Updates on Digital Twin, Yield Forecasting, Predatory Mite Release System for Strawberry

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Machine learning and field robotics for precision agriculture

Smart Agriculture Lab

Where Agriculture & Technology Meet to Build Future

Precision Agriculture

Labor Shortage

Aging workforce
Immigration

Need for Higher Productivity

Global population growth but
less farm labor and farmer

Sustainability/Quality

Precision management and
demand for higher quality crop

An approach using information and technology to observe, measure, and respond to variability in crops.

Goal: to improve

Efficiency	Productivity	Sustainability

Precision Agriculture

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Sustainability/Quality

Precision management and
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Technologies for Enhanced Precision Agriculture

- *AI and Machine Learning: data analytics and forecasting*
- *Field Robotics: Automation with increased efficiency*
- *Digital Twin: digital representation of your farm*

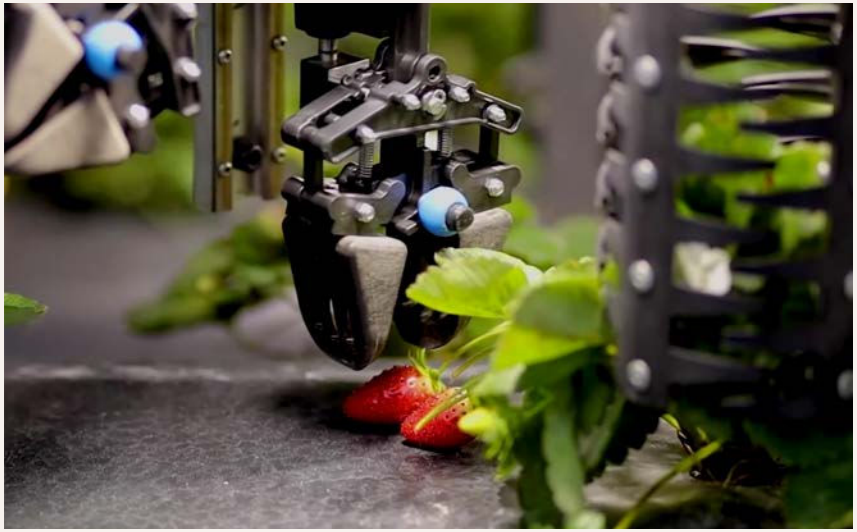
What is AI?

A branch of computer science

- Teaching computer to think and learn like humans
- These machines can do tasks that would normally need human intelligence.

Examples

- Siri, Alexa, Netflix recommendations
- Predict when it might rain
- Determine the best time to plant crops
- Spot diseases in plants before they spread.



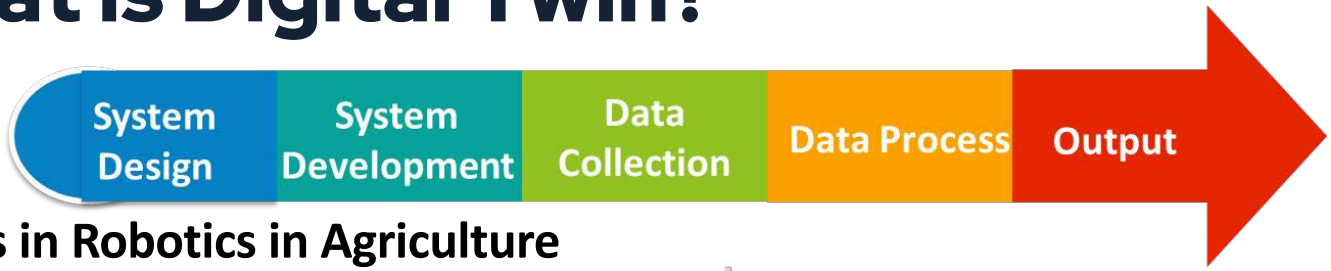
Harvest CROO Robotics' automated strawberry harvester

Harvest Automation's HV-100 (https://www.public.harvestai.com/) for material handling for the Nursery and Greenhouse industry.

Robotics and Automation

A field of ***engineering*** focused on developing robots to perform repetitive tasks.

What is Digital Twin?

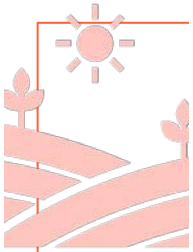


Challenges in Robotics in Agriculture

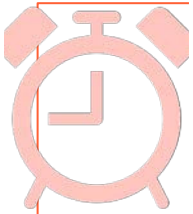
Time-Consuming
Testing is limited to few months

Costly
Data collection
Travel to farm site

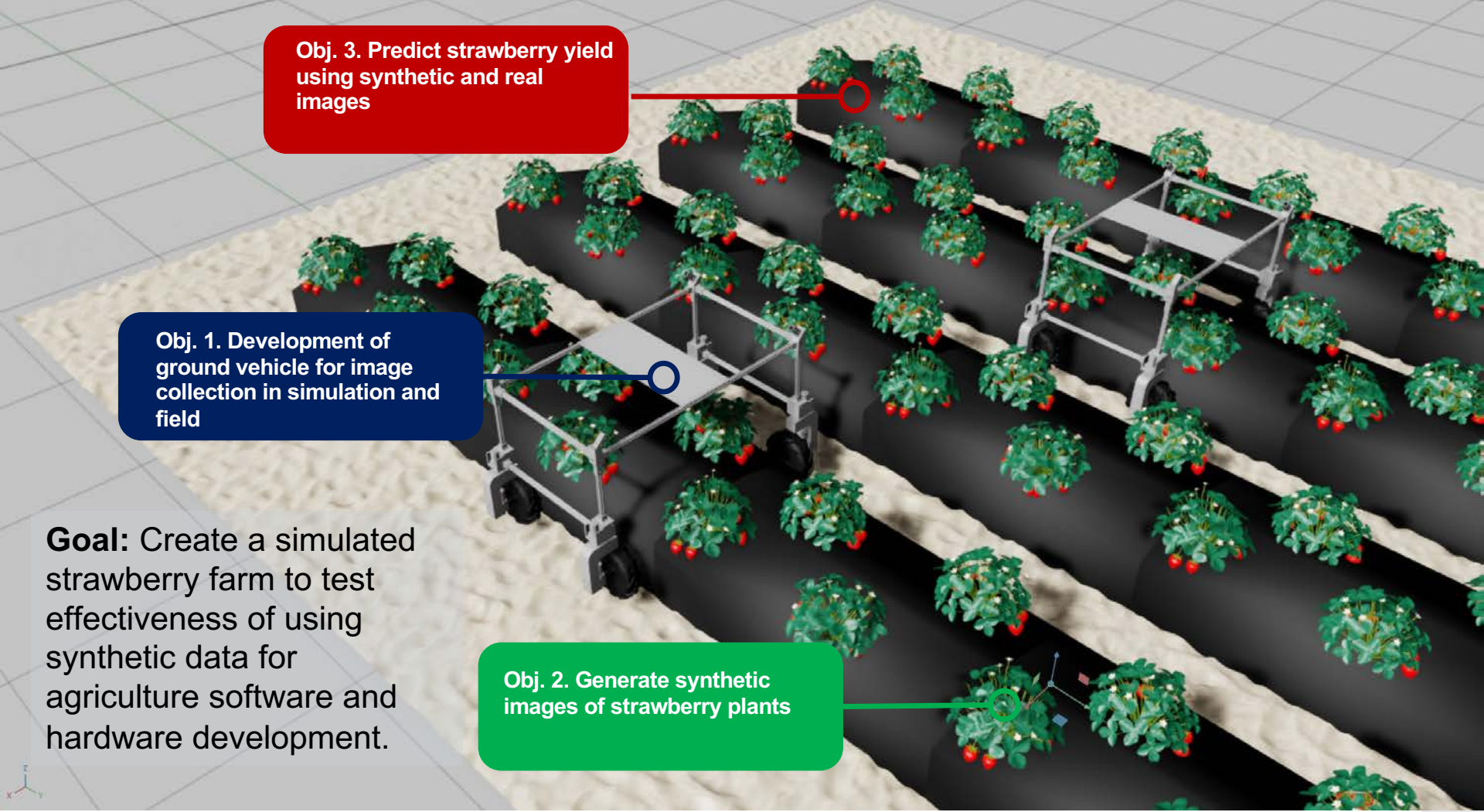
Risk
Bad data
Crop is lost due to disease or frost



