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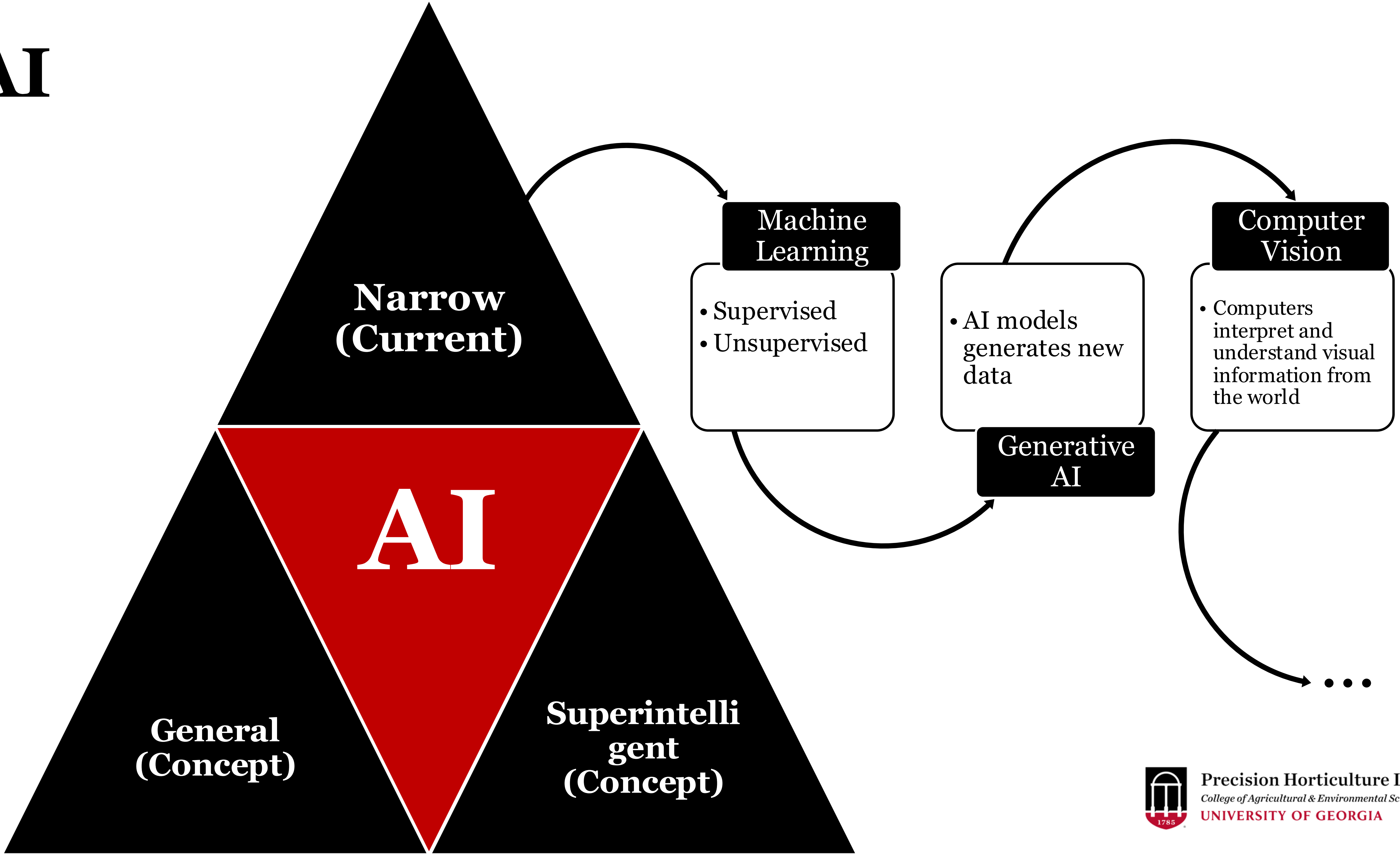
Using Artificial Intelligence (AI) and Drones (UAVs) to Estimate Onion Bulb Counts and Market Sizes

Dr. Luan Pereira de Oliveira, Victor Martins M.S., Dr. Marcelo Barbosa, Regimar dos Santos M.S., Lucas Sales, M.S., and

AI


Narrow (Current)
AI
General (Concept)
Superintelligent (Concept)
Machine Learning
• Supervised
• Unsupervised
Generative AI
• AI models generates new data
Computer Vision
• Computers interpret and understand visual information from the world
…

