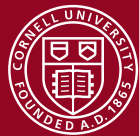


Cornell AgriTech

New York State Agricultural Experiment Station



Cornell **CALS**

College of Agriculture
and Life Sciences

Artificial Intelligence for Grape Disease Research and Management

Yu Jiang

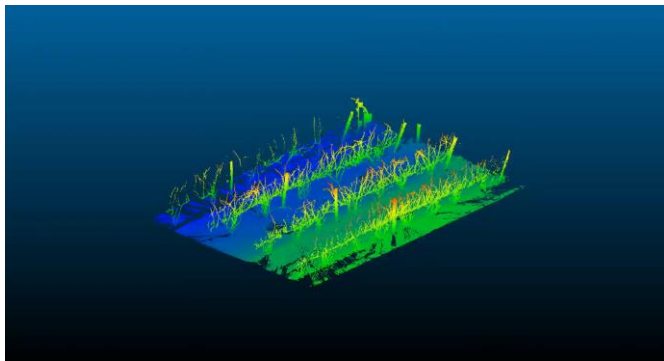
Assistant Research Professor

Horticulture Section, SIPS

NGRA New-Scientist Engagement, May 3, 2021



Cyber-Agricultural Intelligence and Robotics Lab



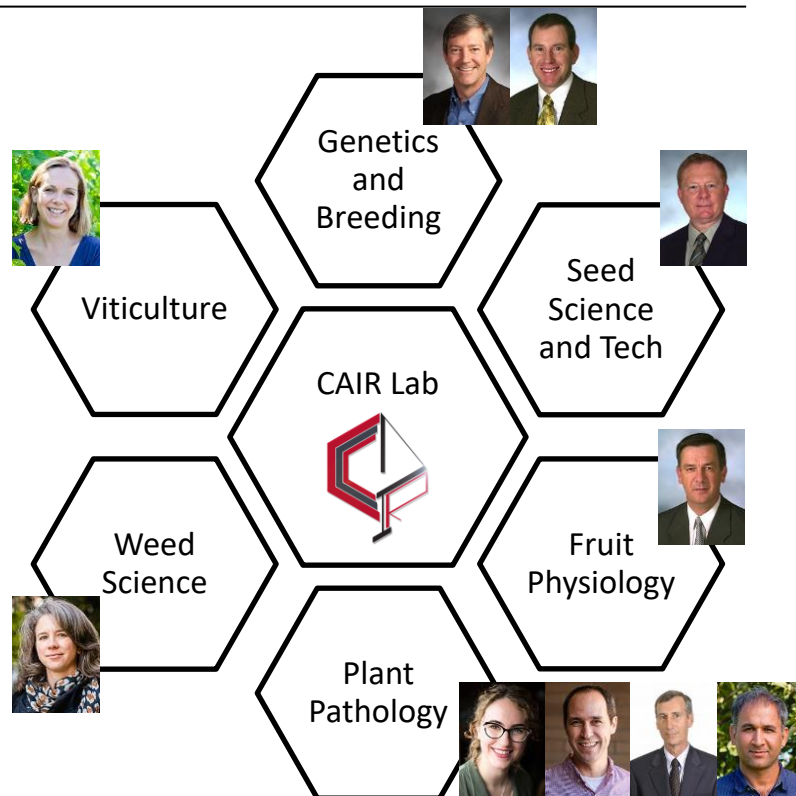
Yu Jiang
(Lab PI)



Ertai "Leo" Liu
(Ph.D.)



Tian Qiu
(Ph.D.)



