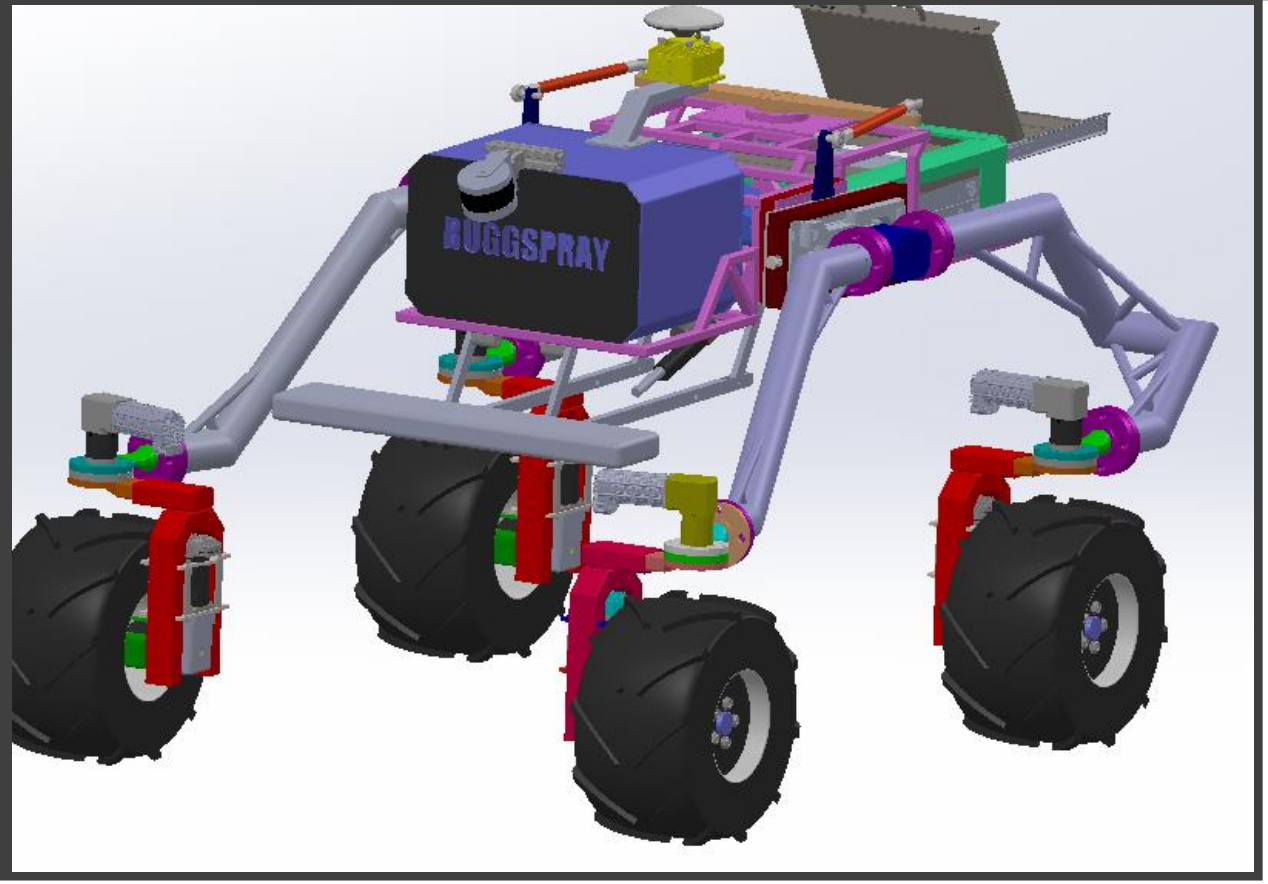
Smart Sprayer
SWFREC, IFAS, UF



https://twitter.com/i/status/1045013127593644032



NRI: INT: COLLAB: ***High Throughput Multi-Robot Weed Management for Specialty Crop***. National Robotic Initiative (NRI), Nasional Research Foundation (NSF).

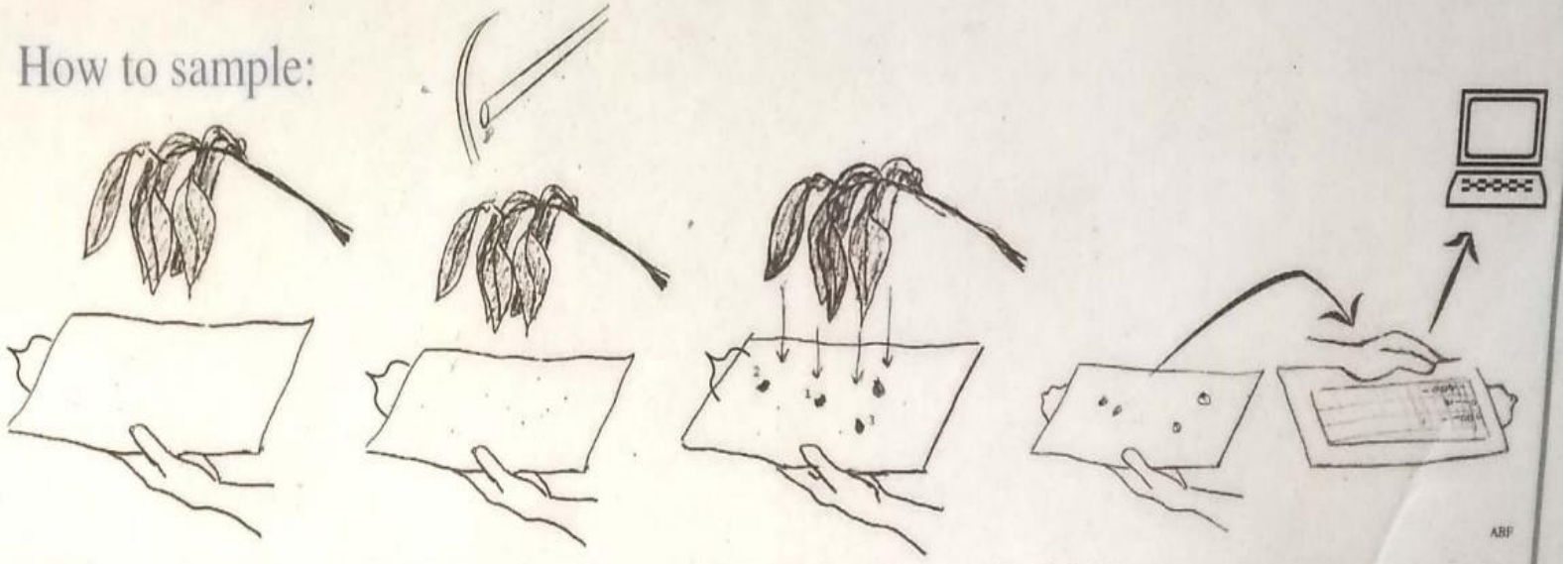


Smart Technology for Precision Weed Management

Traditional (manual) ACP Monitoring Tap Sample Method

Monitoring of ACP populations is an important tool in the integrated management of citrus greening. The most efficient way to estimate field populations of this insect is by monitoring the adults. Tap sampling has proven to provide data needed to make informed decisions for managing this insect pest (Qureshi and Stansly 2007).

How to sample:



1. Place back side of this sheet 1 foot under the branch to be sampled.

2. Tap the selected branch with a PVC tube or your hand 3 times.

3. Quickly count the insects (beneficials and pests) that fall onto the paper. Pay special attention to ACP.

4. Write the number of insects from each sample on the provided datasheet for later reference and entry into a database.

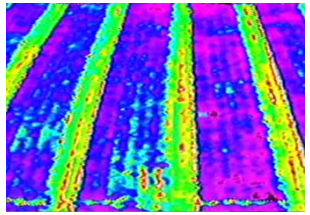
Automated system and method for monitoring and mapping insects (e.g. ACP) in orchards" using AI.
U.S. patent application No. 62/696,089.

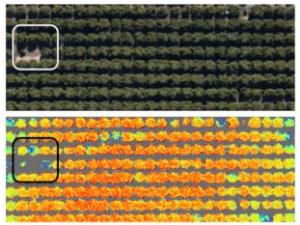
Collaborators:
Dr. Stansly

https://twitter.com/i/status/1110151596770500608

Partel V., Nunes L., Stansly P., and Ampatzidis Y., 2019.Automated Vision-based System for Monitoring Asian Citrus Psyllid in Orchards Utilizing Artificial Intelligence. Computers and Electronics in Agriculture, 162, 328-336.

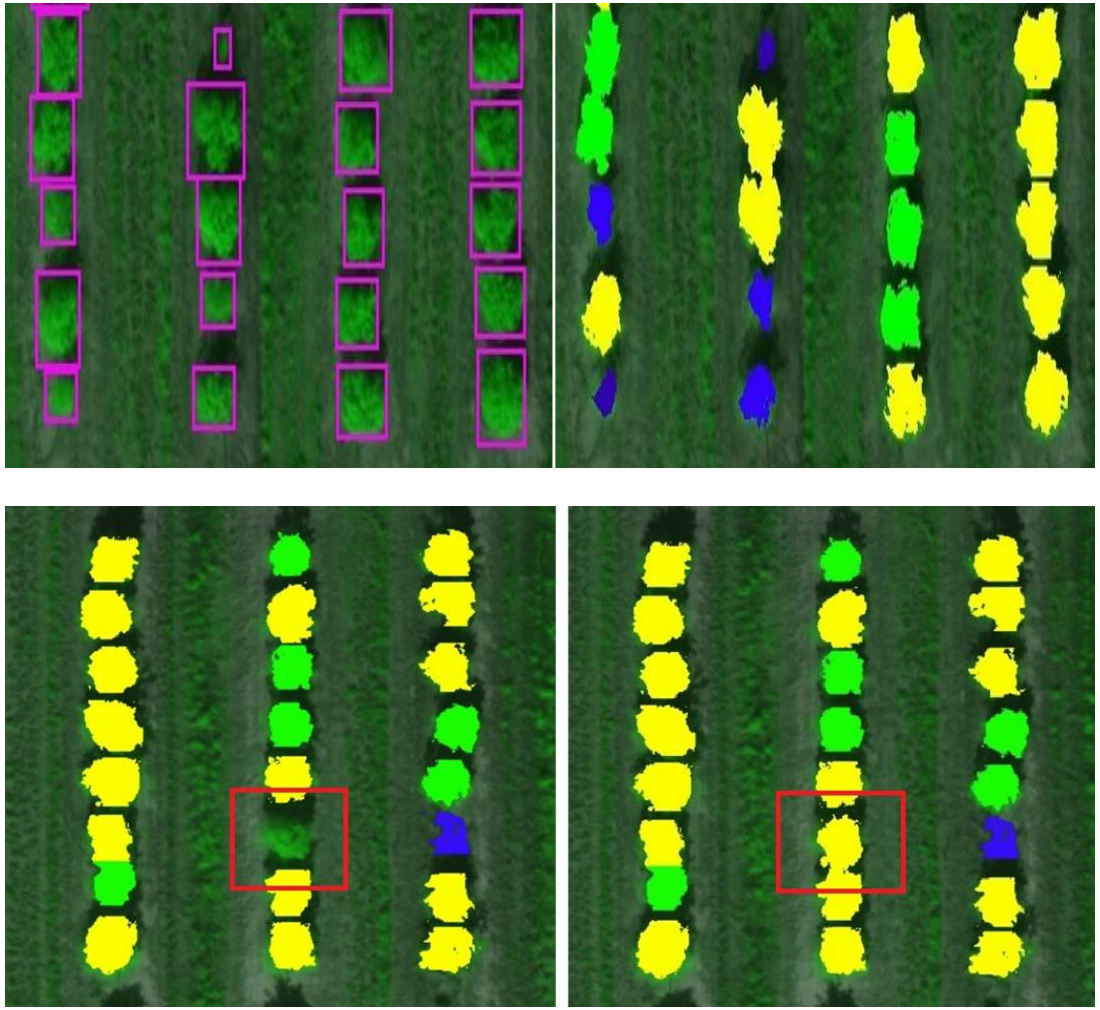
UAVs in Agriculture





UAV-based Object Detection using Artificial Intelligence (AI)