Virtual replica of a physical farm, providing real-time data and insights for improved decision-making and forecasting, or simulation.

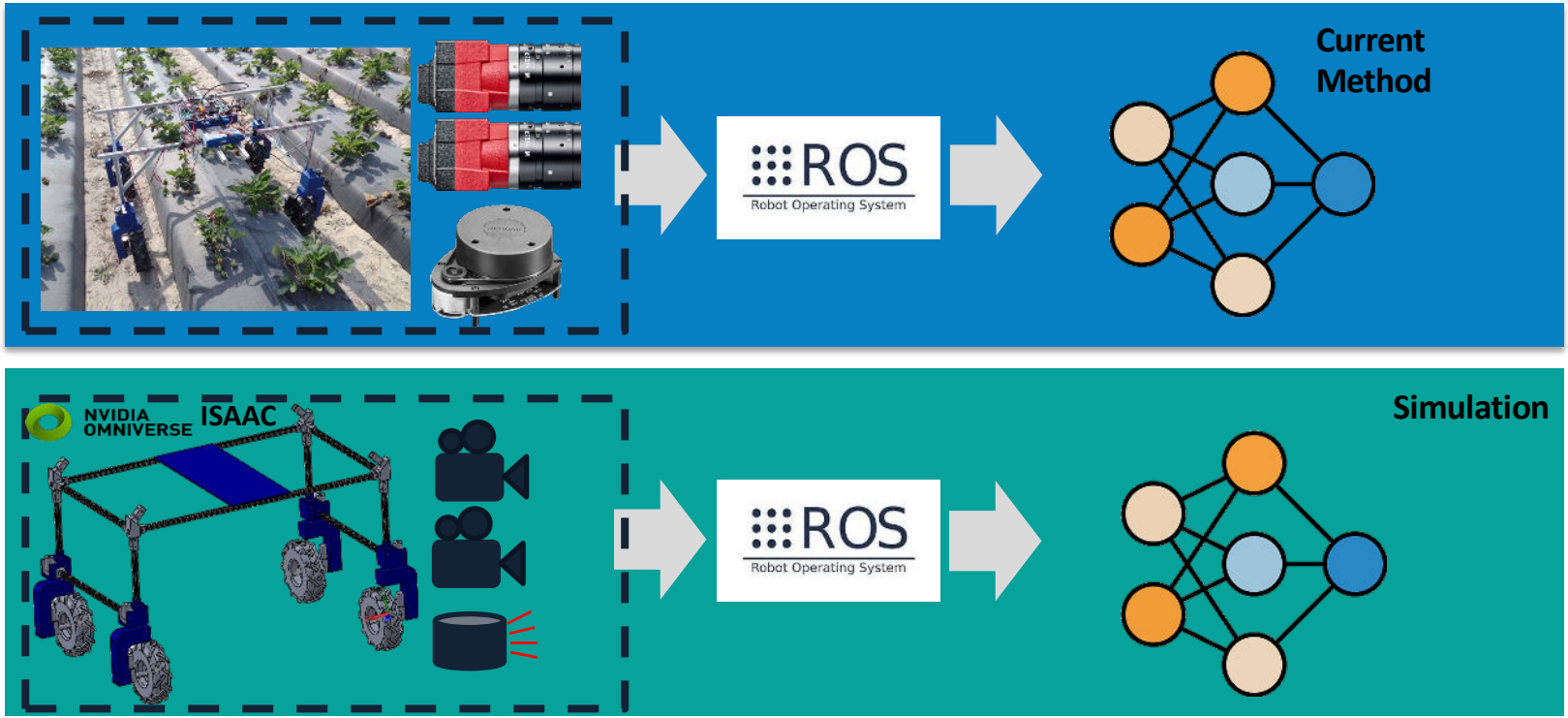


Using digital twins can speed up the development process of robots and AI

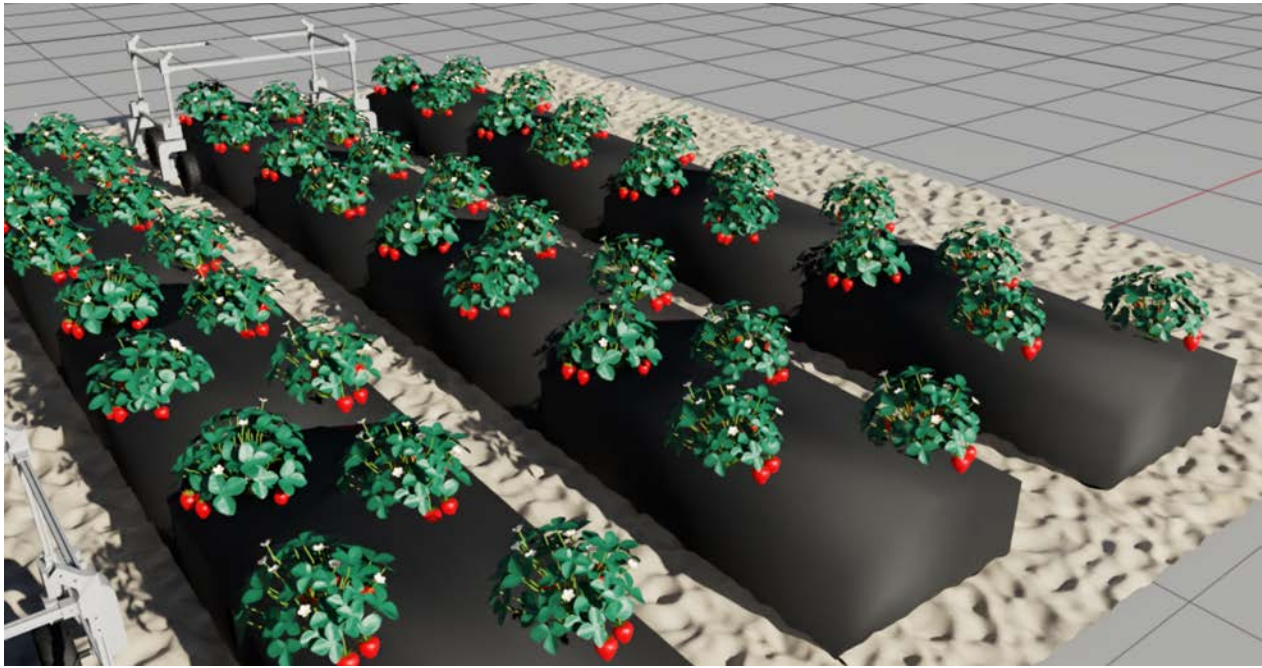


Goal: Create a simulated strawberry farm to test effectiveness of using synthetic data for agriculture software and hardware development.

Method


Current Method
ROS
Robot Operating System
NVIDIA OMNIVERSE
ISAAC
Simulation
ROS