Breeding/Research



Management

Pre-season evaluation



In-season Monitoring



Harvesting

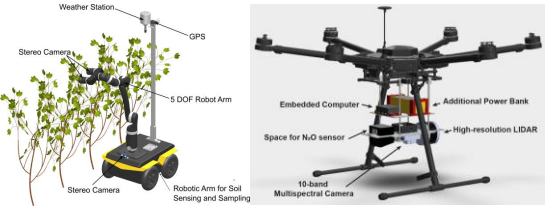


Postharvest

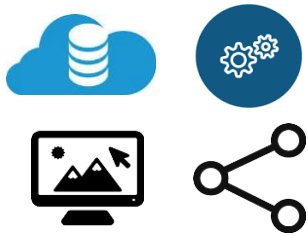
OneAg



Precision Agriculture and Public Infrastructure

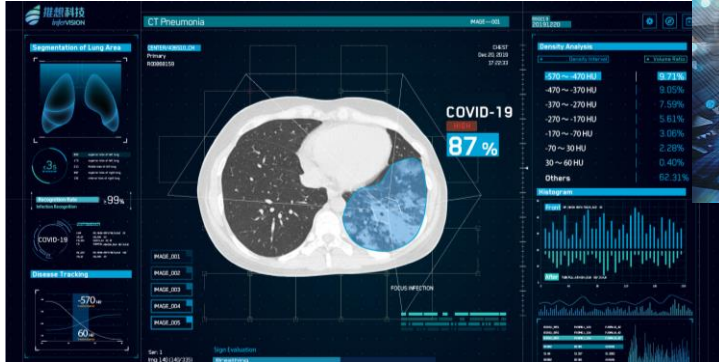
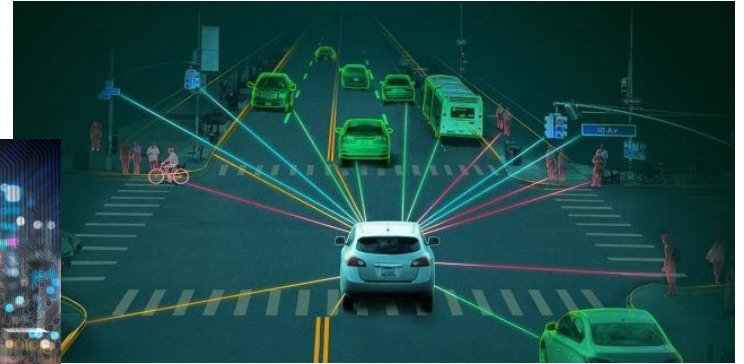
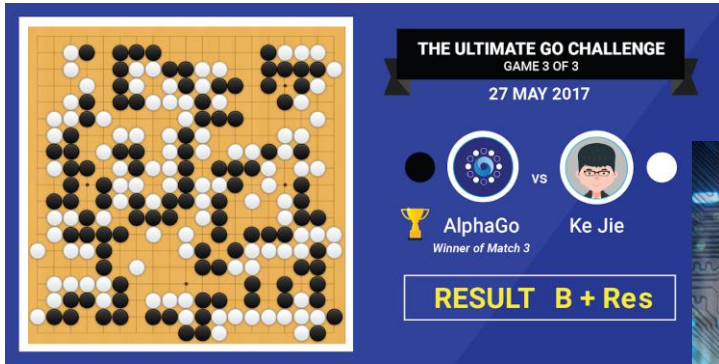


Agricultural Sensing and Robotics



Data Management and Analysis

Artificial Intelligence



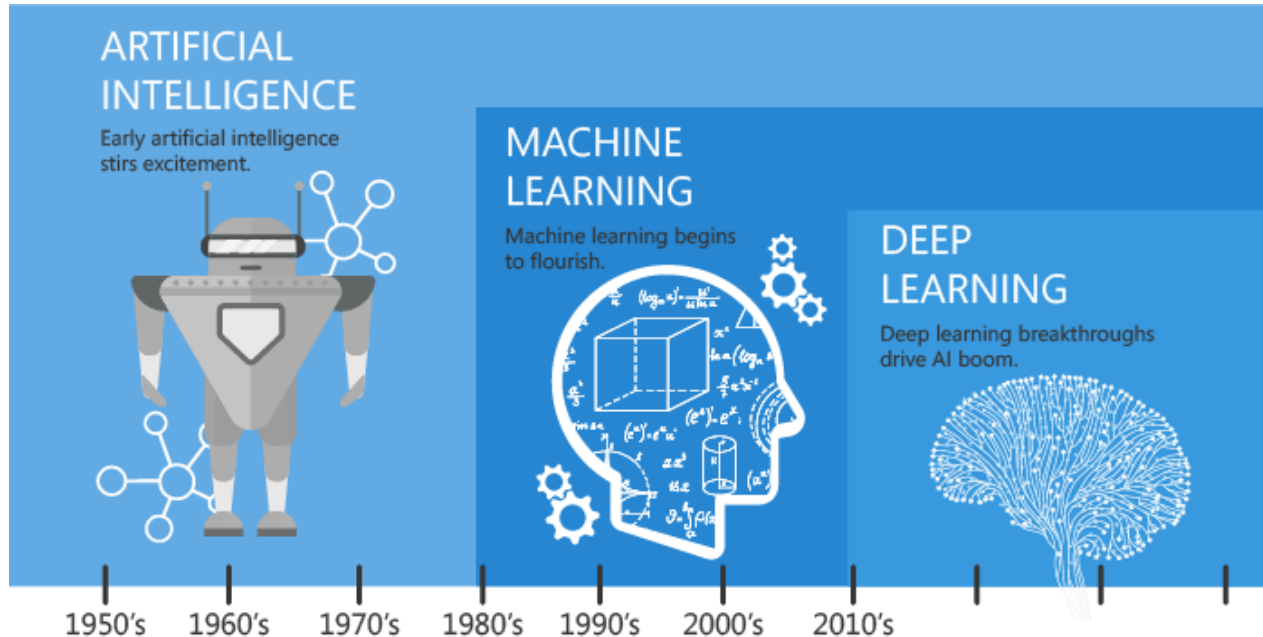
Turing Test



- Natural Language Processing
- Knowledge Representation
- Automated Reasoning
- Machine Learning
- Perception
- Robotics