Image Source: PrecisionMapper

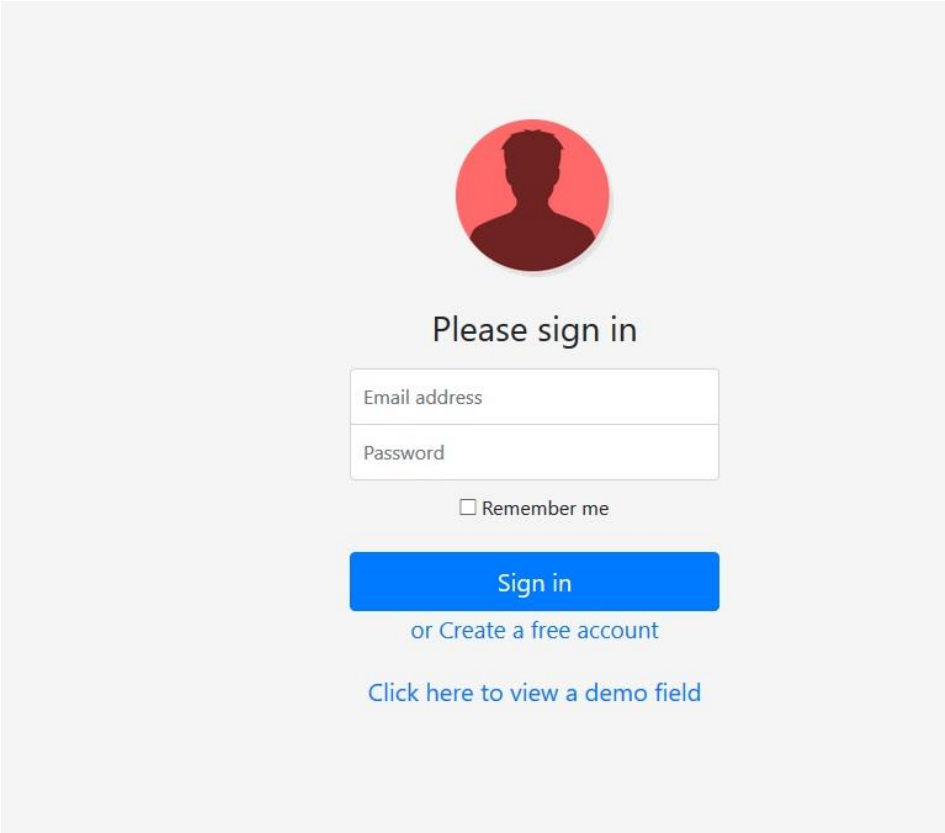


Ampatzidis Y., and Partel V., 2019. UAV-based High Throughput Phenotyping in Citrus Utilizing Multispectral Imaging and Artificial Intelligence. Remote Sensing, 11(4), 410; doi: 10.3390/rs11040410.

Agroview – sing in

Awards

- 2020 UF Invention of the Year.
- 2021 ASABE AE50 winner (2020 top innovative new product).
- 1st Runner Up at the 2020 Florida Aerospace & Technology Competition.
- Finalist at the 2020 Cade Prize.

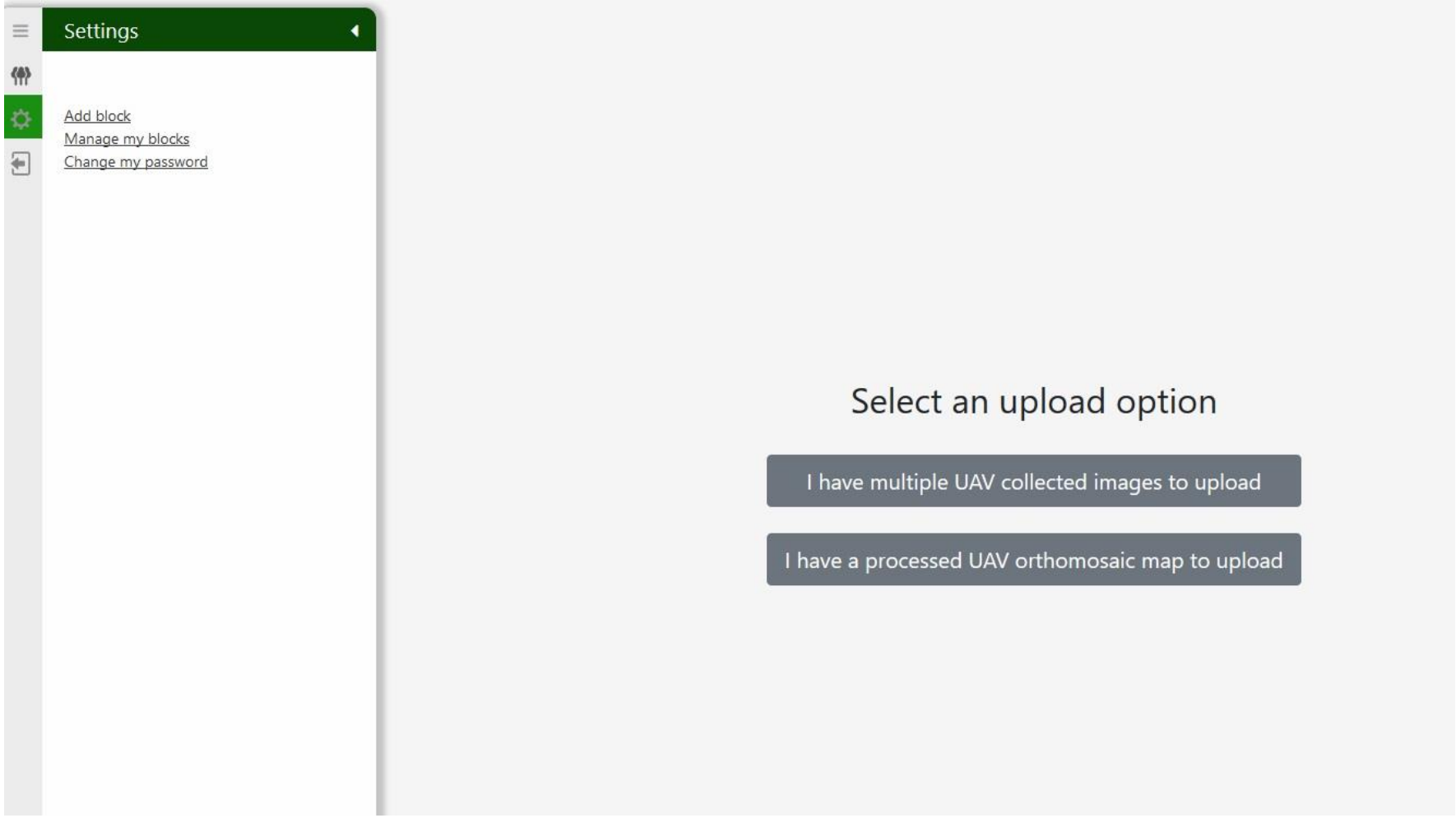


Agriculture Intelligence

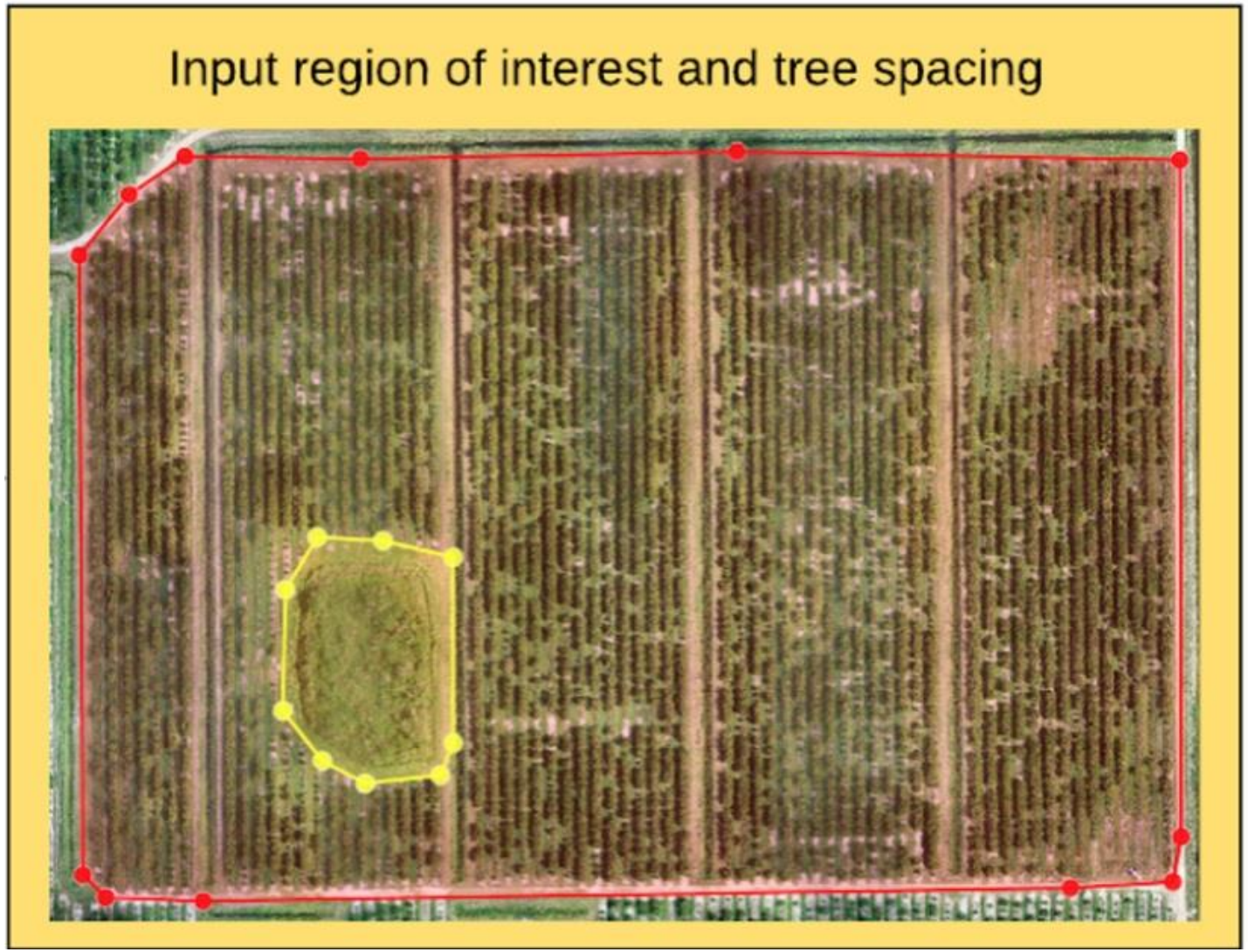
NVIDIA Applied Research Accelerator Award

- UAV and ground-based high throughput phenotyping in citrus utilizing artificial intelligence. Huanglongbing Multi-Agency Coordination (MAC) Group. Duration: 8/1/2019 – 7/31/2021.
- UAV-based high throughput phenotyping in specialty crops utilizing artificial intelligence. Florida Specialty Crop Block Grant Program - Farm Bill (SCBGP-FB). Duration: 1/1/2020 – 8/31/2022.