Robot Operating System

Method



Method

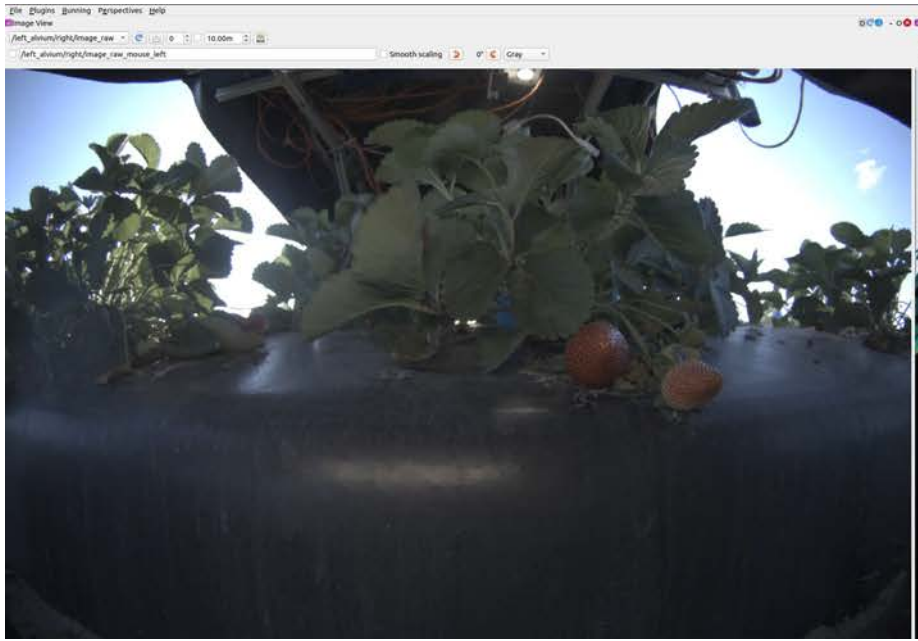

Viewport
RTX - Interactive
Perspective
Stage Lights
FPS: 116.00, Frame time: 8.62 ms
NVIDIA RTX A6000: 3.0 GiB used, 41.4 GiB available
NVIDIA RTX A6000: 2.4 GiB used, 42.0 GiB available
Host Memory: 15.1 GiB used, 122.5 GiB available
PathTracing: 32/32 spp - 0.55 sec
1280x720

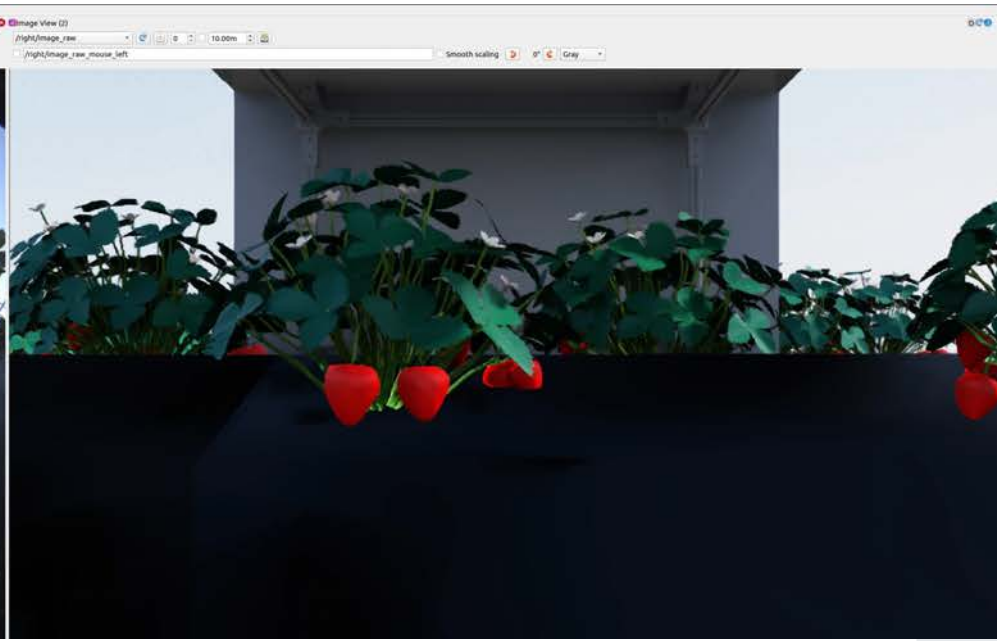
Results: Objective (1) Progress

Build simulation environment including ground vehicle model, strawberry bed, and strawberry plant.