Deep Learning

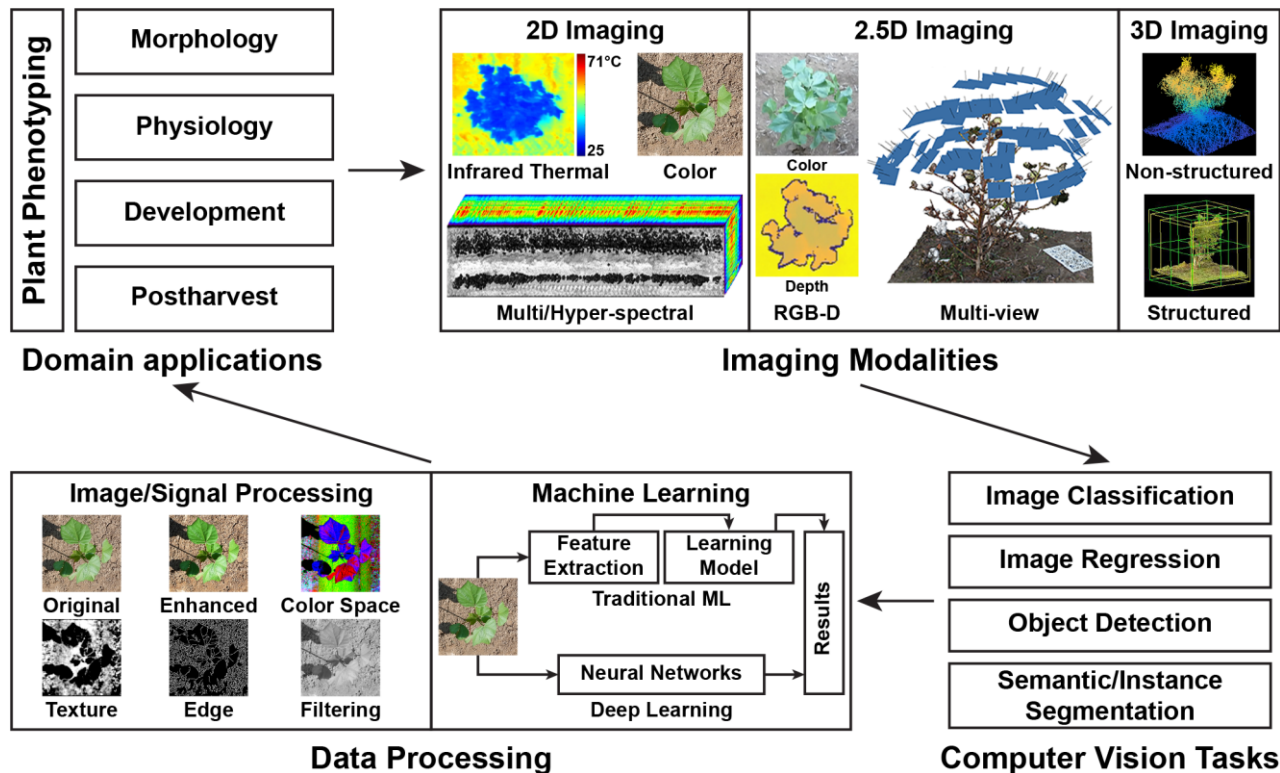
- Deep learning (DL) is a subset of ML



Neural networks with a huge amount of neurons

- **Convolutional neural networks (CNN)**
- **Recurrent neural networks (RNN)**

High Throughput Phenotyping



Quantification of Downy Mildew in the Vineyard

Sensing of the Field



- Downy mildew is one of the most destructive and costly grape diseases in the eastern grape industry
- Can easily cause 50% to 75% crop losses in a season

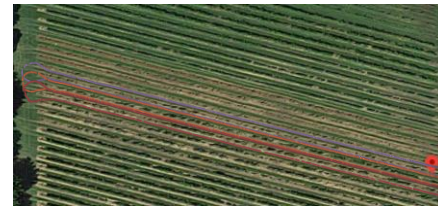
- Human field scouting
- Weather data-based prediction (NEWA)
- Optical sensing system