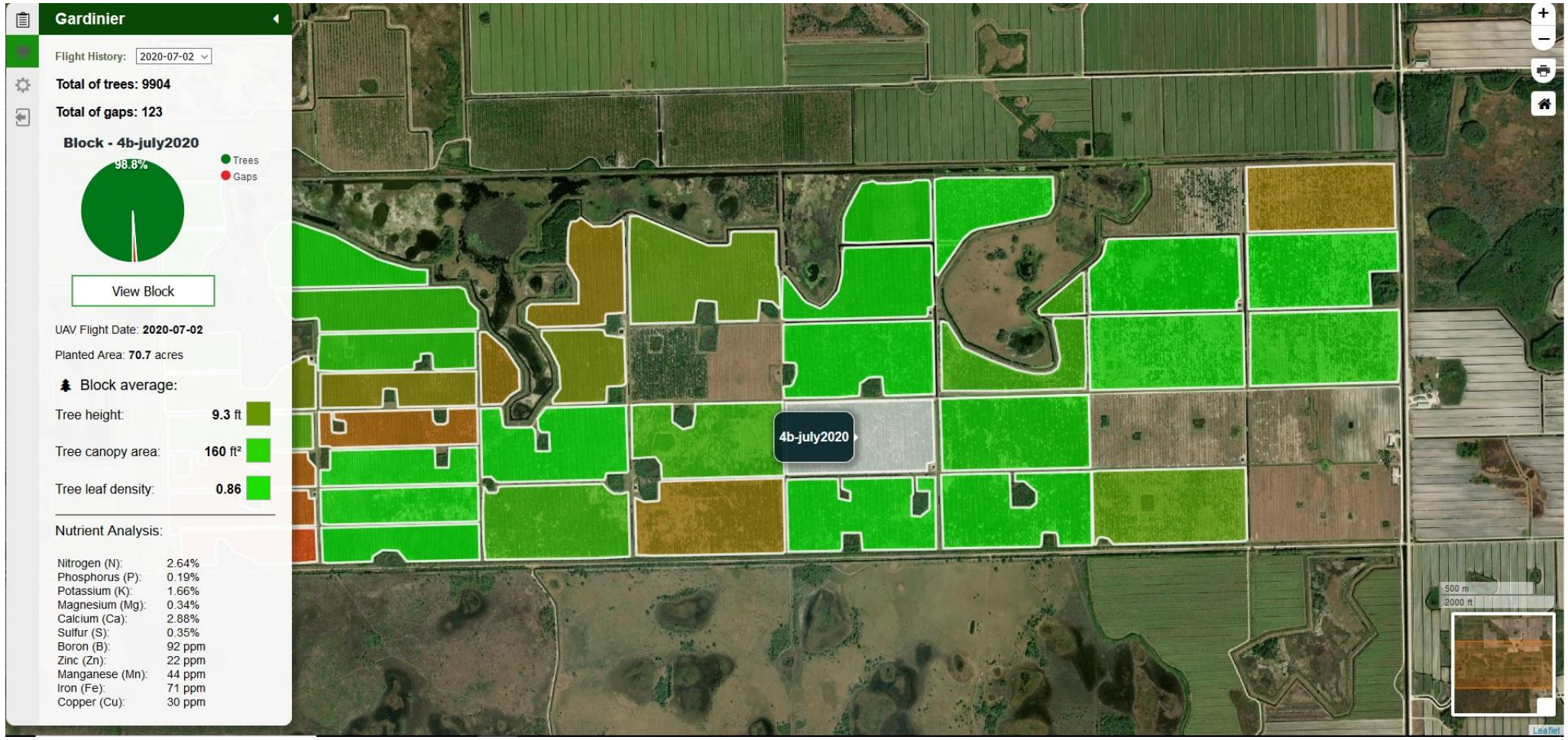
Agroview – add block



Agroview – create field boundaries



Agroview – farm analytics

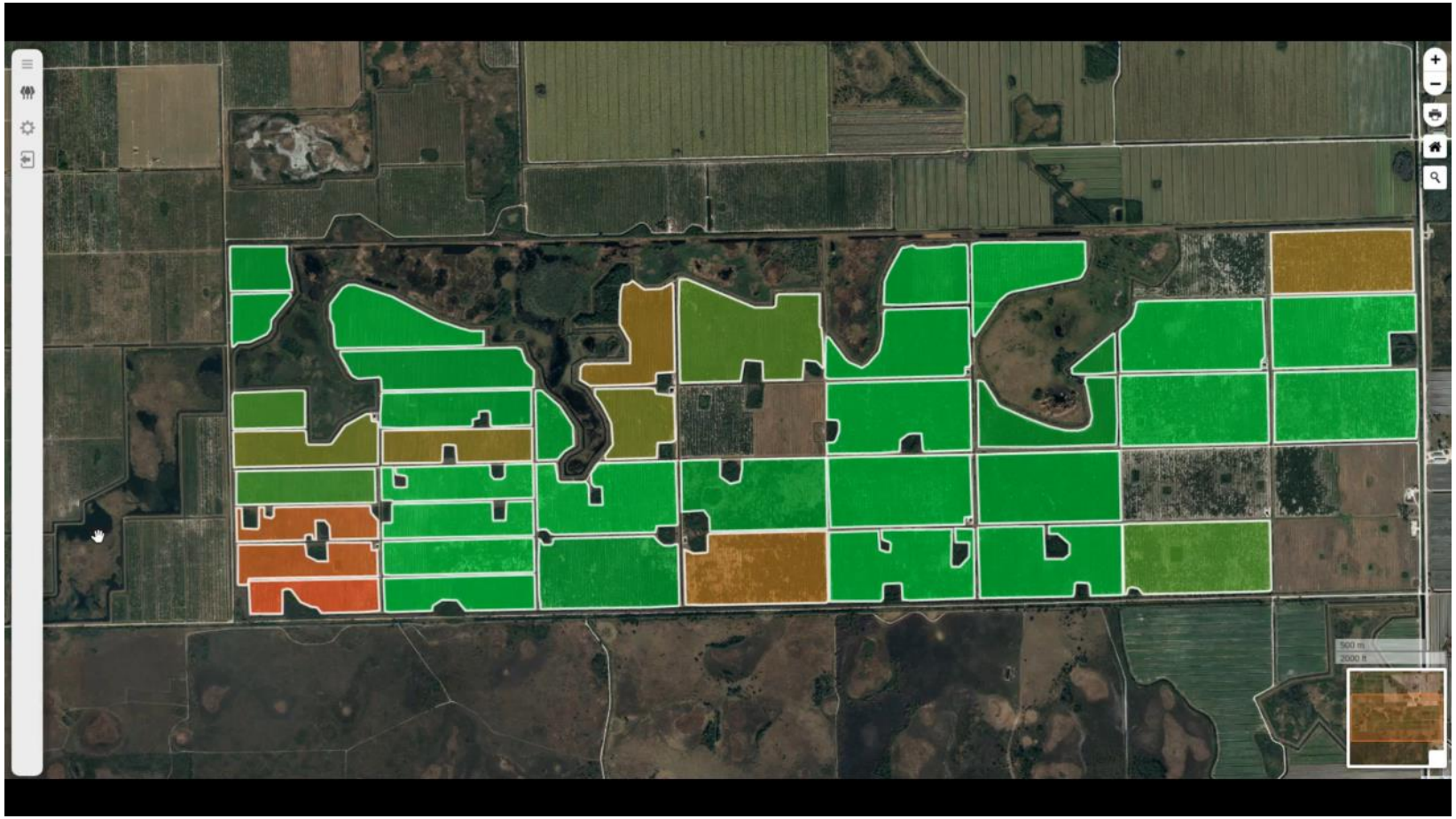


- Ampatzidis Y., Partel V., Costa L., 2020. Agroview: Cloud-based application to process, analyze and visualize UAV-collected data for precision agriculture applications utilizing artificial intelligence. *Computers and Electronics in Agriculture*, 174(July), 105157, doi.org/10.1016/j.compag.2020.105457.
- Costa L., Nunes L., Ampatzidis Y., 2020. A new visible band index (vNDVI) for estimating NDVI values on RGB images utilizing genetic algorithms. *Computers and Electronics in Agriculture*, 172 (May), 105334.

Agroview – field analytics

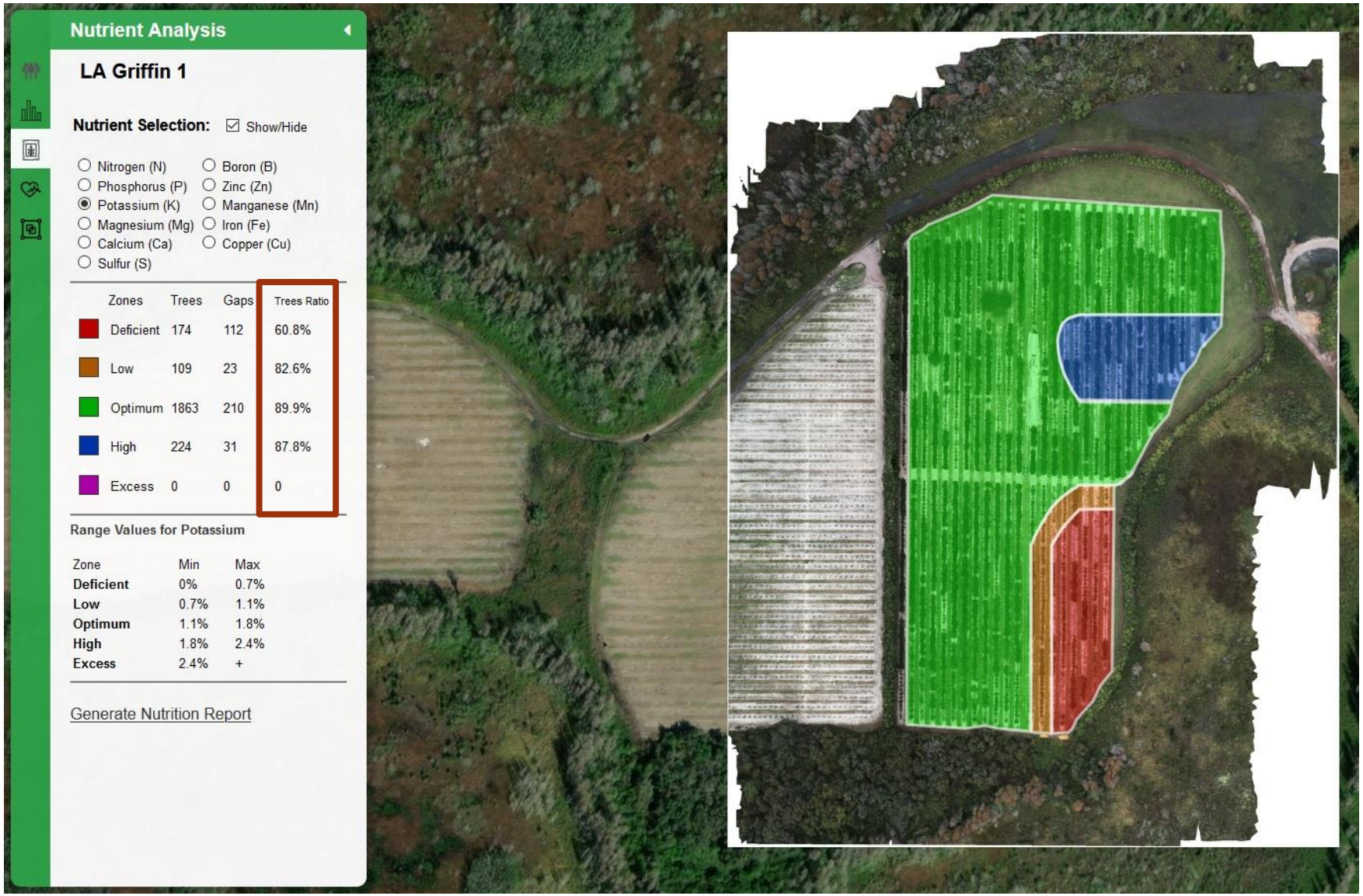
- UAV and ground-based high throughput phenotyping in citrus utilizing artificial intelligence. Huanglongbing Multi-Agency Coordination (MAC) Group. Duration: 8/1/2019 – 7/31/2021.
- UAV-based high throughput phenotyping in specialty crops utilizing artificial intelligence. Florida Specialty Crop Block Grant Program - Farm Bill (SCBGP-FB). Duration: 1/1/2020 – 8/31/2022.