Field

Simulation





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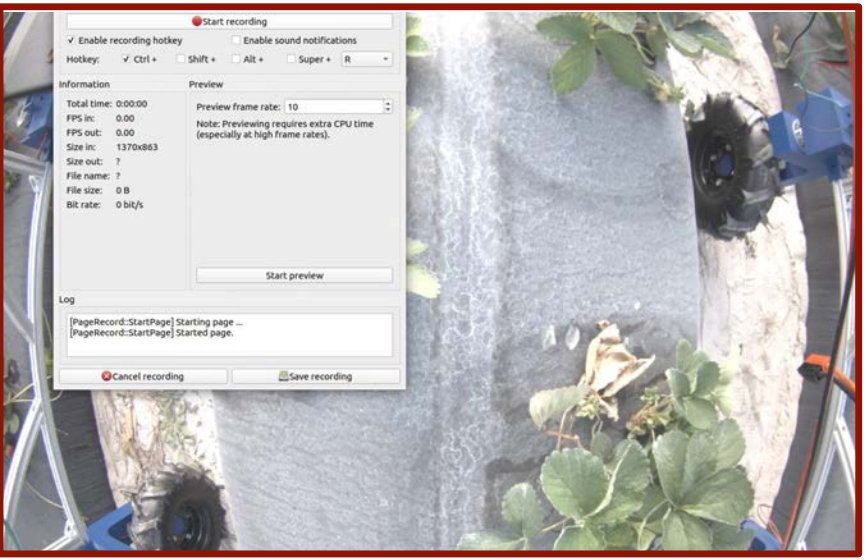
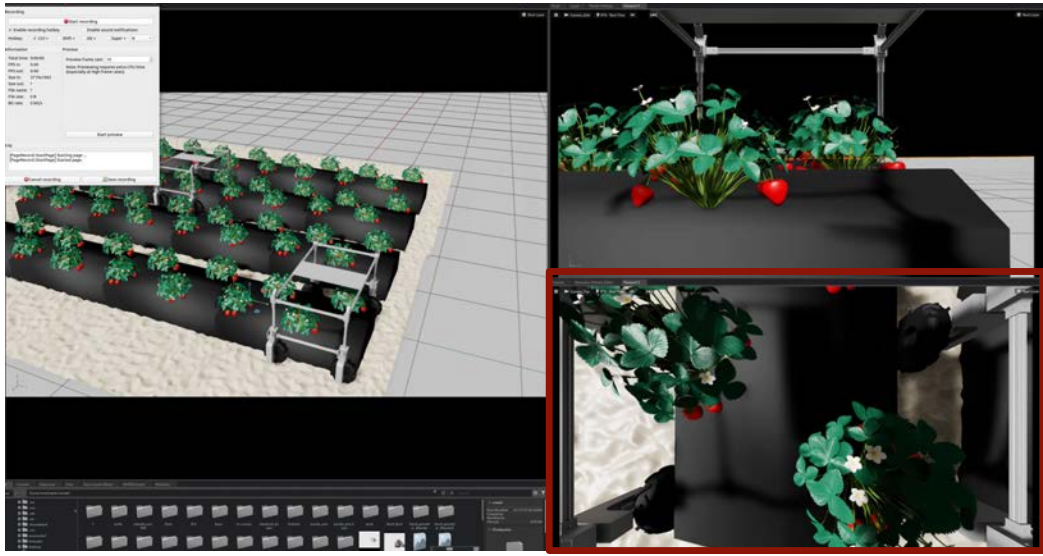
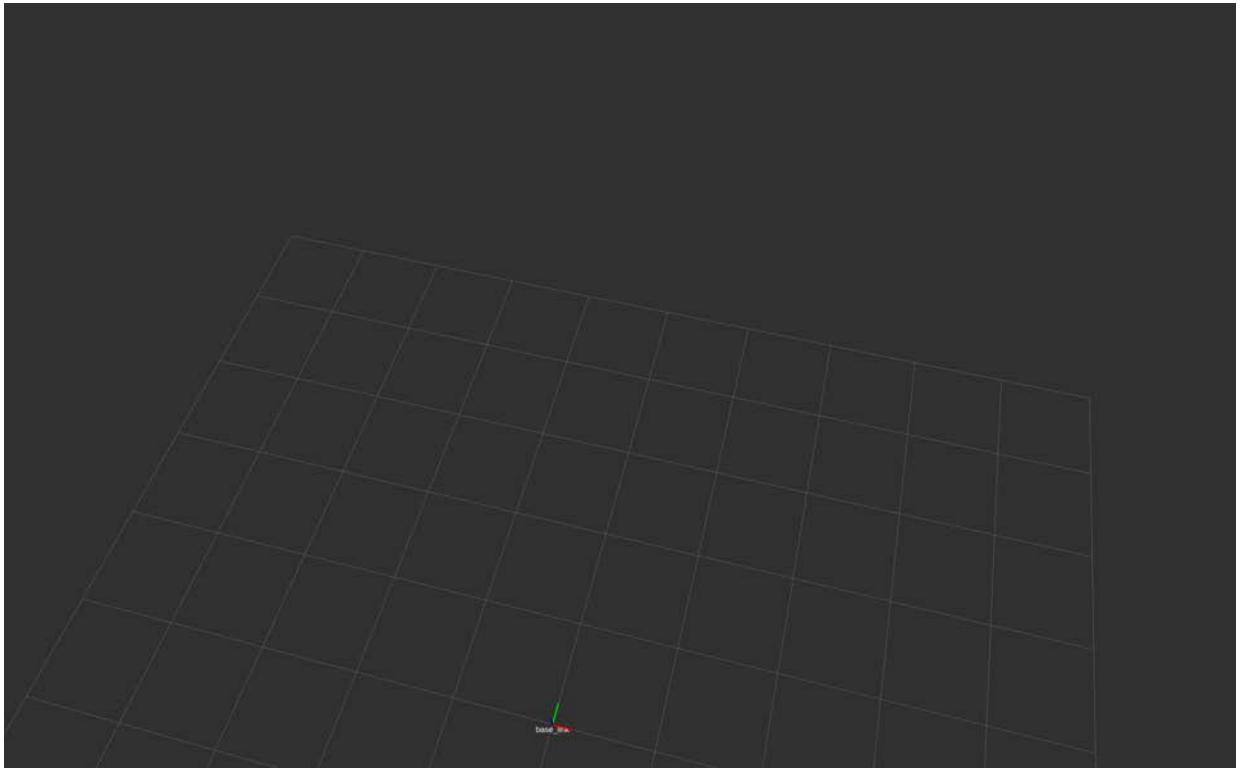