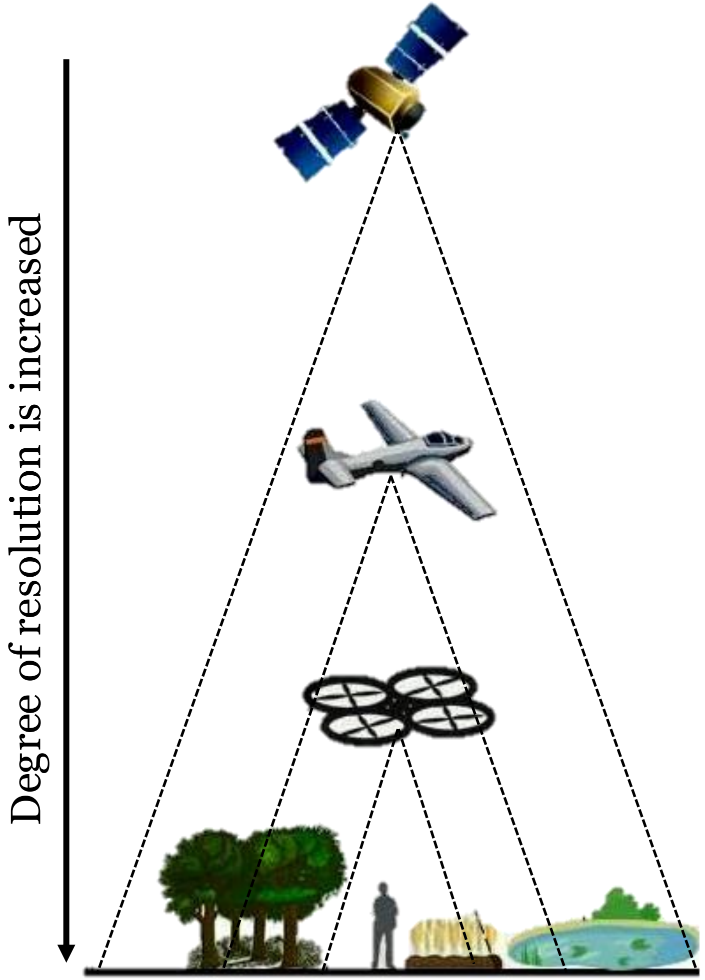
Narrow AI in Agriculture

Robotics and automated machinery: *AI enables unmanned ground vehicles that can take in-site decisions on where to mechanically remove weeds, spray, and harvest crops.*

Crop and soil monitoring: *AI algorithms analyze data from sensors (satellites and drones) to predict crop yields, detect plant diseases, and prescribe effective control methods.*

Predictive analytics: *AI tools forecast environmental impacts, crop productivity, and market conditions.*

Remote Sensing



RGB
(Red, Green, Blue)

Multispectral
(Red, Green, Blue, NIR, and Red Edge)

Hyperspectral
(Multispec. +)

Thermal

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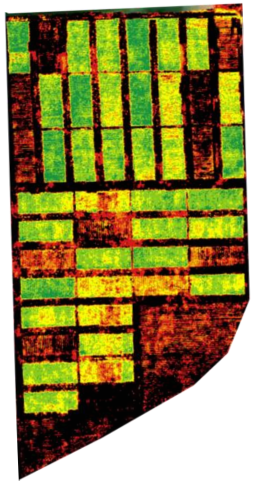
Remote/Proximal Sensing

Approaches to identify issues and variability within a field or sampling set

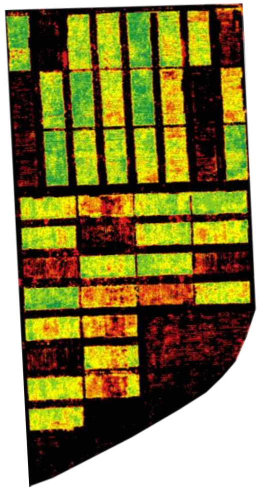
- Spectral Response
- Identification and Segmentation of Objects

NDVI



$$\frac{NIR - RED}{NIR + RED}$$

NDRE



$$\frac{NIR - R.E}{NIR + R.E}$$

"Hard Mode" Vs "Easy Mode" Digital Ag Tech

ArcGIS®
MATLAB®
R
QGIS
python™
Metashape
Minitab®
sas®

+ AI =

DroneDeploy
solvi
HEMAV
PIX4D
sentera
agremo™

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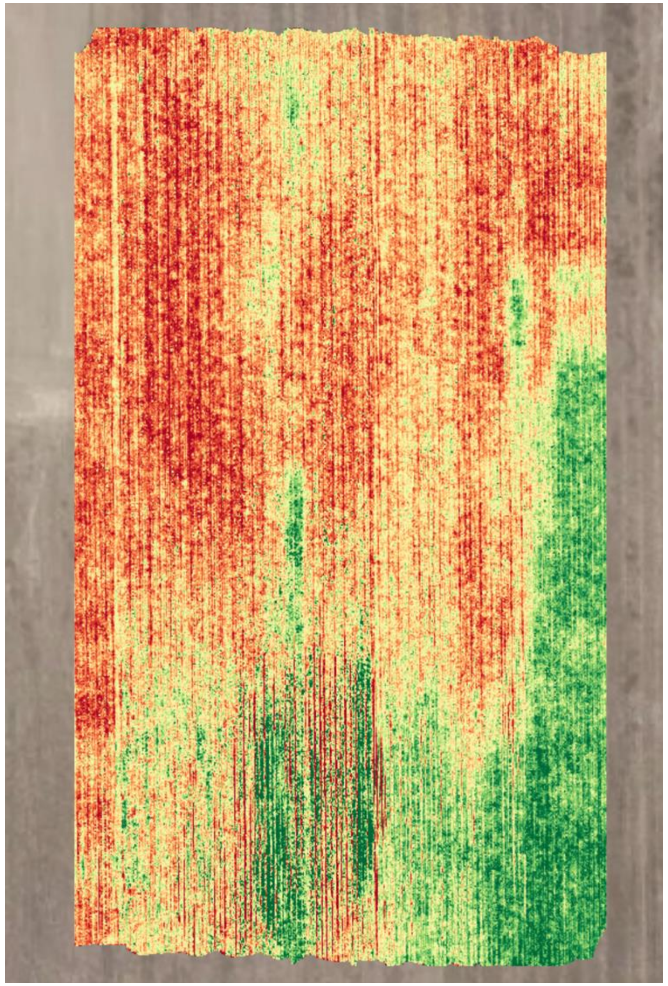
1785