Cloud-based application to process, analyze, and to visualize UAV collected data



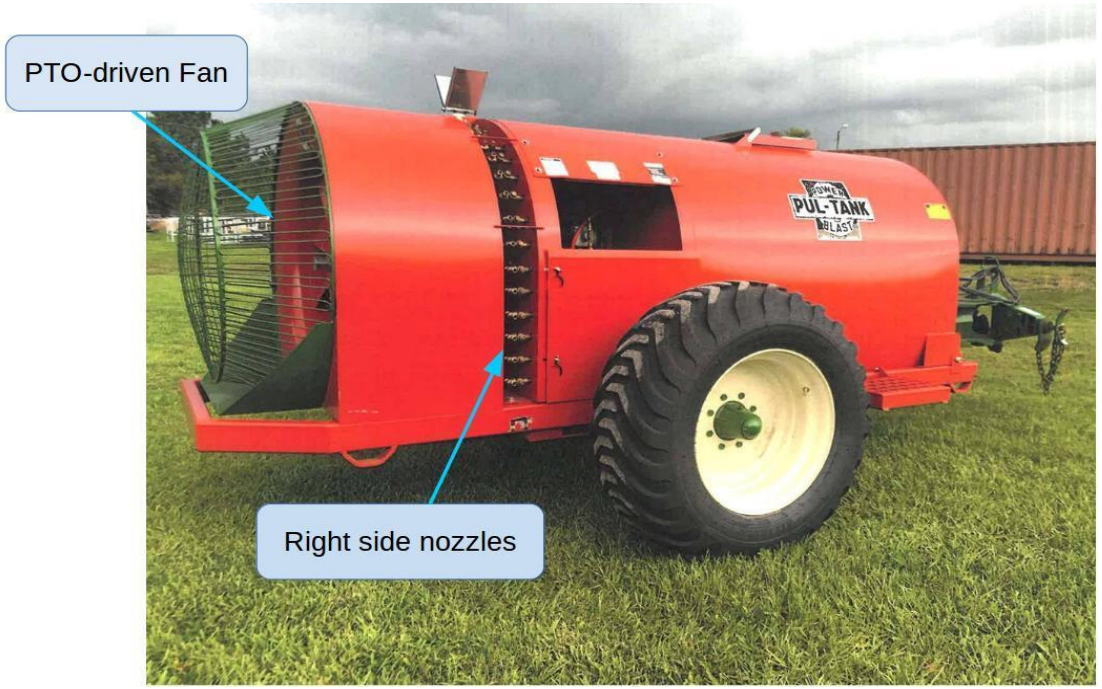
https://twitter.com/i/status/1202671242647490560

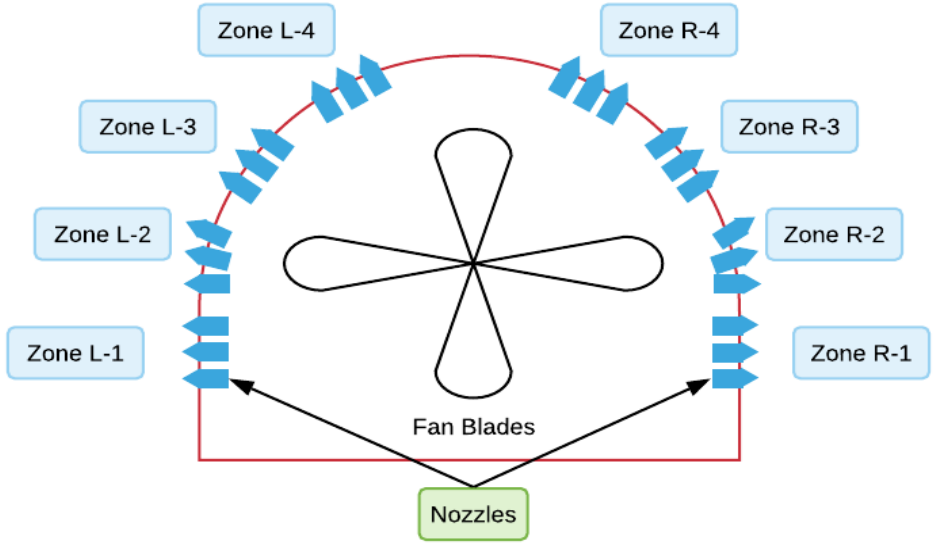
Best Management Practices
Agroview - Nutrient Management



Costa L., Kunwar S., Ampatzidis Y., Albrecht U., 2021. Determining leaf nutrient concentrations in citrus trees using UAV imagery and machine learning. Precision Agriculture, https://doi.org/10.1007/s11119-021-09864-1.

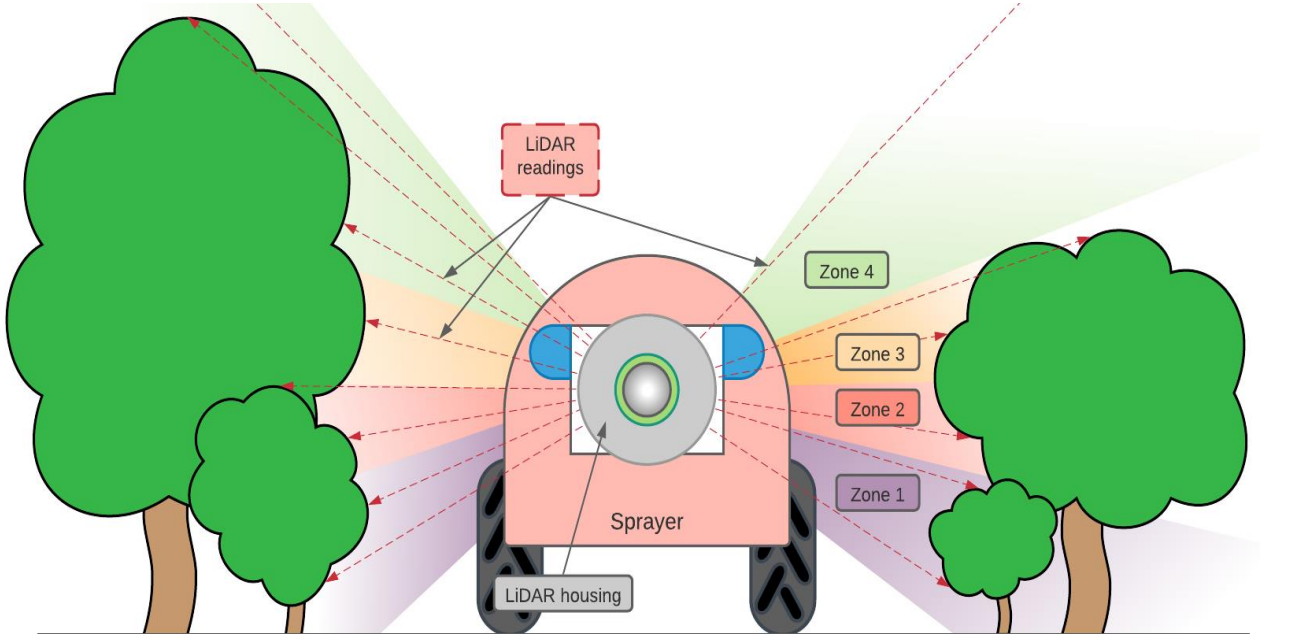
Novel Smart Tree Crop Sprayer

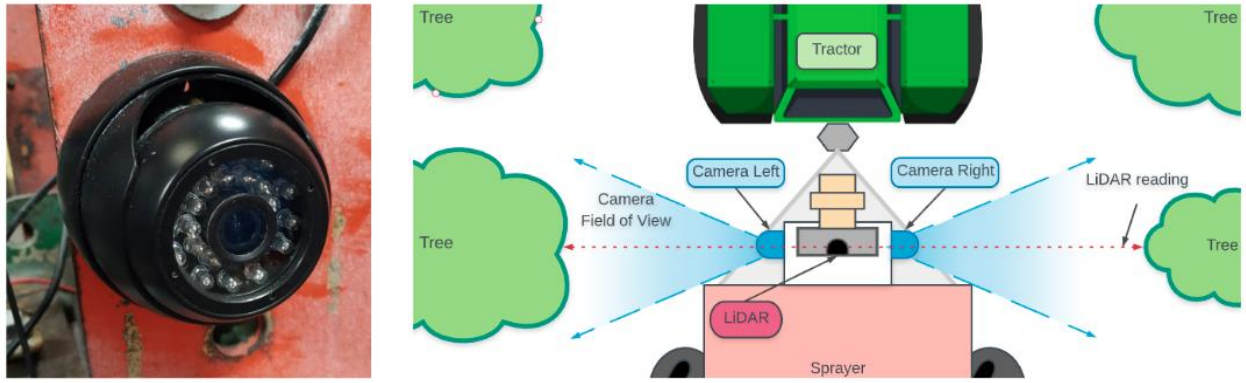




Smart and precision sprayer for tree crops. Florida Specialty Crop Block Grant Program - Farm Bill (SCBGP-FB). Duration: 1/1/2021 – 12/31/2022.