Fungicide Efficiency

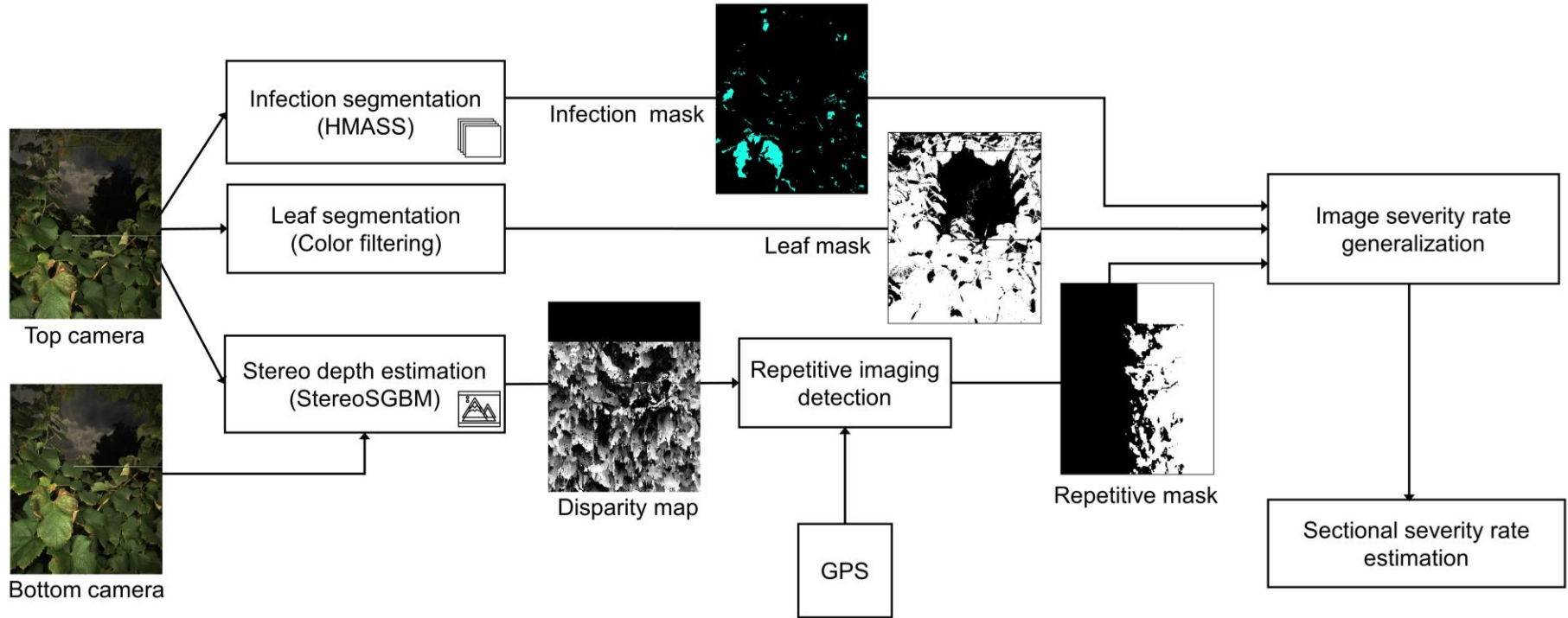
Treatment	Materials (Rate/Acre)	Timing
1	Zampro and Silwett (14.00 fl oz and 0.03%)	Stages 1 to 7
2	Revus Top and Induce (7.00 fl oz and 0.13%)	Stages 1 to 7
3	Lifegard CX-10250 and Induce (2.25 oz and 0.13%)	Stages 1 to 2
	Lifegard CX-10250 and Induce (4.5 oz and 0.13%)	Stages 3 to 7
4	Zampro and Silwett (14.00 fl oz and 0.03%)	Stages 1, 3, 5
	Lifegard CX-10250 and Induce (2.25 oz and 0.13%)	Stage 2
	Lifegard CX-10250 and Induce (4.5 oz and 0.13%)	Stages 4, 6, 7
5	Dithane DF and Induce (4 lb and 0.13 %)	Stages 1 to 3
	Lifegard CX-10250 and Induce (4.5 oz and 0.13%)	Stages 4 to 7
6	Untreated control	Stages 1 to 7

- Imaged both sides of each grape row on Aug 29, 2019 (4144 images in this dataset)
- Field manual assessment for 20 leaves on Sep 9, 2019



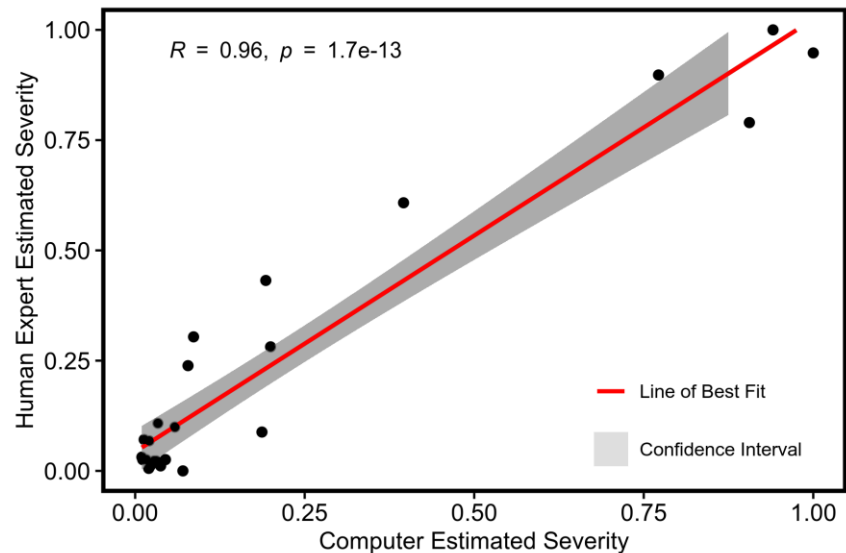
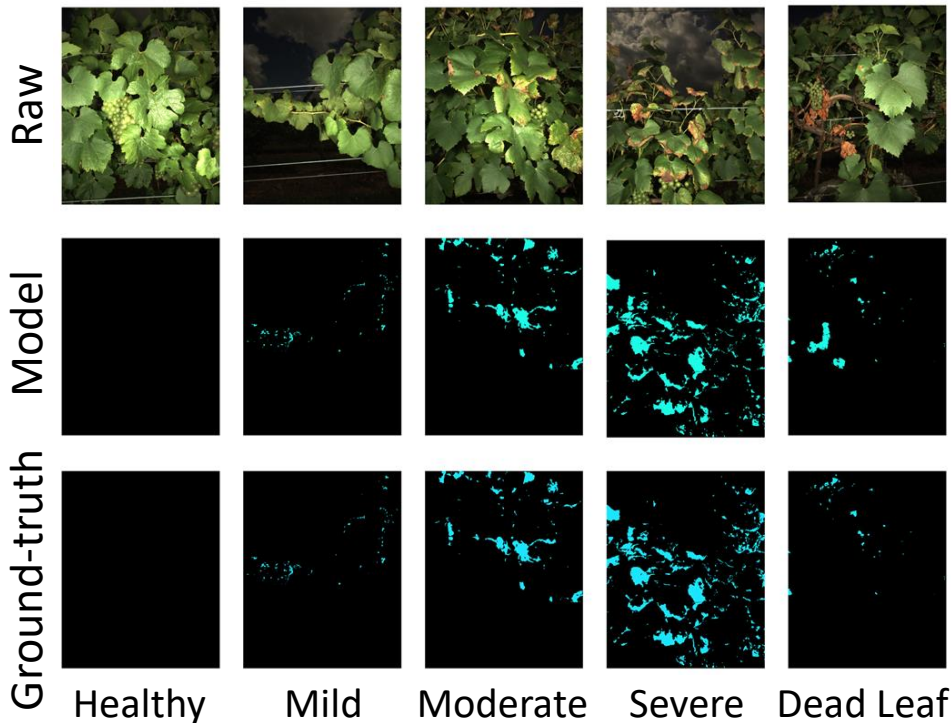
Five different treatment strategies for grape downy mildew