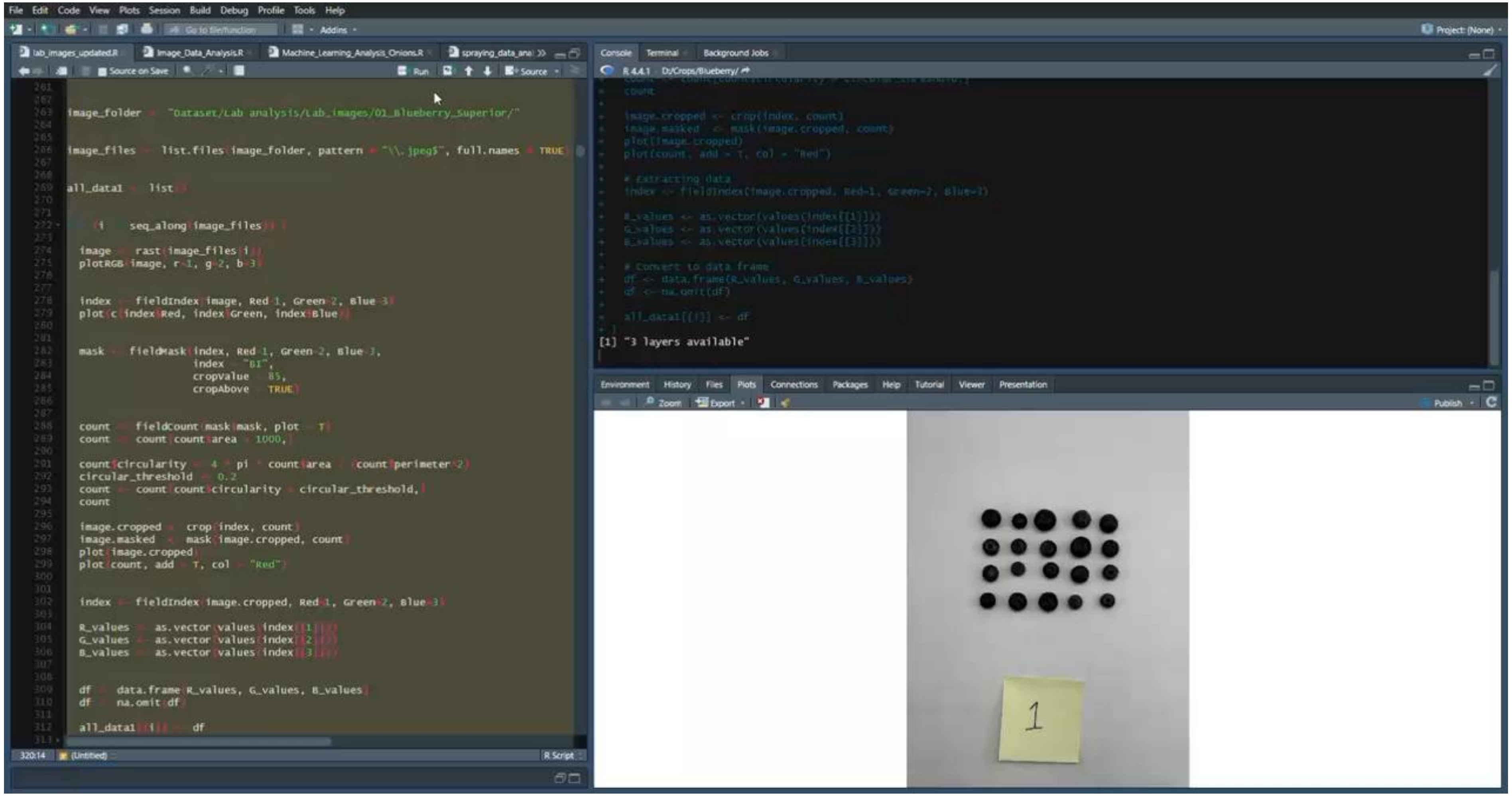
Manual "Hard" Mode

Phyton, R, SAS, Metashape, etc...

```
async def run():

    """ Does Offboard control using attitude commands. """

    drone = System(mavsdk_server_address='localhost', port=50051)
    await drone.connect(system_address="udp://:14540")

    print("Waiting for drone to connect...")
    async for state in drone.core.connection_state():
        if state.is_connected:
            print(f"-- Connected to drone!")
            break

    print("Waiting for drone to have a global position estimate...")
    async for health in drone.telemetry.health():
        if health.is_global_position_ok and health.is_home_position_ok:
            print("-- Global position estimate OK")
            break
```