Novel Smart Tree Crop Sprayer

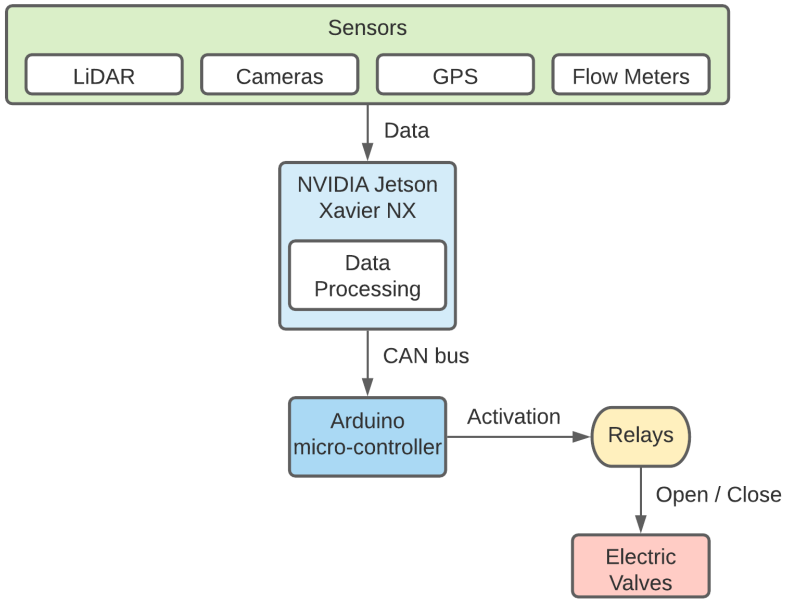


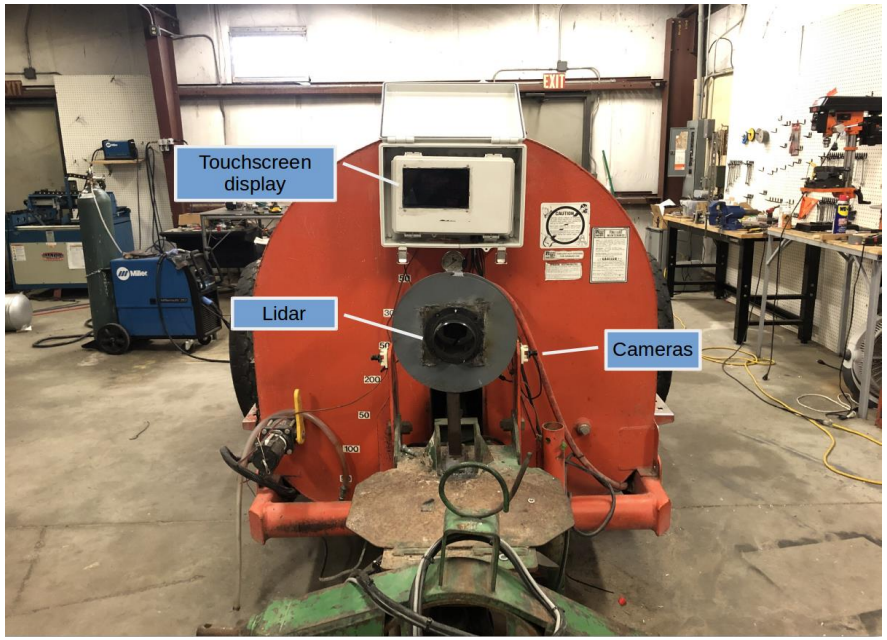


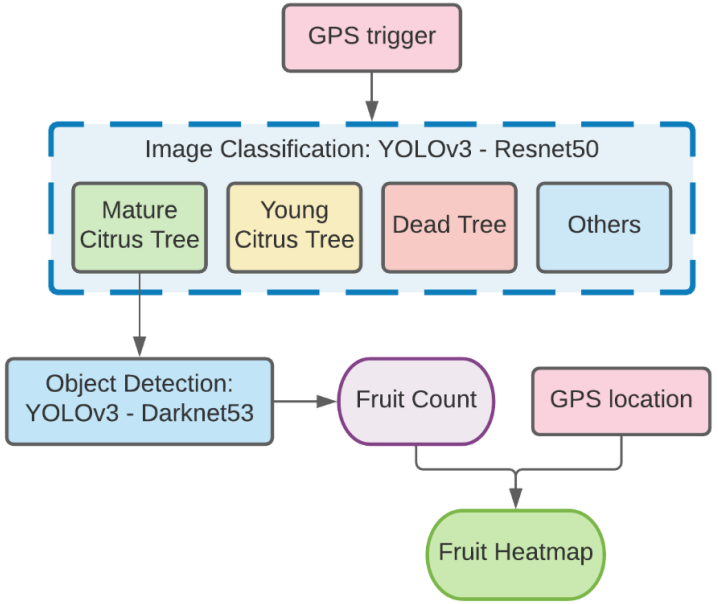
a) b)

a) RGB camera installed on the sprayer, b) top view of the schematic of the positioning of cameras and LiDAR on the sprayer

Work Flow – Sensor Fusion



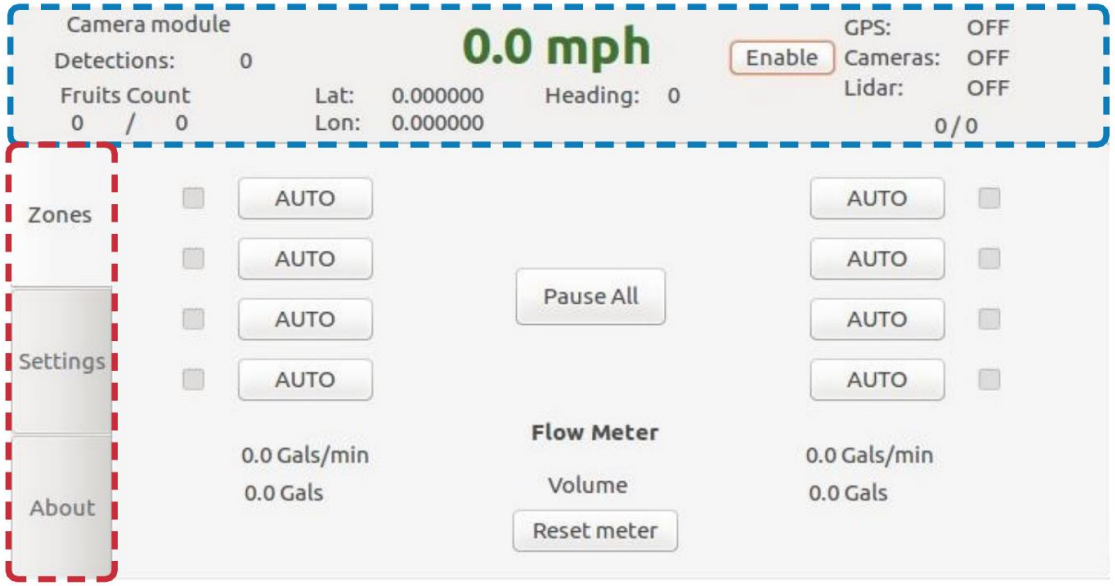


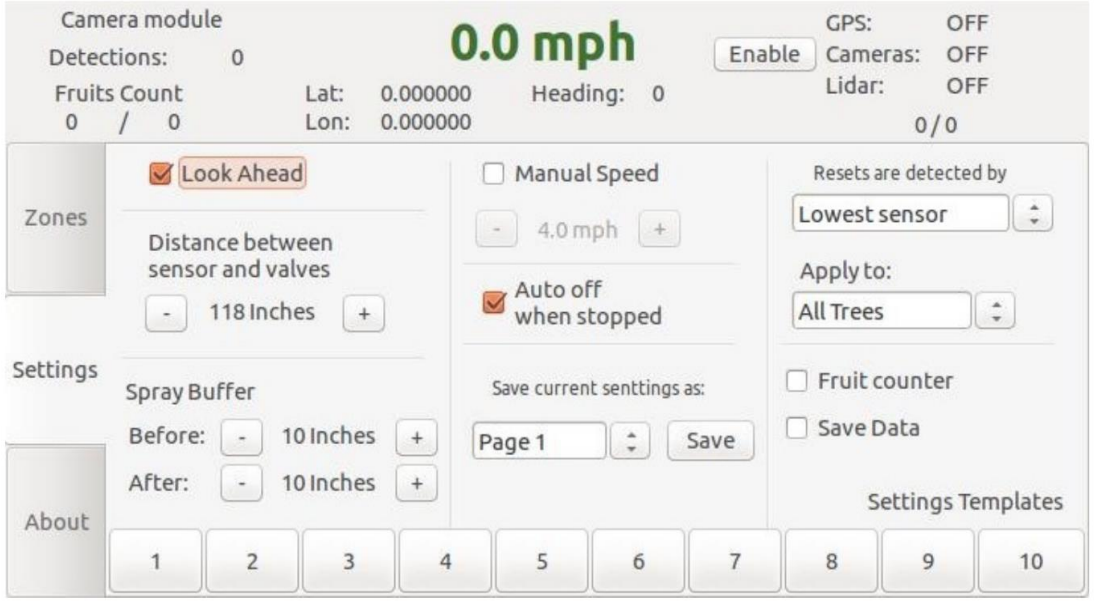


Patent Pending

Partel V., Costa L., Ampatzidis Y., 2021. Smart tree crop sprayer utilizing sensor fusion and artificial intelligence. Computers and Electronics in Agriculture 191, https://doi.org/10.1016/j.compag.2021.106556.

Graphical User Interface





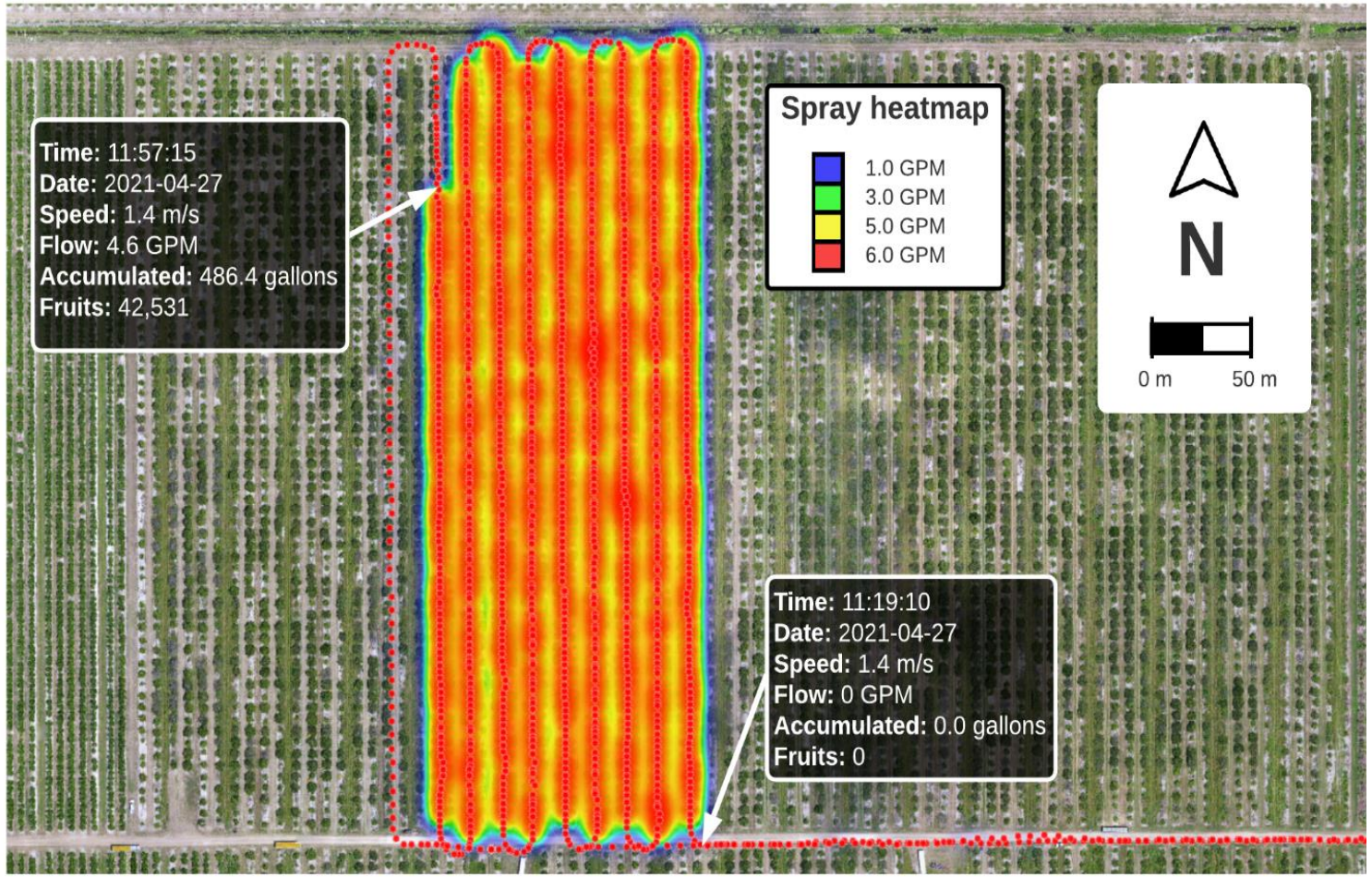
Patent Pending

Smart Tree Sprayer using Artificial Intelligence (AI)