Simulation

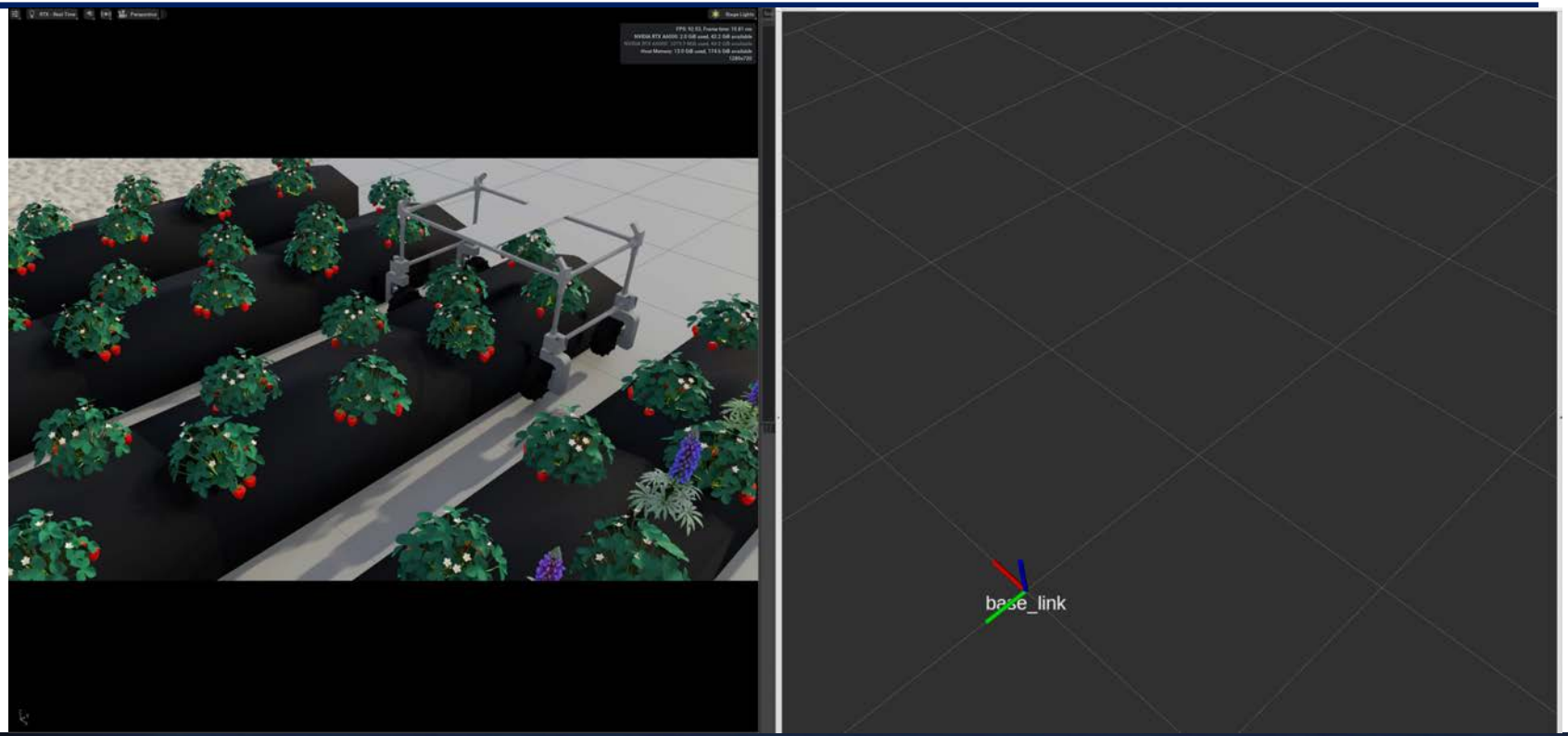



RTX - Interactive
Perspective
Stage Lights
FPS: 89.56, Frame time: 11.17 ms
NVIDIA RTX A6000: 2.4 GiB used, 37.3 GiB available
NVIDIA RTX A6000: 1.9 GiB used, 37.8 GiB available
Host Memory: 21.5 GiB used, 166.1 GiB available
PathTracing: 32/32 spp : 1.02 sec
1280x720