Manual “Hard” Mode



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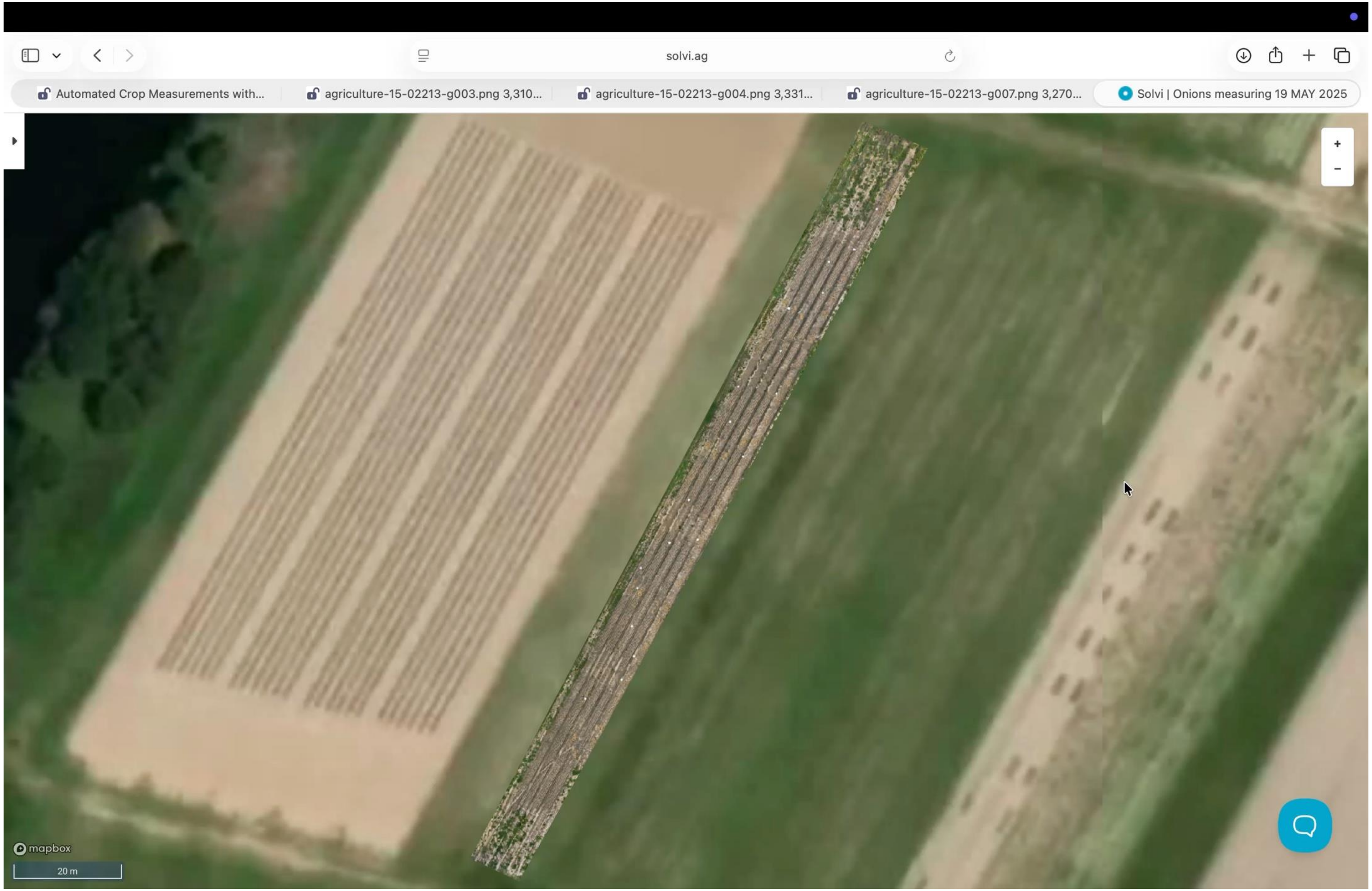
AI-driven “Easy” Mode



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Is it possible to count and measure Onions with Drones and AI?

Open Access | Article

Automated Crop Measurements with UAVs: Evaluation of an AI-Driven Platform for Counting and Biometric Analysis

by João Victor da Silva Martins [1,2,*], Marcelo Rodrigues Barbosa Júnior [1], Lucas de Azevedo Sales [1], Regimar Garcia dos Santos [1], Wellington Souto Ribeiro [2] and Luan Pereira de Oliveira [1,*]