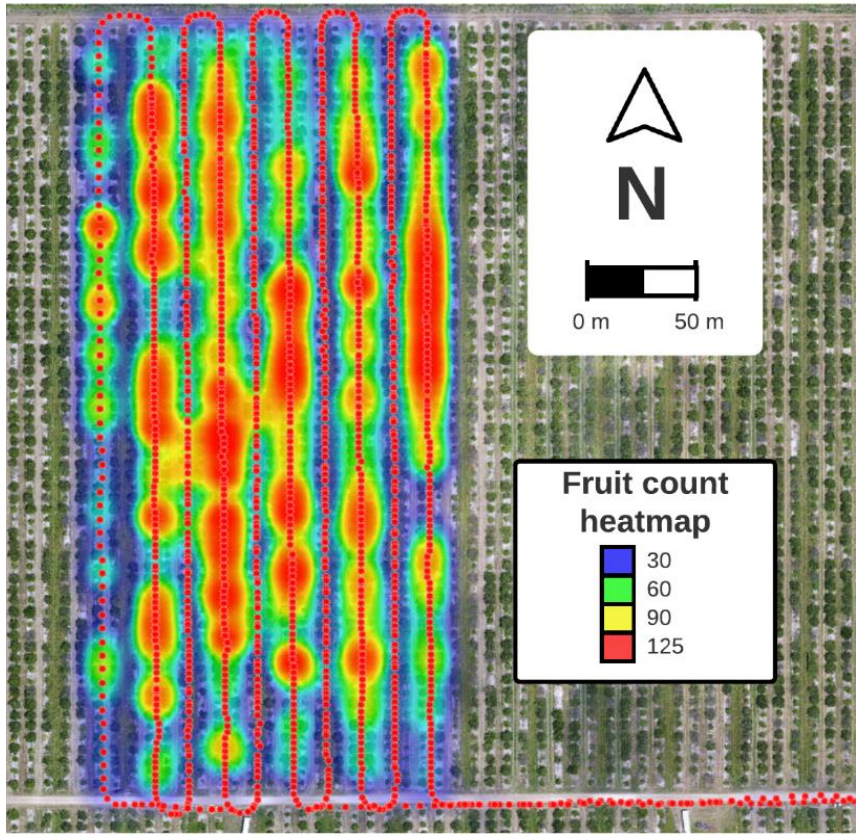
https://youtu.be/SZvmALvoSUQ?list=TLGGlrt2a6JeEp0xODAxMjAyMg

Smart Tree Sprayer using Artificial Intelligence (AI)

Spray path and spraying heat-map



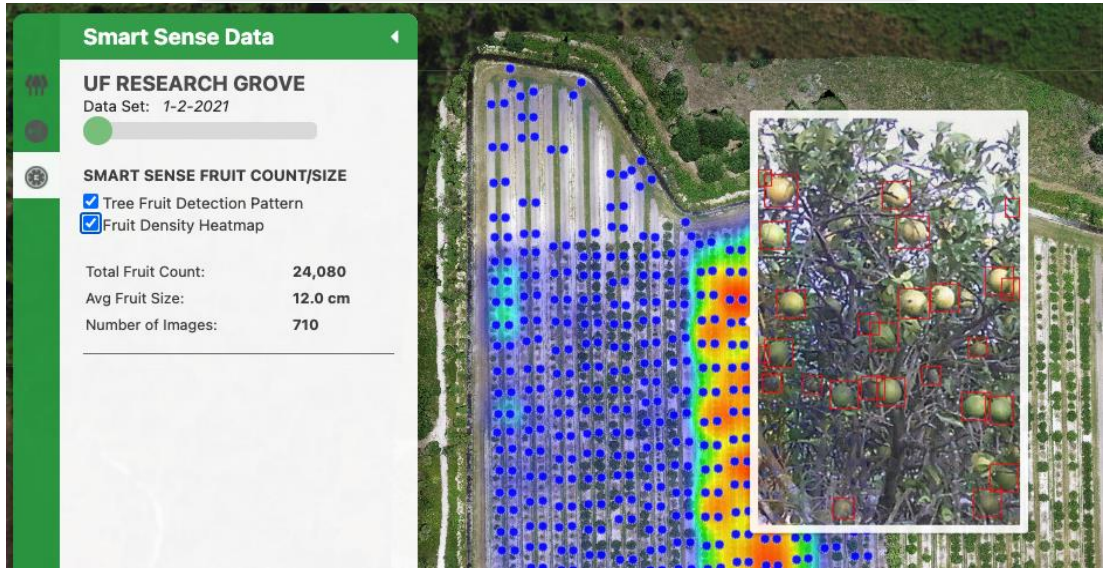
Fruit detection and fruit heat-map



Smart Tree Sprayer using Artificial Intelligence (AI)

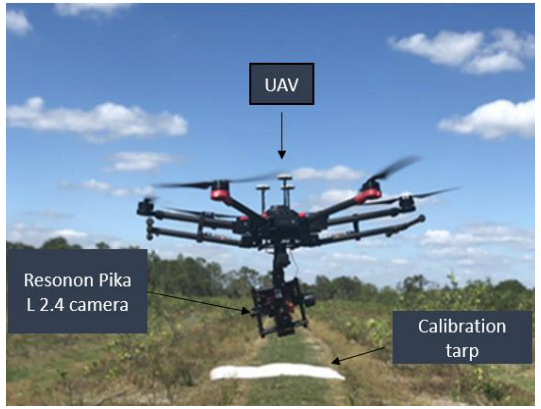
Spray path and spraying heat-map

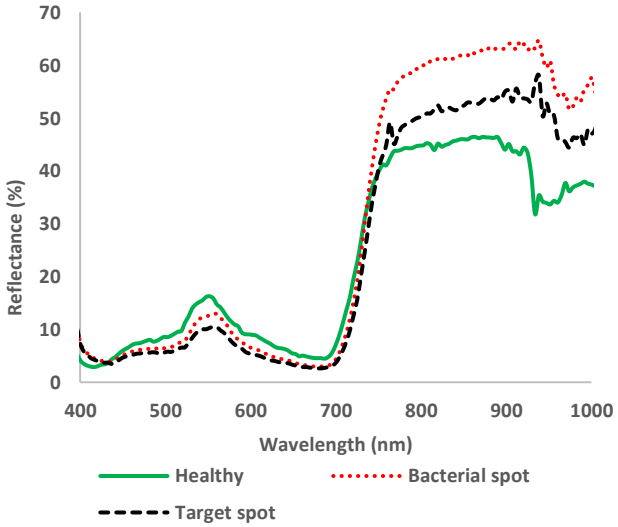
Fruit detection and fruit heat-map

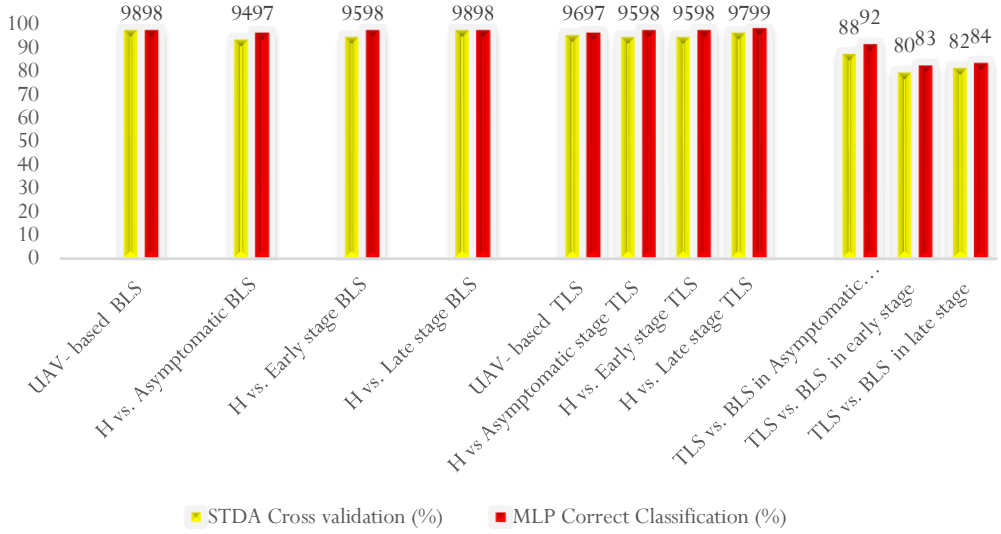


Detection of crop diseases utilizing UAV-based hyperspectral imaging and AI

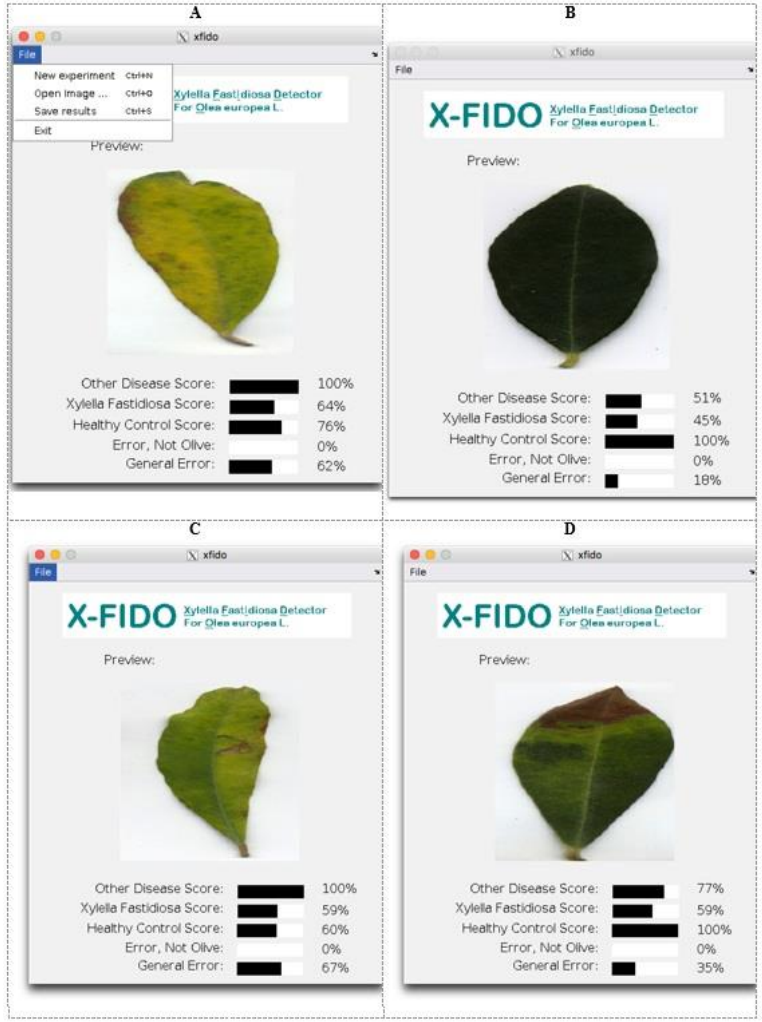
Collaborators:
Dr. Roberts
Dr. Batuman
Dr. Qureshi