Deep Learning-based Approach



Quantification Results

Representative Segmentation



Correlation between image-derived
infection severity and human field
assessment

Statistical Power

Infection severity differences among treatments

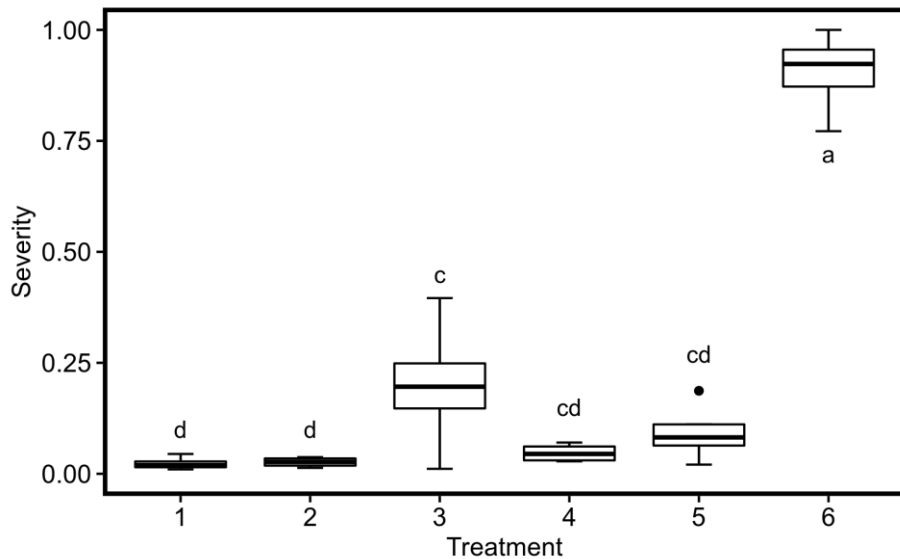
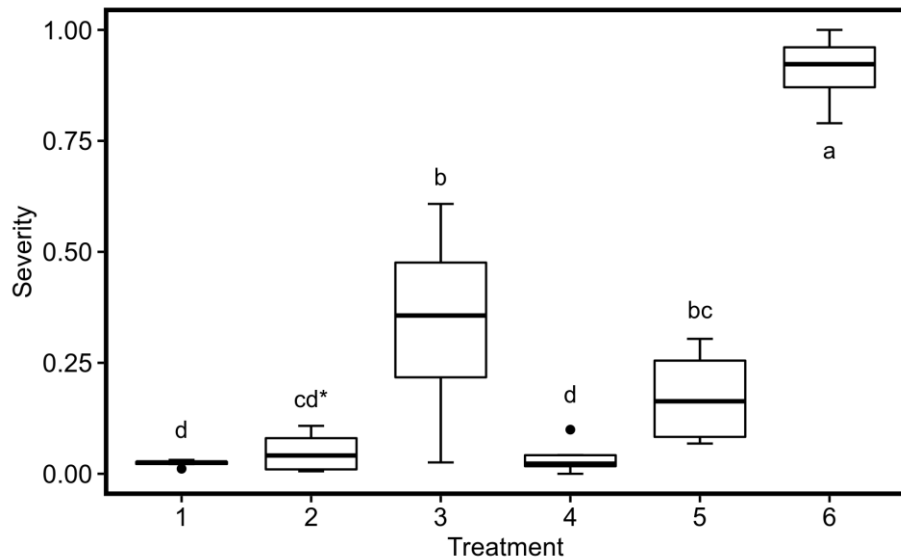
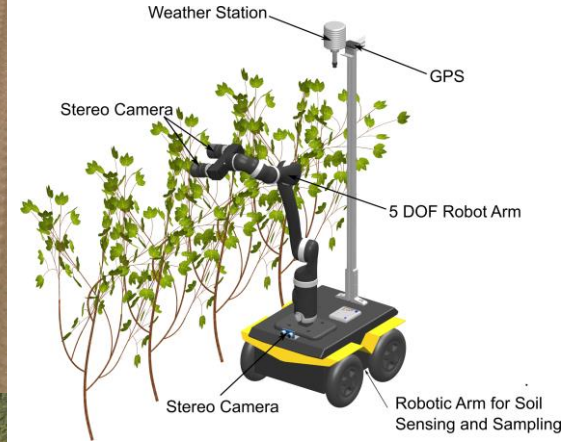
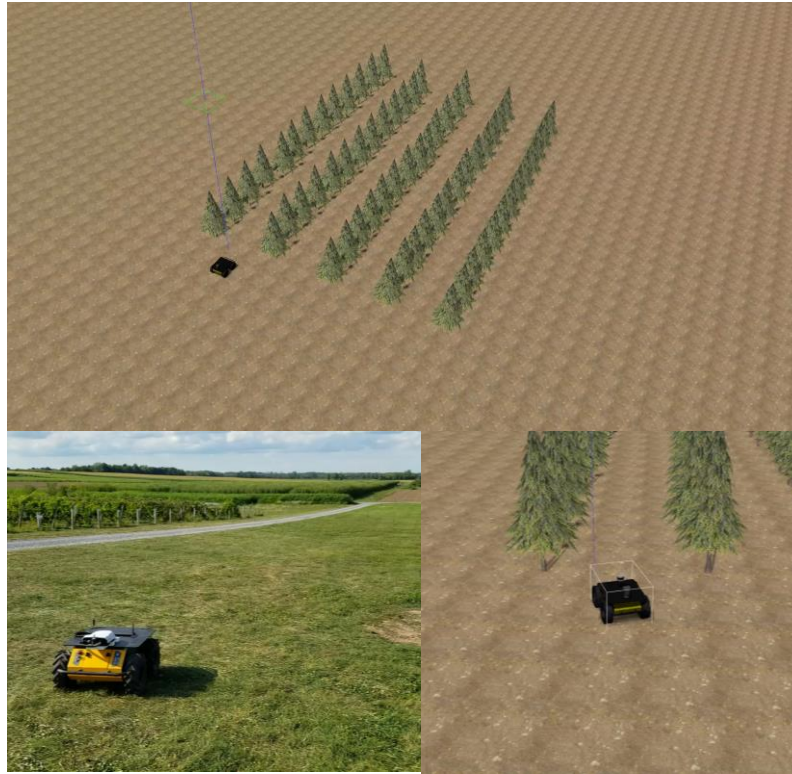