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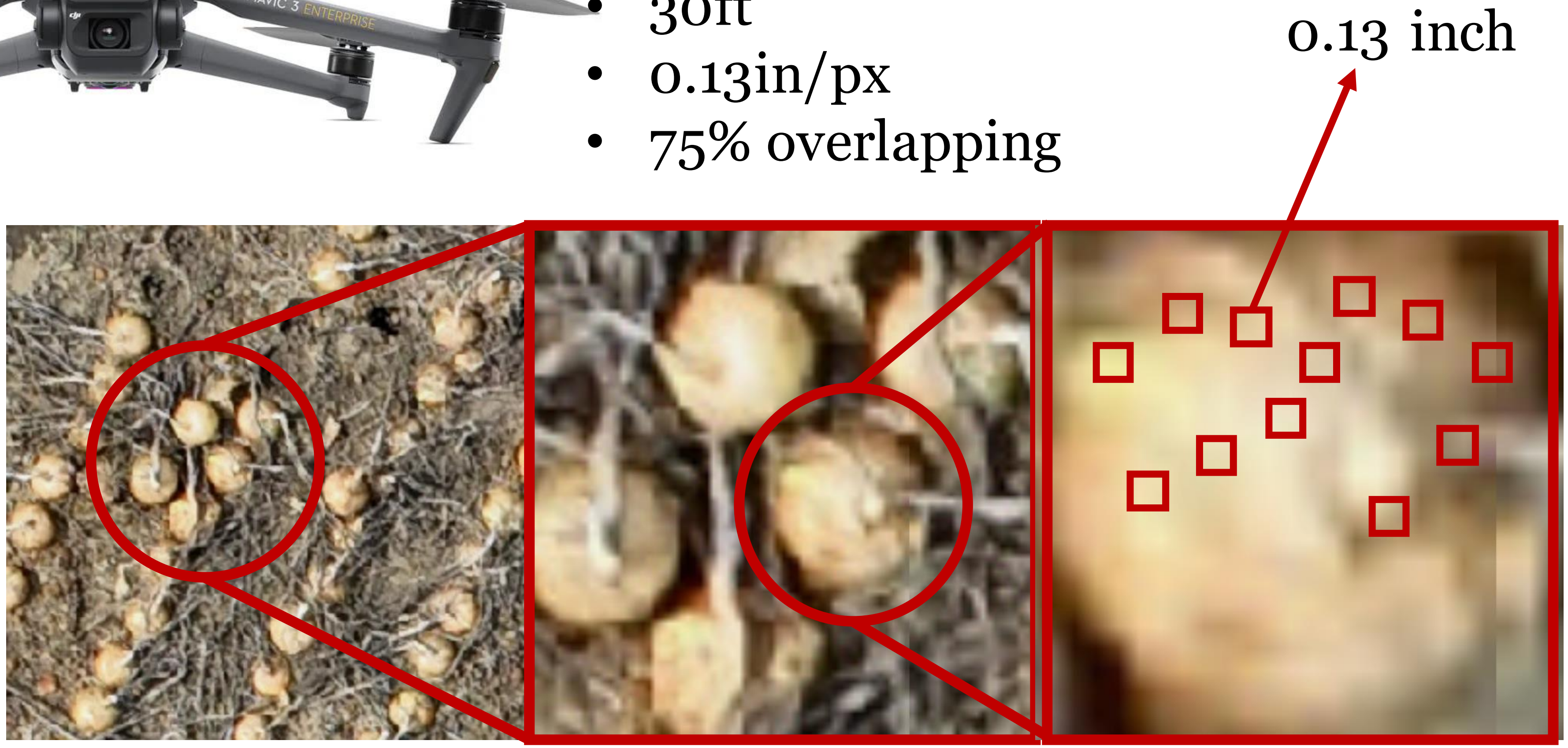
Objectives

- To evaluate the performance of a commercial AI-powered digital agriculture web platform (Solvi) for automated biometric analysis in specialty crops (pecan and onion) using (Drone) UAV-acquired imagery.
- To verify the accuracy and precision of onion counting after undercutting
- To verify the potential of onion classification into USDA market sizes.
- To explore the possibility of predicting yield based on the data.

Material and Methods

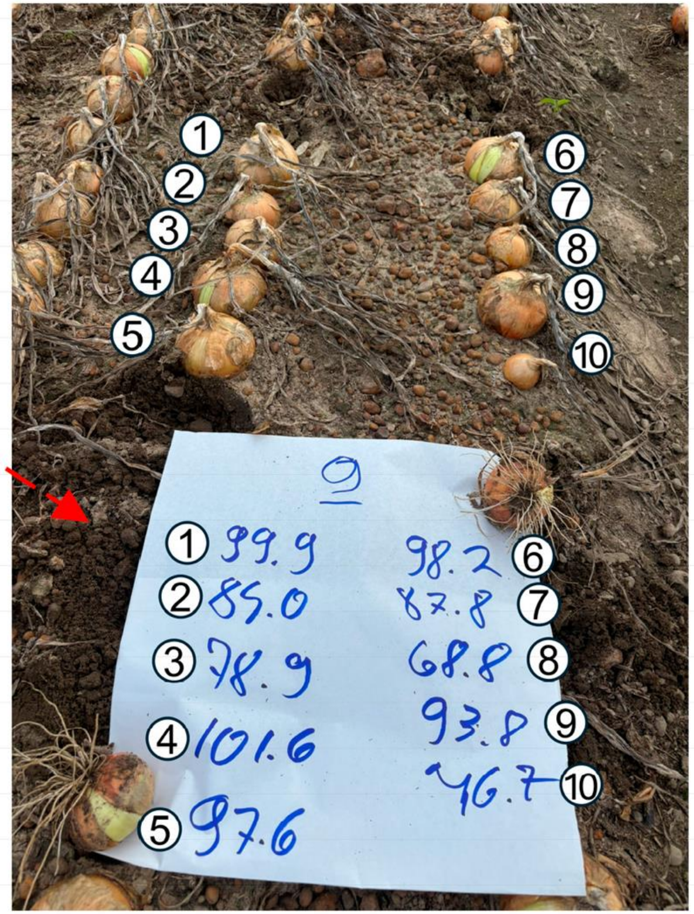
- Vidalia Onion Research and Education Center, Lyons, GA
- DJI Mavic 3M
- RGB Img
- 30ft
- 0.13in/px
- 75% overlapping