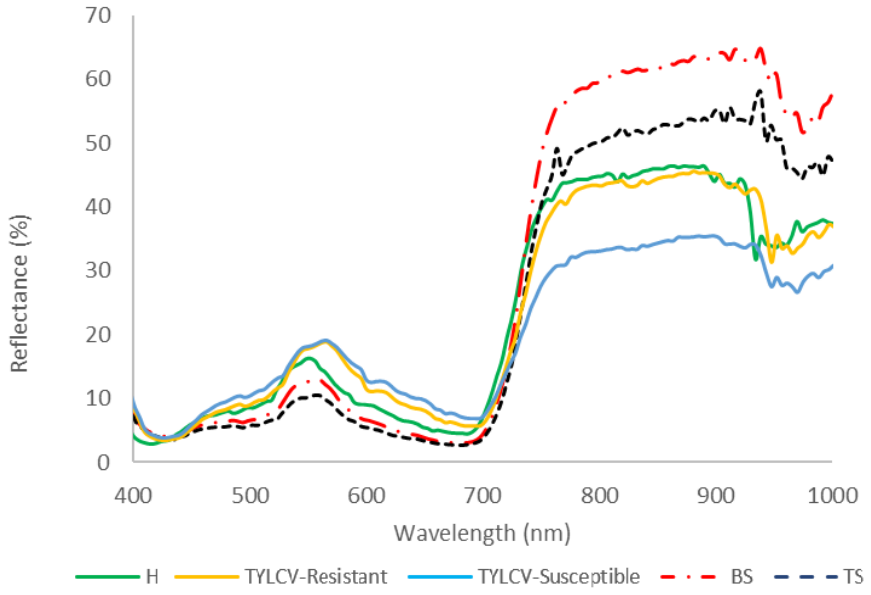


Application for detecting symptoms of plant diseases

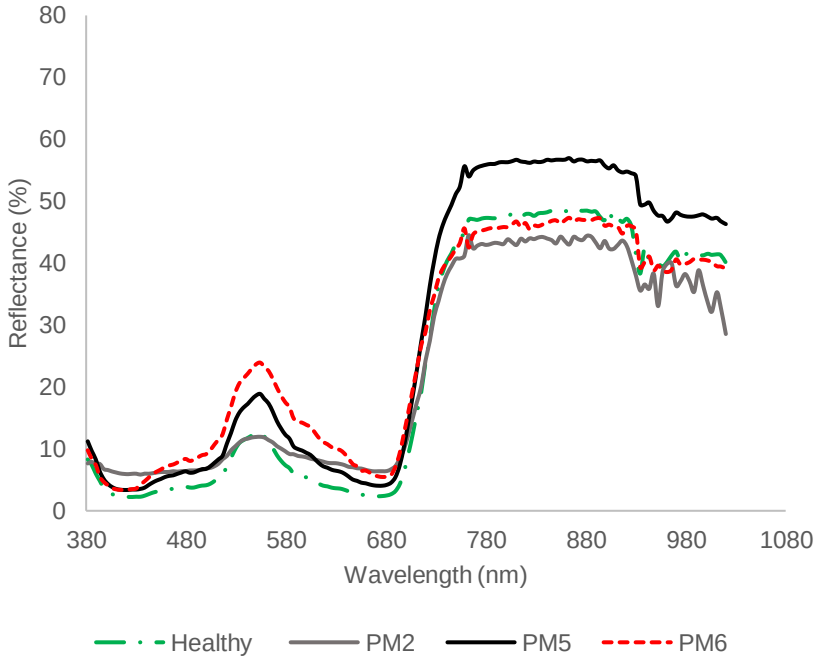


Cruz A.C., Luvisi A., De Bellis L., and Ampatzidis Y., 2017. X-FIDO: An effective application for detecting olive quick decline syndrome with novel deep learning methods. *Frontiers, Plant Sci.*, 10 October 2017 | https://doi.org/10.3389/fpls.2017.01741

UAV-based Disease Detection utilizing Hyperspectral Imaging and AI



Spectral reflectance signatures of *Tomato yellow leaf curl virus (*TYLCV, on susceptible and resistant tomato varieties), Bacterial Spot (BS), and Target Spot (TS) infected tomato plants.



Spectral reflectance signatures of healthy squash plants and Powdery Mildew (PM) infected plants in different disease development stages (asymptomatic, early and late stages).

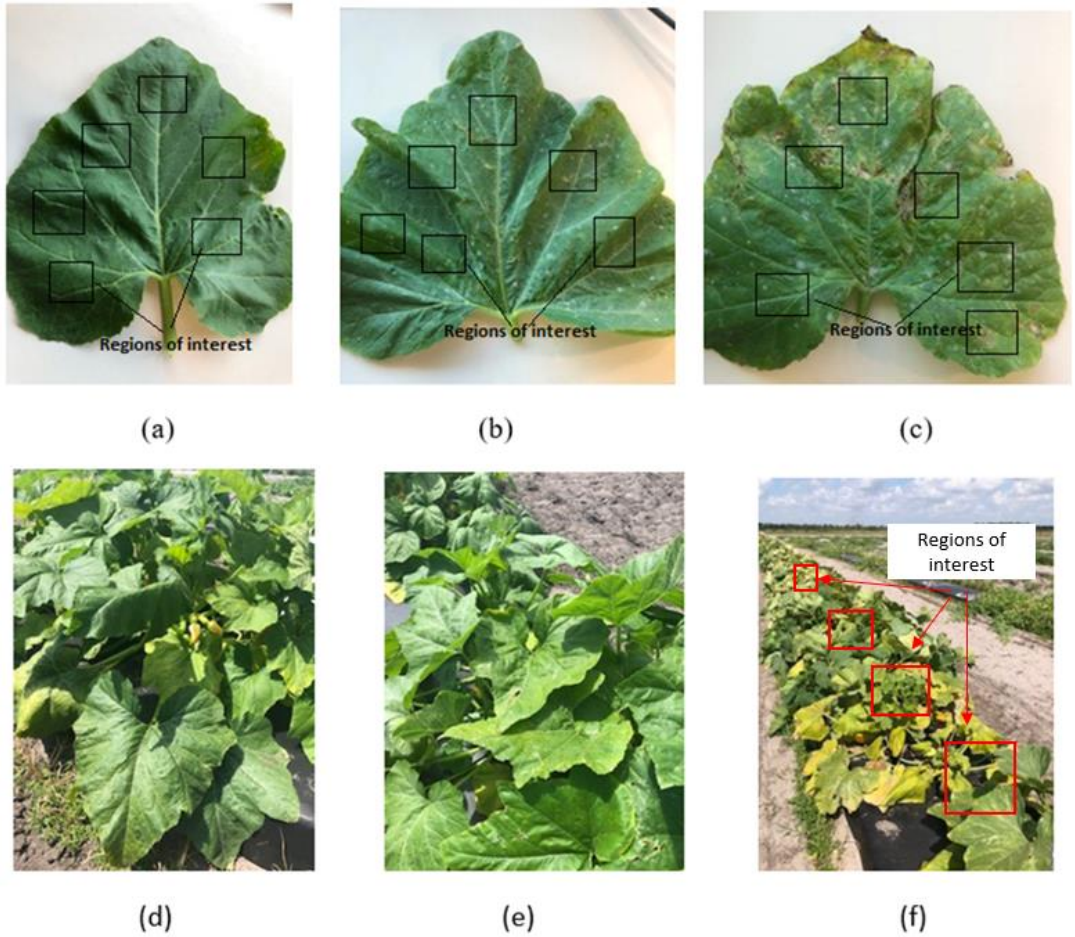
- Abdulridha J., Ampatzidis Y., Roberts P., Kakarla S.C., 2020. Detecting powdery mildew disease in squash at different stages using UAV-based hyperspectral imaging and artificial intelligence. *Biosystems Engineering*, 135-148; doi.org/10.1016/j.biosystemseng.2020.07.001.
- Abdulridha J., Ampatzidis Y., Kakarla S.C., Roberts P., 2019. Detection of target spot and bacterial spot diseases in tomato using UAV-based and benchtop-based hyperspectral imaging techniques. *Precision Agriculture,* (November) 1-24.

UAV-based Disease Detection utilizing Hyperspectral Imaging and AI

Squash plants in different development stages of the powdery mildew disease.

The indoor pictures with regions of interest are: a) healthy leaf (prior to any disease detection in field), b) early symptoms (low disease severity), and c) late stage (high disease severity).

Outdoor data collection in different disease development stages are d) asymptomatic plants, e) initial symptomatic stage (low disease severity), and f) the late PM symptomatic stage (high disease severity).



- Abdulridha J., Ampatzidis Y., Roberts P., Kakarla S.C., 2020. Detecting powdery mildew disease in squash at different stages using UAV-based hyperspectral imaging and artificial intelligence. *Biosystems Engineering*, 135-148; doi.org/10.1016/j.biosystemseng.2020.07.001.

UAV-based Disease Detection utilizing Hyperspectral Imaging and AI

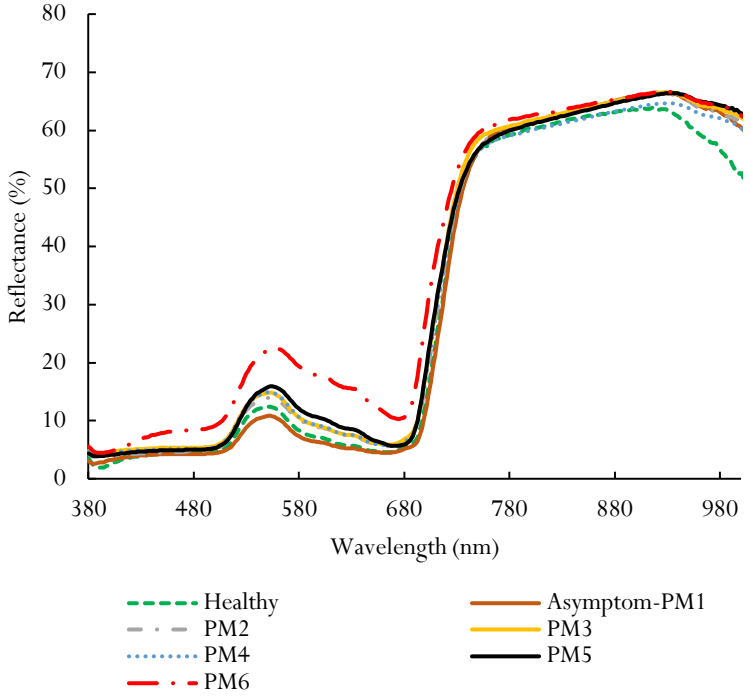
Laboratory spectral measurements of squash leaves using a benchtop hyperspectral imaging system.

UAV-based imaging data collection with a hyperspectral Resonon camera

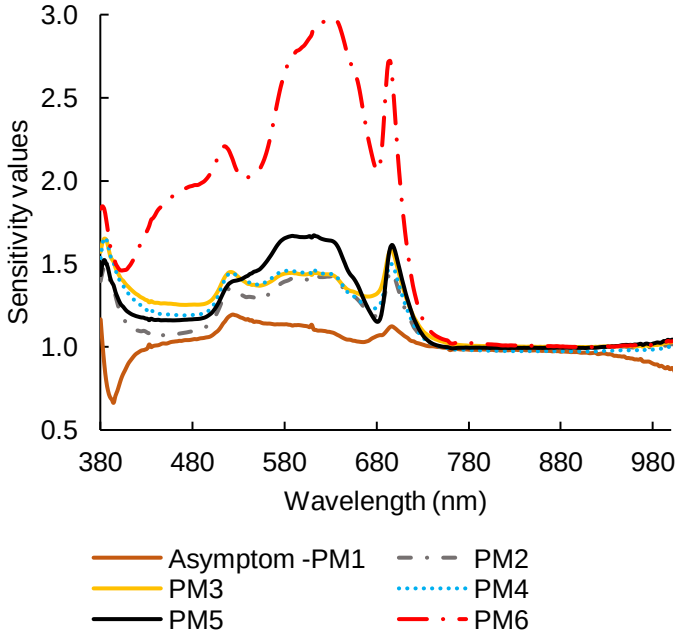
- Abdulridha J., Ampatzidis Y., Roberts P., Kakarla S.C., 2020. Detecting powdery mildew disease in squash at different stages using UAV-based hyperspectral imaging and artificial intelligence. *Biosystems Engineering*, 135-148; doi.org/10.1016/j.biosystemseng.2020.07.001.