Image-derived



Human field scouting

PhytoPatholoBot (PPB)

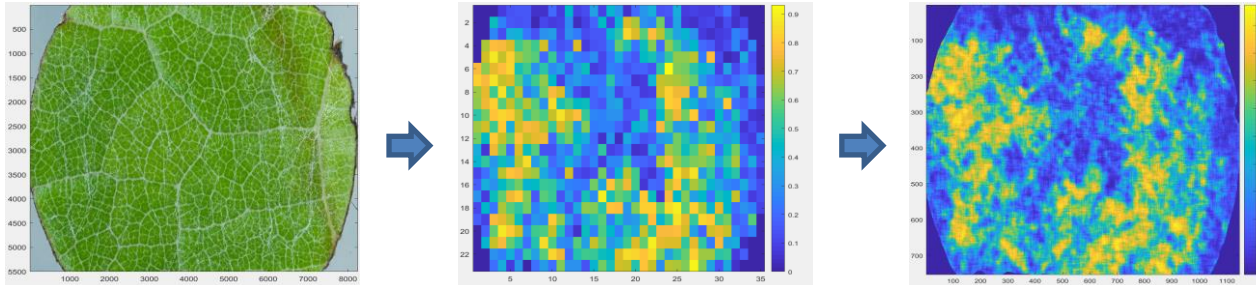


- Autonomous
- Multimodal
- Realtime

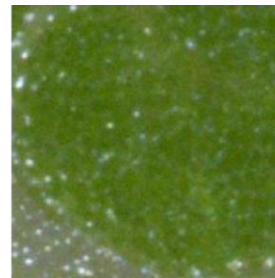
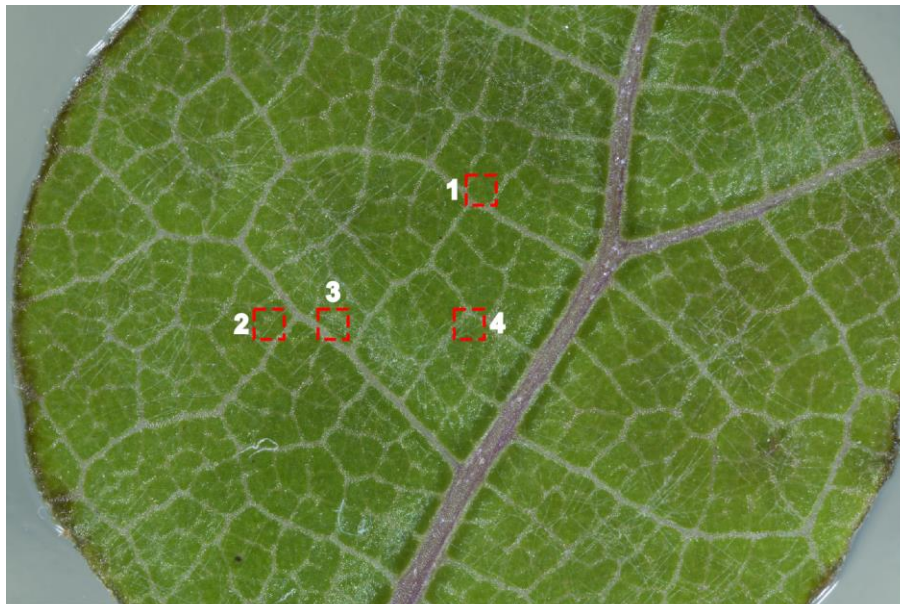
Quantification of Grape Powdery Mildew at the Microscopic Level