Material and Methods

Orthomosaic

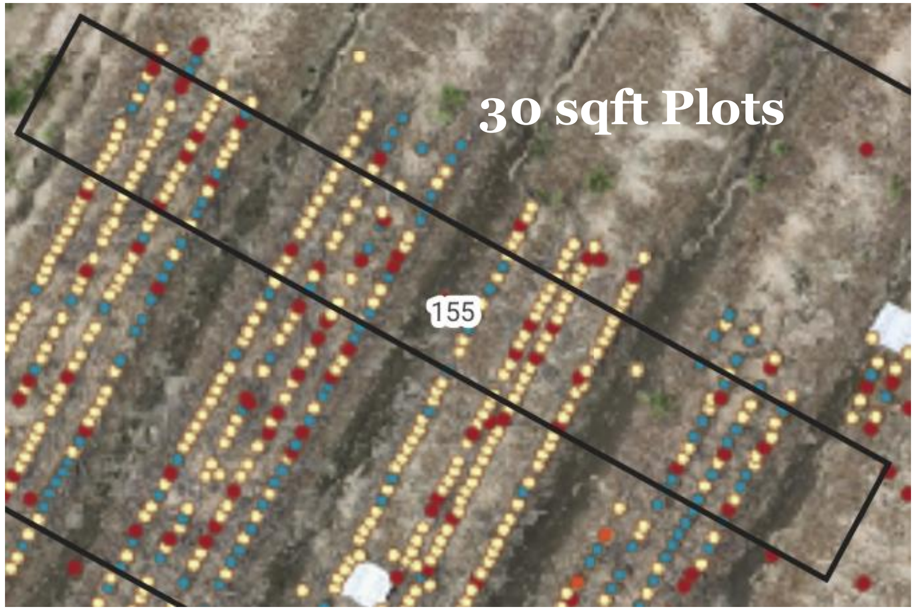
Sample point (ID 9)



Data classification

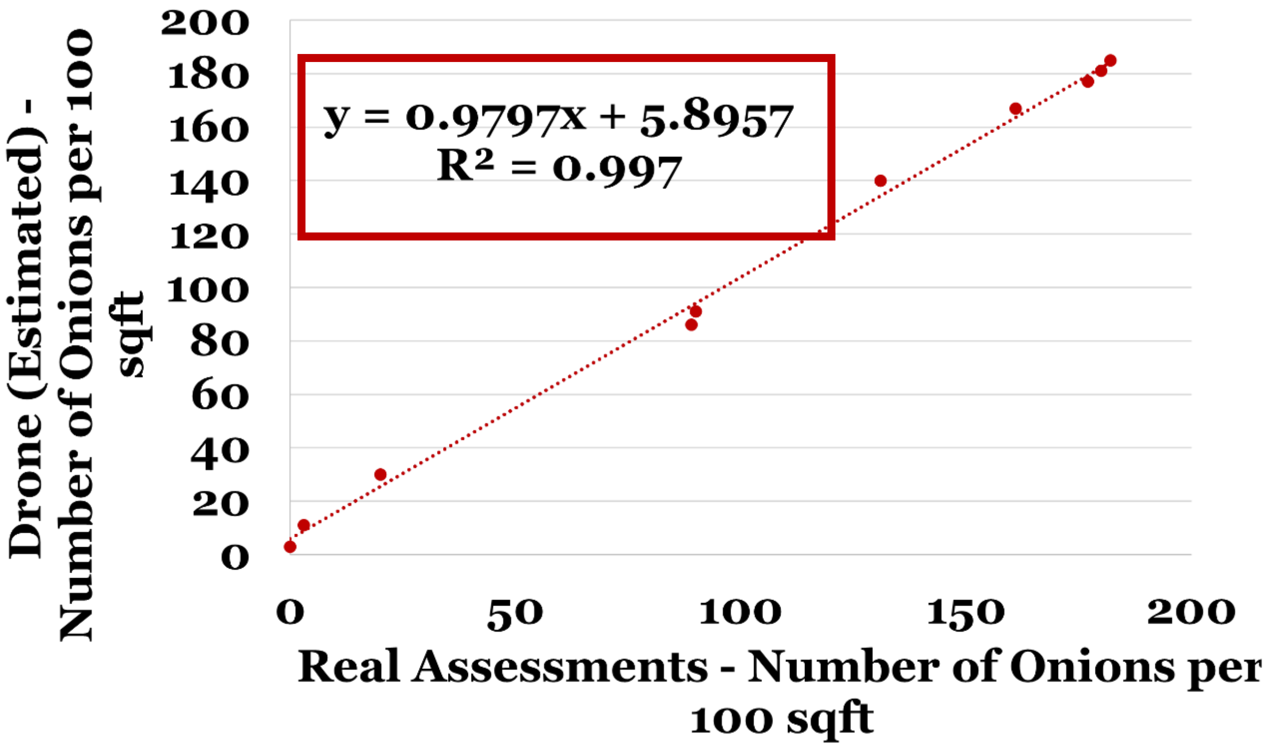
ID	Diameter (mm)	Class
1	99.9	Colossal
2	85.0	Jumbo
3	78.9	Jumbo
4	101.6	Colossal
5	97.6	Colossal
6	98.2	Colossal
7	87.8	Jumbo
8	68.8	Medium
9	93.8	Jumbo
10	46.7	Medium

Material and Methods



- Total Number of Onions
- Number of True Positives (Proper measurements)
- Number of False Positives (Other objects counted as onions)
- Number of True Negatives (Objects that were not counted as onions)
- Number of False Negatives (Onions not counted)

Results - Counts



$$\text{Precision} = \frac{\textit{True Positives}}{\textit{False Positives} + \textit{False Negatives}}$$