Results: Lidar Data In Field

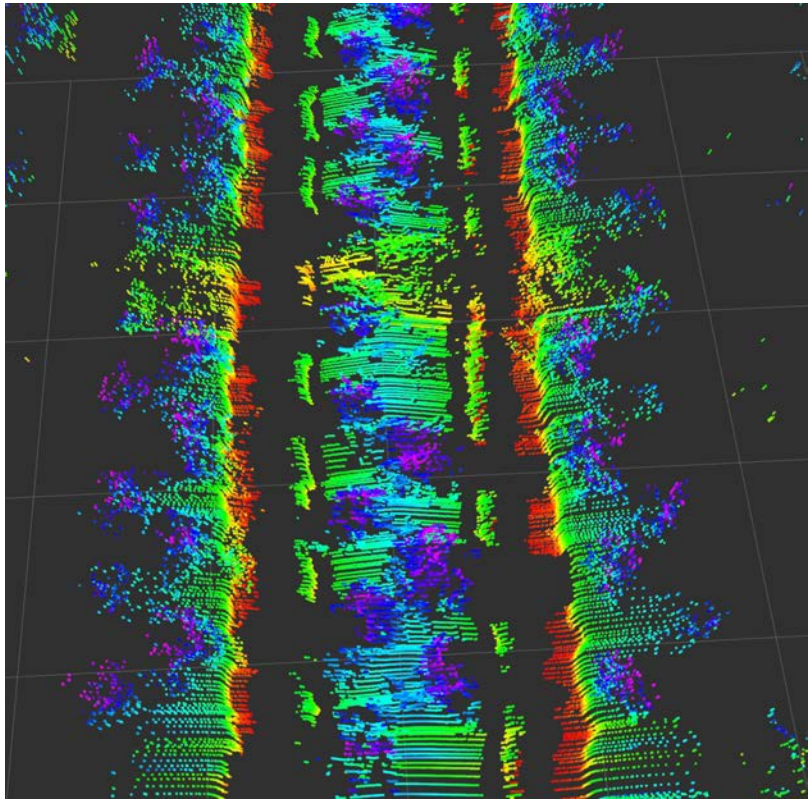


Results: Lidar Data In Simulation

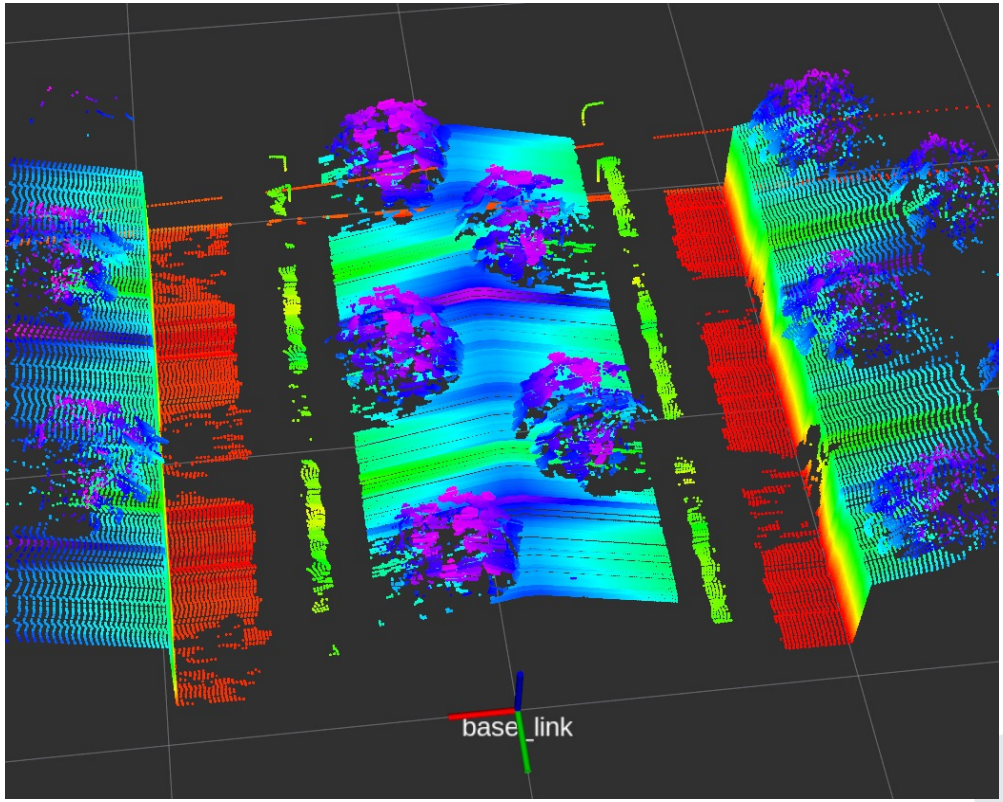


Results: Lidar Data Comparison

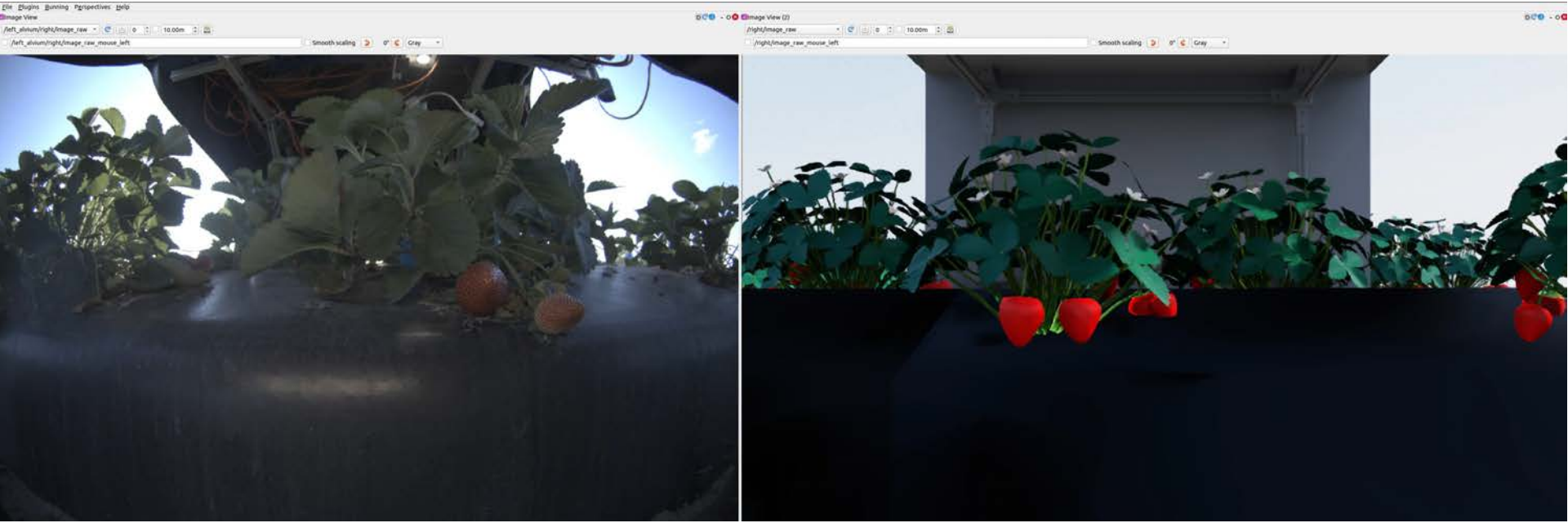
Field



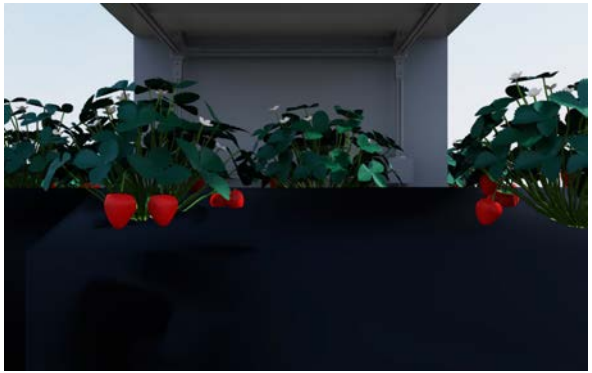
Simulation



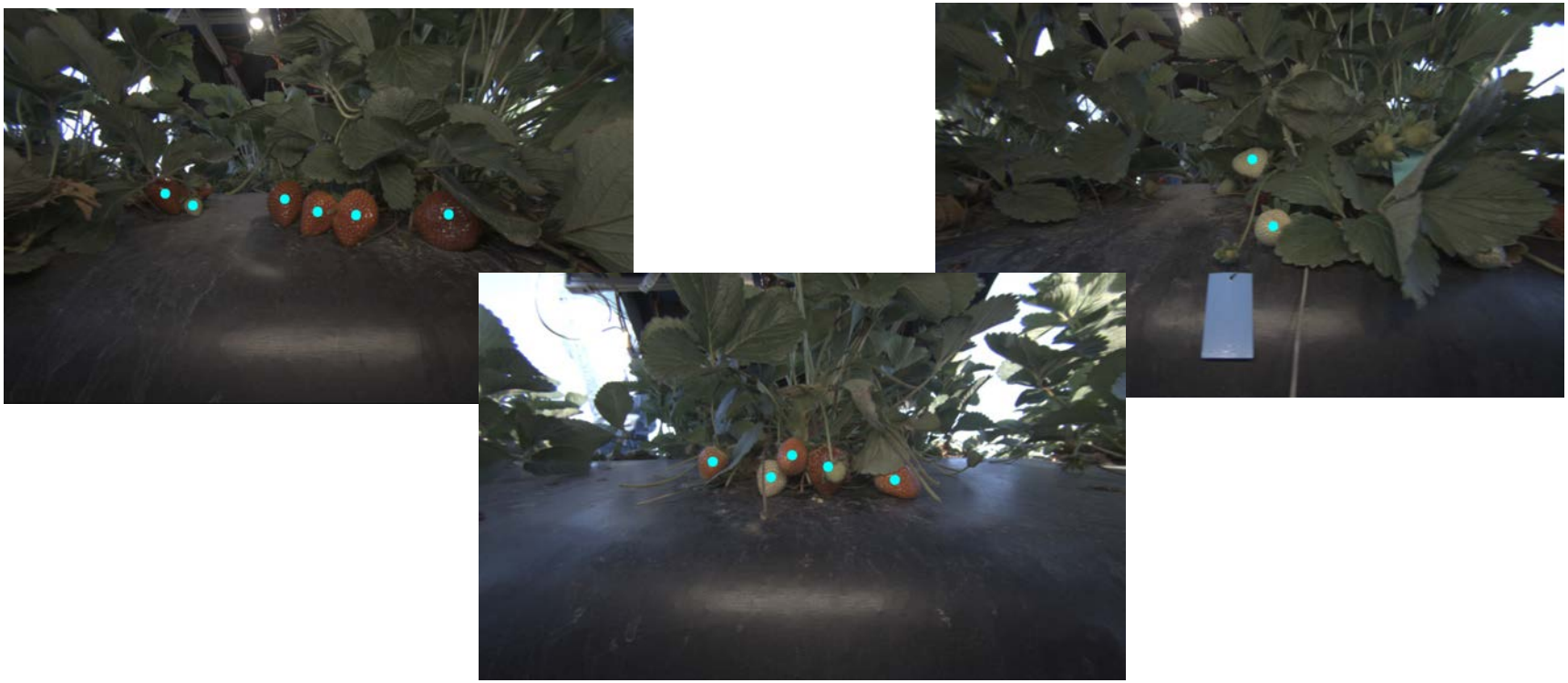
Results: Camera Image Comparison



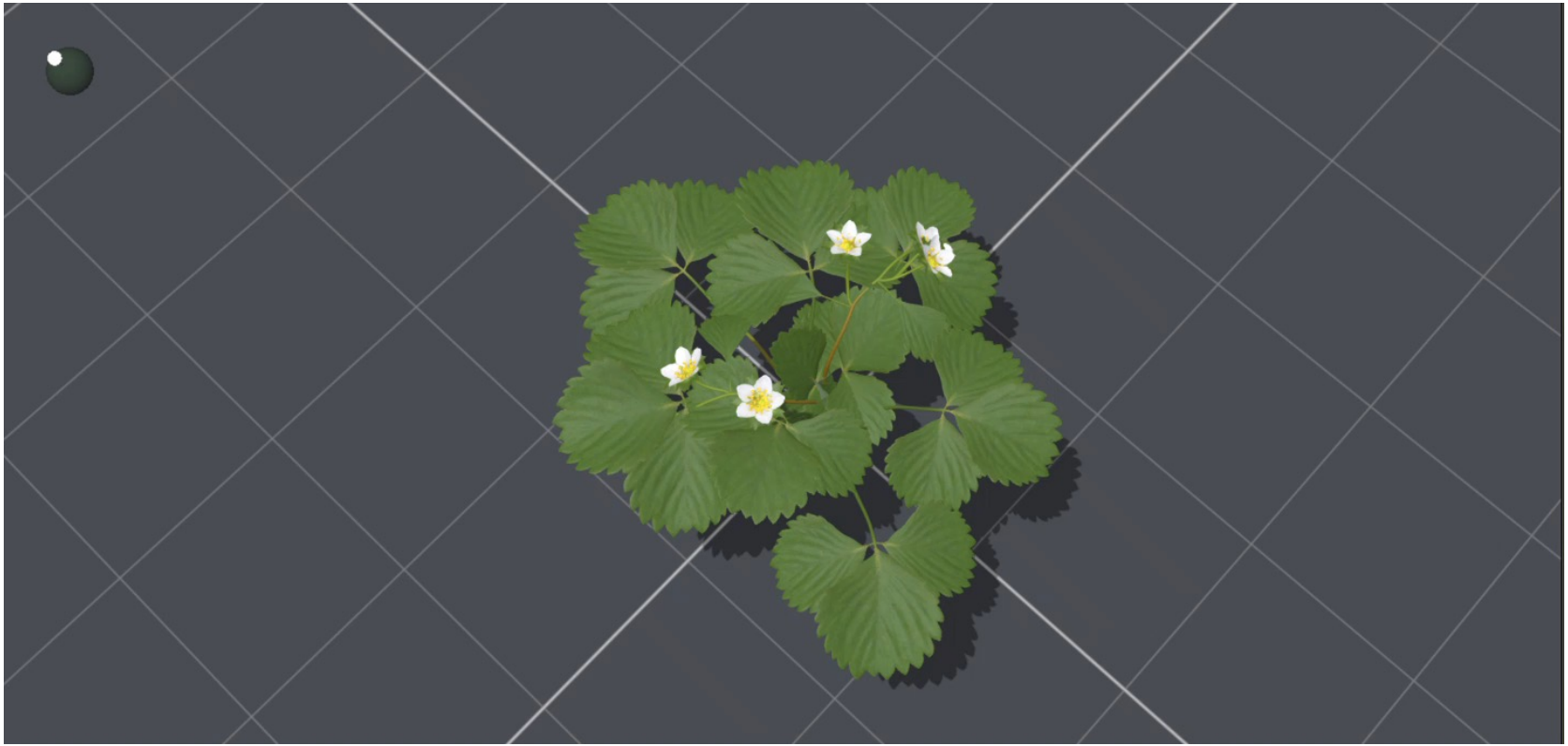
Results: Sample Training Images

Results: Fruit Detection on Field Images



Future Work: More realistic strawberries



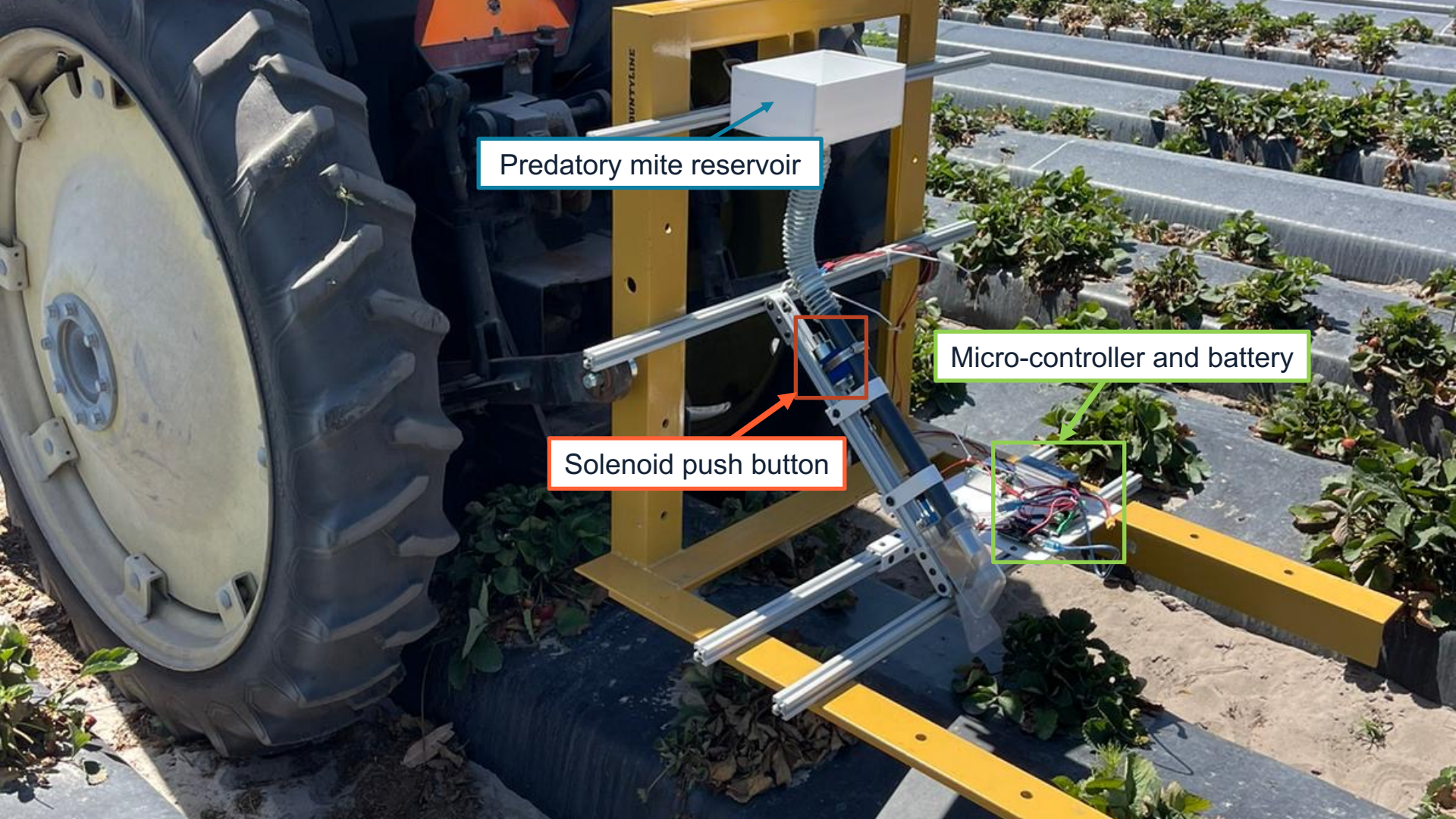
Predatory Mite Releaser

Examples of commercially used manual biocontrol release methods




Drone release to reduce the time and labor of introducing mites to plants.


However, it is still unknown how many predatory mites actually survive


Predatory mite reservoir
Micro-controller and battery