UAV-based Disease Detection utilizing Hyperspectral Imaging and AI

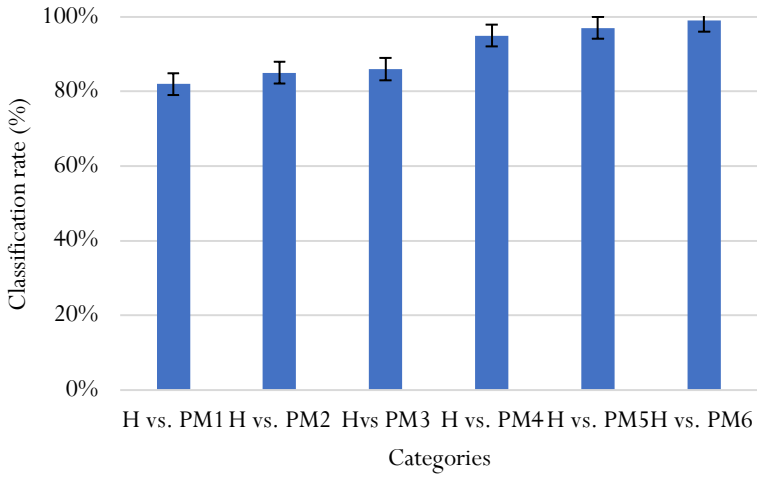
Lab-based Analysis



Spectral reflectance signatures of healthy squash plants and Powdery Mildew (PM) infected plants in different disease development stages (asymptomatic, early and late stages).



Sensitivity values of PM-infected squash plants under laboratory conditions.

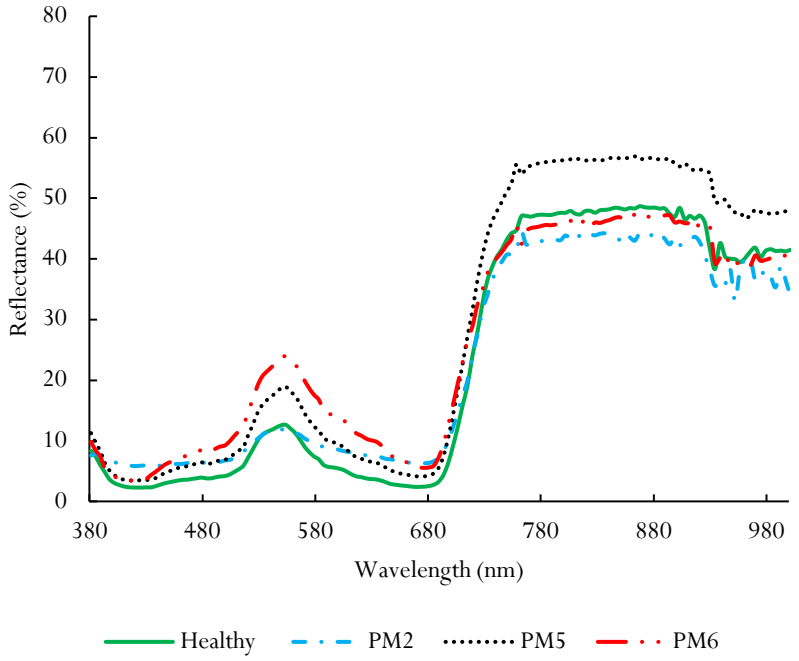


Classification results and standard error (RBF method).

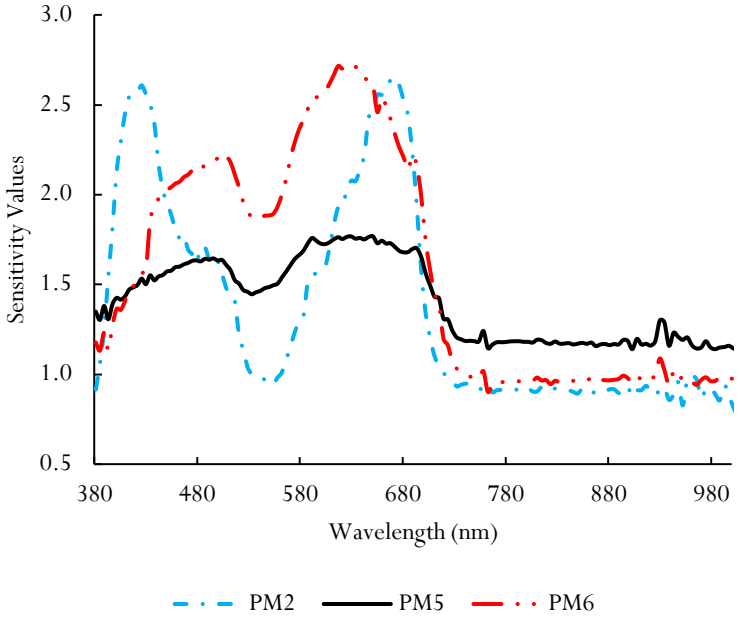
➢ Abdulridha J., Ampatzidis Y., Roberts P., Kakarla S.C., 2020. Detecting powdery mildew disease in squash at different stages using UAV-based hyperspectral imaging and artificial intelligence. *Biosystems Engineering*, 135-148; doi.org/10.1016/j.biosystemseng.2020.07.001.

UAV-based Disease Detection utilizing Hyperspectral Imaging and AI

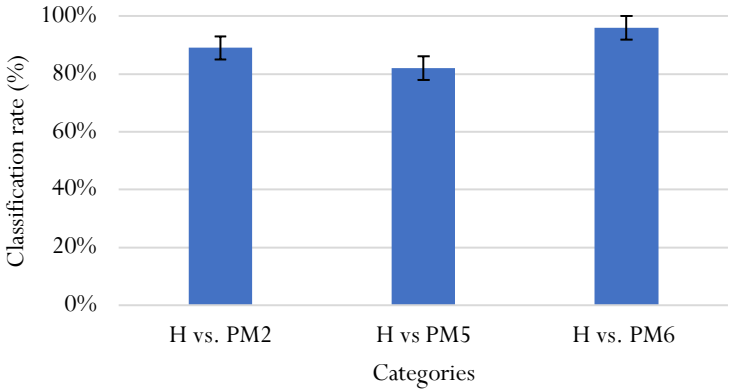
UAV-based Analysis



UAV-based spectral reflectance signatures of healthy squash plants and PM-infected plants in different disease development stages (asymptomatic, early and late stages).



UAV-based analysis: sensitivity values of PM-infected squash plants.



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Yield prediction in winter wheat under stress environmental conditions

Collaborator:
Dr. Babar

- Panel A: 40 genotypes (250 plots) (2018-2019) for heat stress tolerance.
- Panel B: 260 genotypes (2017-2018) under irrigated and drought conditions.

- Plot size: 5.1 m2 (3.3 x1.52 m)

- UAV-based hyperspectral data (400–1000 nm) at 200 ft

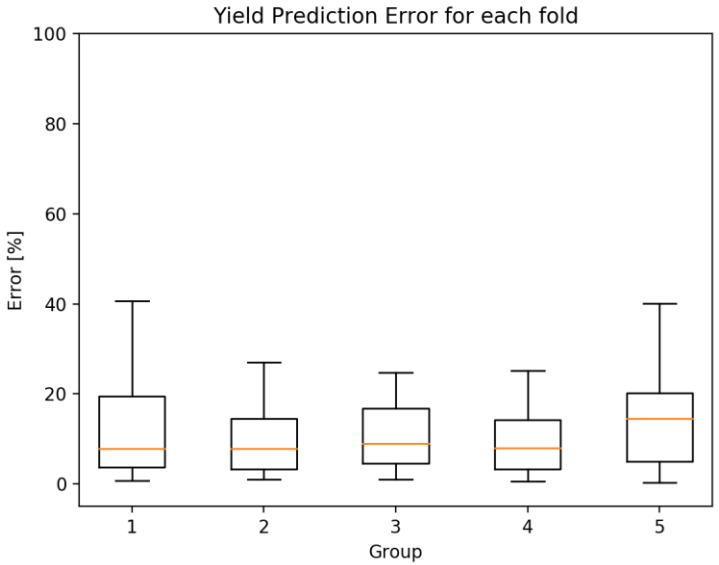
(last fight: 1 month before harvest).

Yield prediction in winter wheat under stress environmental conditions

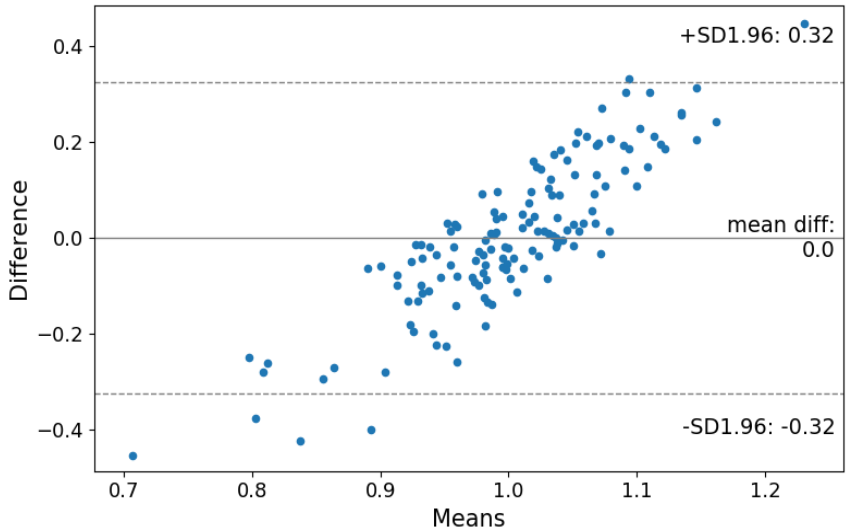
Mean Absolute Percentage Error (MAPE) for each group in the cross-validation of Panel A.

	Group 1	Group 2	Group 3	Group 4	Group 5	Mean
MAPE	15,6%	10,2%	12,2%	12,0%	17,1%	13.4%

Whisker graph for the error in yield prediction for Panel A.



Bland and Altman diagram in percentage for the Panel A dataset.



Plant breeding partnerships: More wheat crops under stress: multi-dimensional phenomics combined with genomics to improve heat stress resilience in wheat. USDA/AFRI. Budget: $649,872 (w/ PI: Babar; Co-PIs: Guo, Reynolds). Duration: 12/1/2020 – 11/30/2024.

KIWI UAV Spraying System

UAV-based EDIS Documentation

- Kakarla S.C., and Ampatzidis Y., 2021. ***Types of unmanned aerial vehicles (UAVs), sensing technologies, and software for agricultural applications***. EDIS, University of Florida, IFAS Extension.
- Ampatzidis Y., and Albrecht U., 2021. D***rones and artificial intelligence to determine plant nutrient concentrations and develop fertility maps***. EDIS, University of Florida, IFAS Extension.
- Gorucu S., and Ampatzidis Y., 2021. ***Drone injuries and safety recommendations***. EDIS, University of Florida, IFAS Extension.
- Ampatzidis Y., and Wade T., 2020. ***Scouting with UAVs and AI in citrus production***. EDIS, University of Florida, IFAS Extension.
- Kakarla S.C., De Morais L., and Ampatzidis Y., 2019. ***Pre-Flight and Flight Instructions on the Use of Unmanned Aerial Vehicles (UAVs) for Agricultural Applications***. EDIS, University of Florida, IFAS Extension.
- Kakarla S.C., and Ampatzidis Y., 2019. ***Post-Flight Data Processing Instructions on the Use of Unmanned Aerial Vehicles (UAVs) for Agricultural Applications***. EDIS, University of Florida, IFAS Extension.
- Kakarla S.C., and Ampatzidis Y., 2018. ***Instructions on the Use of Unmanned Aerial Vehicles (UAVs) for Agricultural Applications***. EDIS, University of Florida, IFAS Extension.
- Ampatzidis Y., 2018. ***Applications of Artificial Intelligence for Precision Agriculture***. EDIS, University of Florida, IFAS Extension.

Thanks for your attention!

Yiannis Ampatzidis
Associate Professor
Agricultural and Biological Engineering Department
University of Florida
Southwest Florida Research and Education Center, Immokalee
Office: 239-658-3451
Email: i.ampatzidis@ufl.edu

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