BlackBird

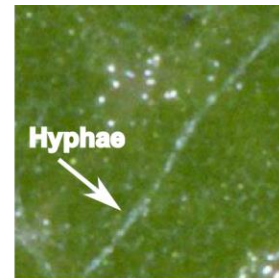
- i. 2,800 leaf disks per day
 - ii. 1.2 μm spatial resolution
 - iii. LIVE imaging for repeated measures
- Disease progress



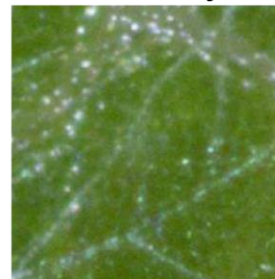
What Limits Better Accuracy?



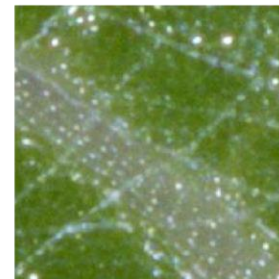
1 - Healthy



2 - Mild

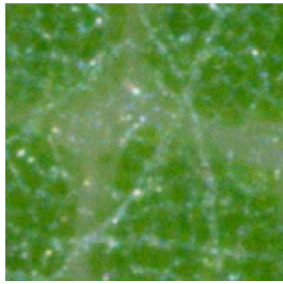


3 - Moderate

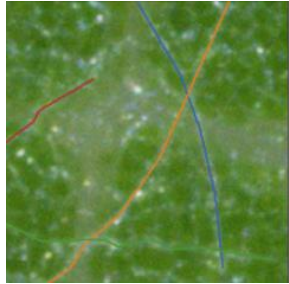


4 - Severe

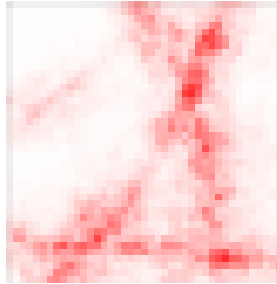
Explainable AI



Single patch



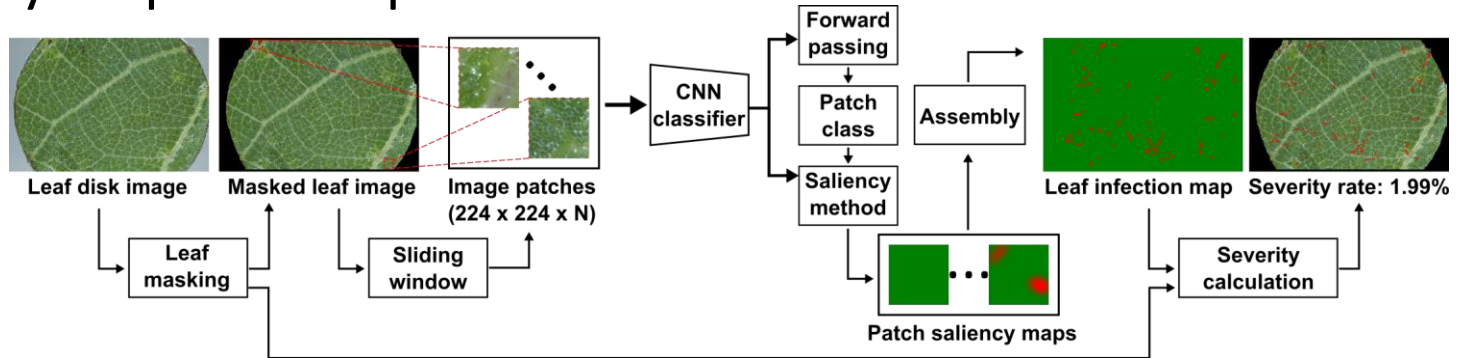
Annotated



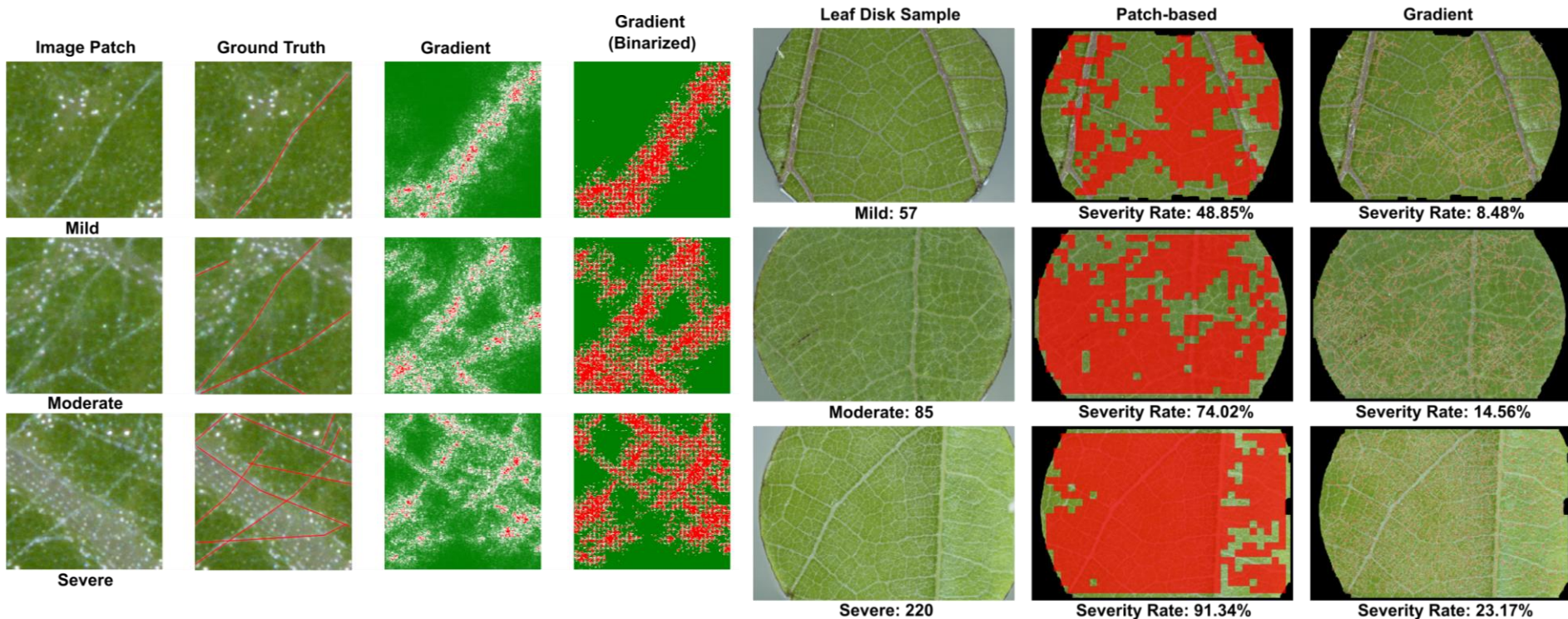
Saliency Map