Solenoid push button

How Many Mites Do We Need?

100000 to 150000 mites per acre with an average of 17000 strawberry plants per acre

0.12 ml of mites (roughly 6 mites) per plant

Test Results

Length of side A (in)	Length of Side B (in)	Angle of releaser to the Horizontal (deg)			
15	21	35.5			
Mass of eppendorf tube before (g)	Mass of eppendorf tube after (g)	Change in mass (g)	volume after shaking to remove air pockets (ml)	uncertainty	
0.95	1.19	0.24	1.1	0.25	
0.95	1.2	0.25	1.1	0.25	
0.95	1.17	0.22	1.1	0.25	
0.95	1.18	0.23	1.1	0.25	
0.95	1.19	0.24	1.1	0.25	
0.95	1.22	0.27	1.3	0.25	

Testing Release Pattern
Influence of End Opening Shape

	Length of short side (in)	Length of long side (in)
1	6.25	8.75
2	5.88	8.5
3	7	8.75
4	7.75	8.38
5	6.5	8.5
6	4.5	8
7	6.5	8.68
8	7.5	9.5
9	8.5	8
10	6	8.5
AVG	**6.64**	**8.56**

By optimizing the end opening, we can facilitate a more uniform distribution of mites across the entire plant

Future Work

- *Modification of release system design*
- *Currently implementing plant detection for autonomous release trigger*
- *Detection of Thrip Damage (Targeting between Stage 2 and Stage 3)*


Stage 1


Stage 2


Stage 3


Stage 4

Summary

The digital twin effectively simulates physical processes, enhancing operational efficiency.

Using simulated data, we can detect most fruit in the field, and are developing a more detailed reporting system.

The predatory mite release system is being optimized to evenly distribute mites for effective pest management.

The system will soon detect thrip damage between stages 2 to 3, allowing for more precise mite releases.

These projects were supported by FSGA.

Thank You!

Any questions?

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