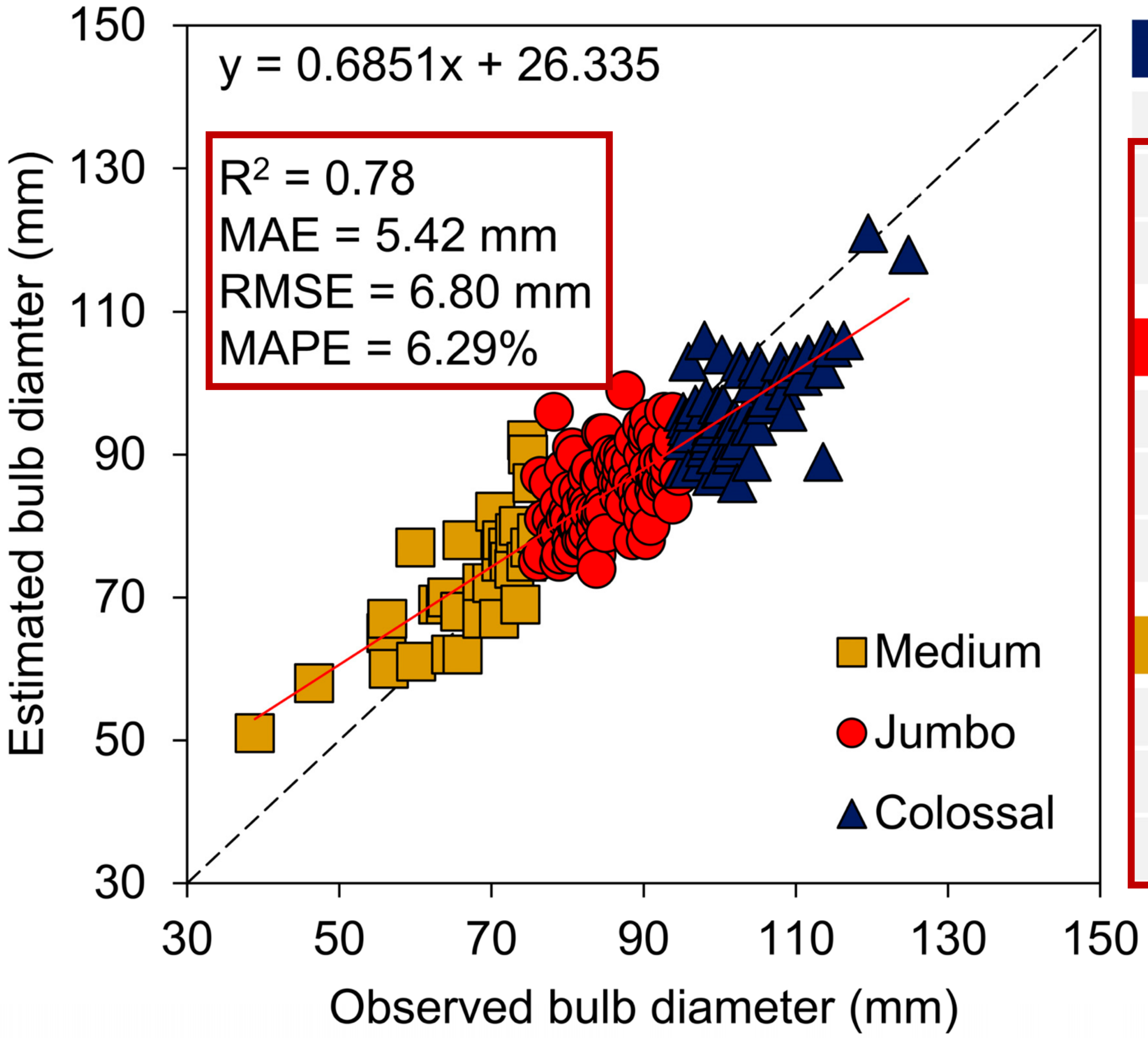
$$\text{Recall} = \frac{\textit{True Positives}}{\textit{True Positives} + \textit{False Negatives}}$$

$$\text{F1 Score} = 2 \text{ x } \frac{\textit{Precision} + \textit{Recall}}{\textit{Precision x Recall}}$$

Table 2. Onion counting analysis results.

Metric	Value
Precision	0.985
Recall	0.970
F1 Score	0.978

Results - Size



Colossal			
y = 0.694x + 25.403			
R^2	MAE	RMSE	MAPE
0.45	6.92 mm	8.21 mm	6.62%
Jumbo			
y = 0.5608x + 36.997			
R^2	MAE	RMSE	MAPE
0.25	4.20 mm	5.31 mm	4.90%
Medium			
y = 0.8166x + 17.54			
R^2	MAE	RMSE	MAPE
0.60	6.32 mm	7.86 mm	9.99%

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Results - Size

(b) Size Requirements - Provided that unless otherwise specified, size shall be specified in connection with the grade in terms of one of the size classifications listed below:

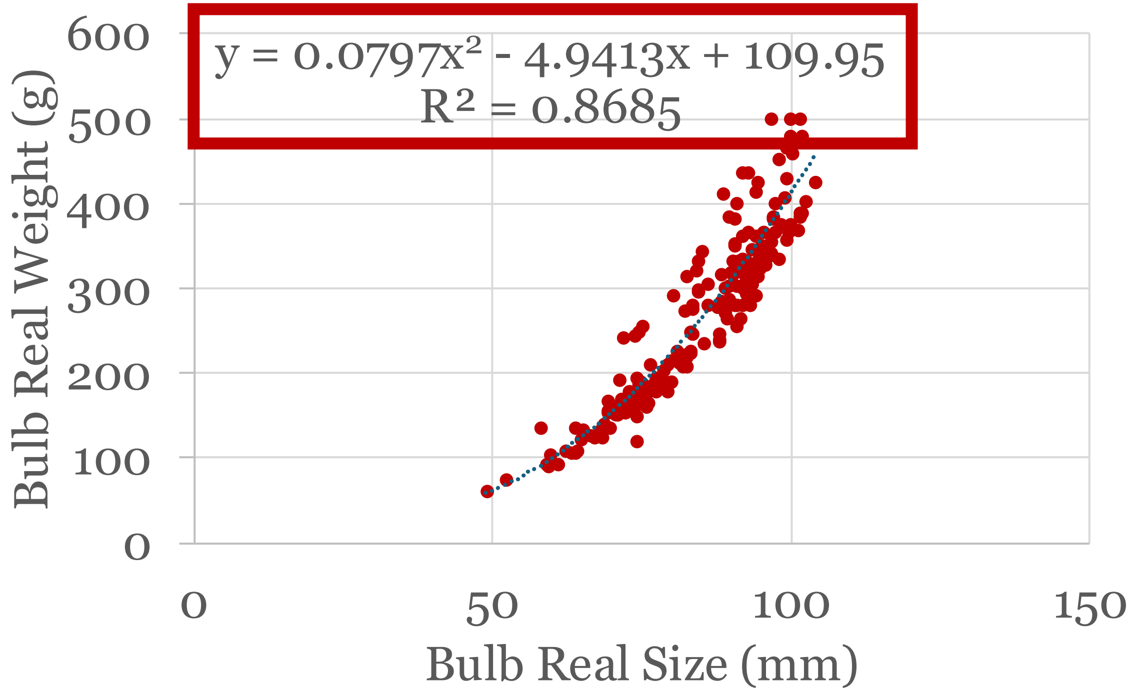
1. "*Small*" shall be from 1 to 2 1/4 inches in diameter.
2. "*Medium*" shall be from 2 to 3 1/4 inches in diameter.
3. "*Large Medium*" shall be 2 1/2 inches or larger in diameter.
4. "*Large*" or "*Jumbo*" shall be 3 inches or larger in diameter.
5. "*Colossal*" shall be 3 3/4 inches or larger in diameter.

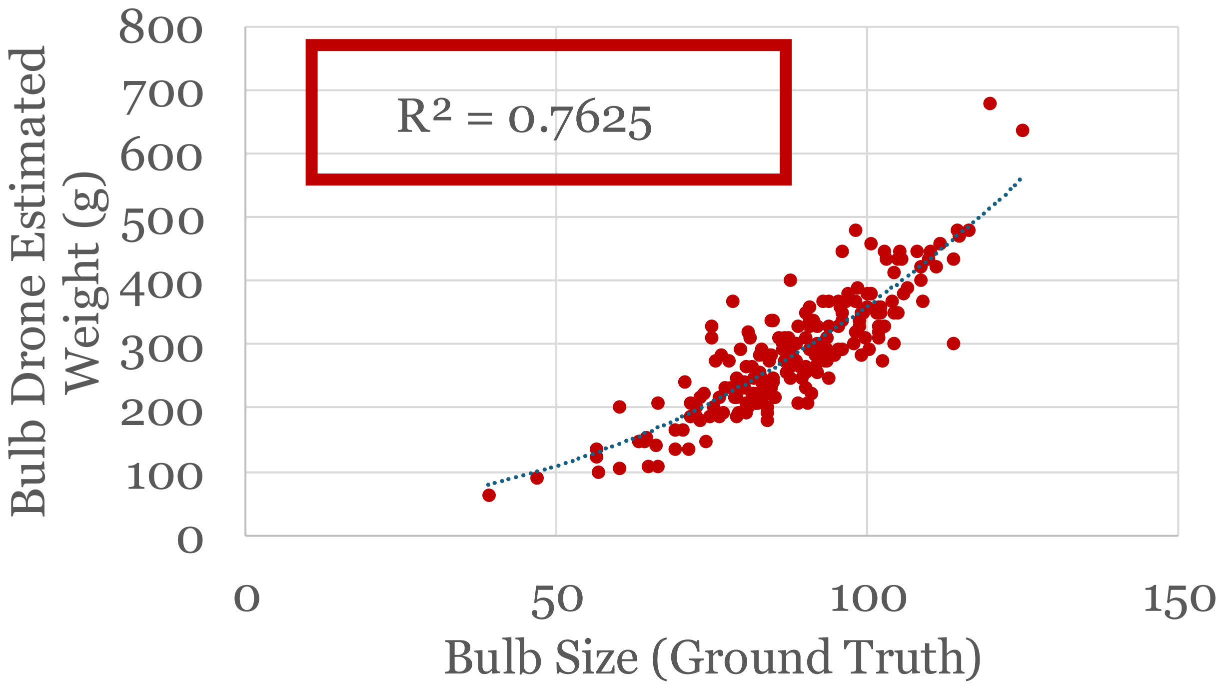
Source: https://rules.sos.state.ga.us/gac/40-7-8#:~:text=5.,inches%20or%20larger%20in%20diameter.&text=Tolerances%20for%20size:%20In%20order,than%20the%20maximum%20diameter%20specified.&text=Special%20Purpose%20Shipments:,set%20forth%20in%20this%20section.

Conclusions

- The AI-powered web platform showed **good accuracy in estimating onion biometric traits**, particularly **bulb diameter**, when compared with ground-truth measurements.
- The results support the **use of cloud-based AI tools for automated morphological measurements** in onion production systems under real field conditions.
- **Future work** should validate performance across additional **phenological stages**, **production environments**, and **onion cultivars**.
- Further expansion could include **yield and quality prediction models** specifically tailored for onions.
- The platform may also benefit from integrating **additional sensing technologies**—such as ground-based robotics—to improve **scalability**, **resolution**, and **early-season measurement accuracy**.

Next Steps – Predicting Yield – Preliminary





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Thanks!

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Special Thanks...

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