Not only get the classification result but also visualize which regions/pixels in the image support such a result

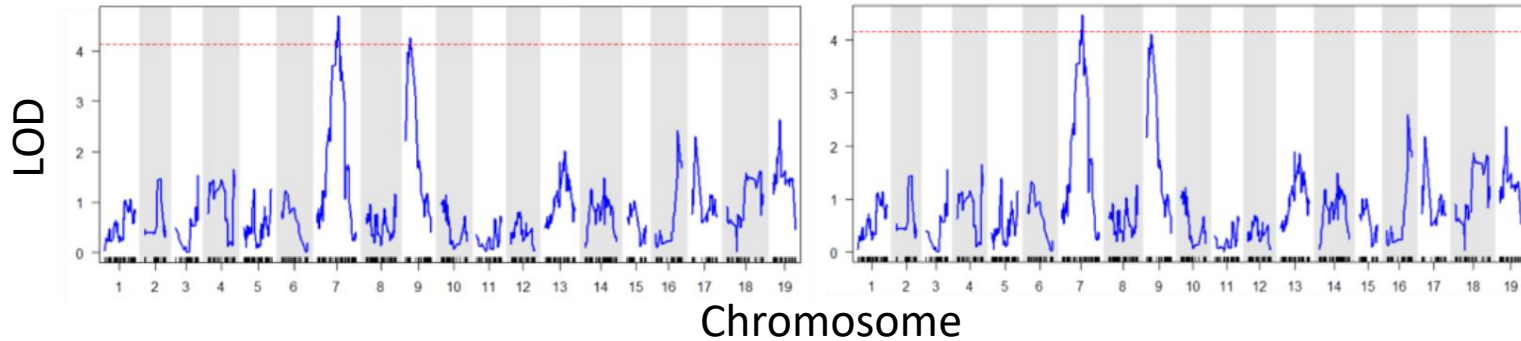
Saliency map-based quantification



Better Quantification Resolution



Benefits from Better Accuracy



Models	Chromosome	Threshold LOD	Peak QTL	Phenotypic variance (%)
Patch	7	4.34	4.47	8.84
Saliency	7	4.19	4.62	9.21
	9	4.19	4.31	8.36

Human Engagement

- Human computer interface
- Reserve human experiences and knowledge
- More job opportunities
- Better education

Thanks for Your Attention!



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