SENIOR CAPSTONE/
SENIOR DESIGN EXPERIENCE
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Stem Holding Robot

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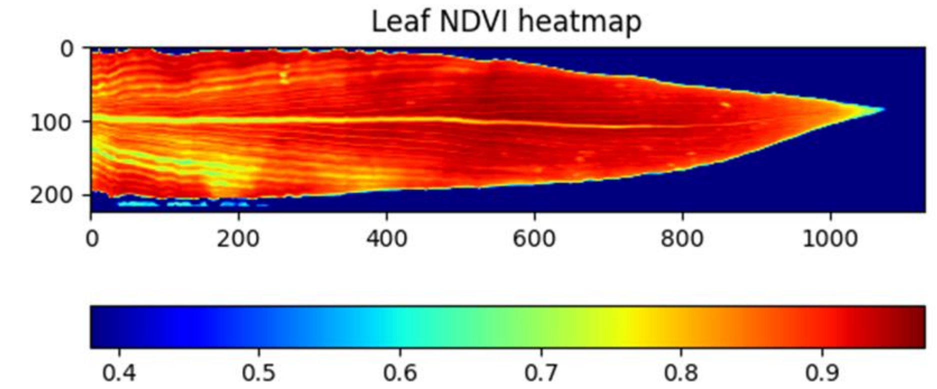
Executive Summary

In order to feed the growing population, plant breeders are developing new strains of crops to yield more while requiring less inputs. To determine how well a strain performs, non-destructive data is sought. This data is collected using hyperspectral imaging sensors which can determine the contents within plants for analysis. When collecting automated plant phenotyping data, specimens have experienced non-recoverable damage. To prevent this, researchers have manually supported the plants during the scan, which has led them to seek an automated solution. The solution needed 3 key elements: a height adjustable pedestal for different growth stages, a versatile end effector to interact with the plants, & to use a ROS compatible robot. The solution created utilizes an electromechanical gripper for clamping, a hydraulic jack to preset height, and a UFactory xArm to hold plants still while undergoing data collection.

Data in Question?

The system designed works in tandem with another 6 DOF arm to collect hyperspectral images of the leaves using LeafSpec, a sensor developed by Purdue ABE's Dr. Jian Jin.



Project Environment

The system was designed to operate within the Purdue Ag Alumni Seed Phenotyping Facility using V6-V8 Stage Corn. Monitored conditions include light, humidity, water, nutrients, & more. The facility uses a conveyor system to transfer plants from the greenhouses to the sensor equipment for data collection, allowing for a static system.

Design Requirements

The guiding principles of the design were cost, capability & commercialization. By lowering expenses, creating potential for usage in different settings, & sourcing from reputable suppliers, LeafSpec will have the option to provide units to multiple universities & source parts in the future in the case of repairs. The project had 4 primary constraints:

- $9,000 Budget (25% of Master Robot)
- Transportability and Tip Resistance
- 100% Test Effectiveness and no Stalk Damage
- Total testing cycle of less than 3 minutes

Gripper Concepts



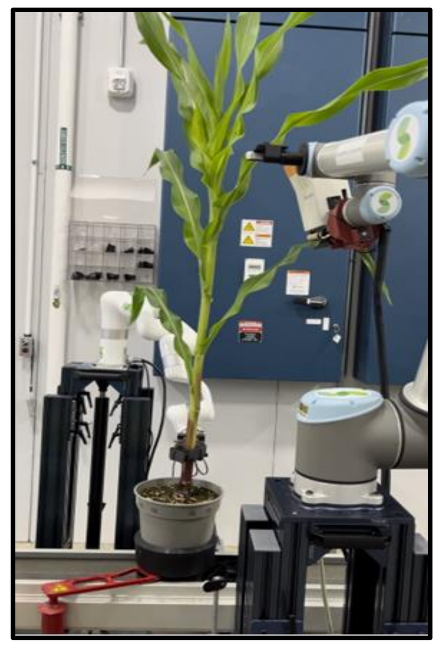
- The end-effector should be able to hold the stem sturdily throughout the leaf scan process
- Size should support multiple species as scope of data collection scales upward
- The design had a budgetary constraint of $200
- Electromechanical, constant-torque system design met all criteria, resulting in its selection
  - InstaGrasp solution chosen due to its cost effectiveness & scalability

Pedestal Concepts


- Final design was based on the master robot's pedestal to align aesthetics & function
- Using the master's pedestal design as the baseline, the options for height adjustment narrowed down, allowing for a Cost vs. Performance comparison
- The hydraulic cylinder was selected due to its cost & the infrequency in which height adjustment was used

Project Impact

The Stem-Holding Robot was showcased at the 2024 North American Plant Phenotyping Network Conference & in a resulting research paper "Robust Phenotyping Robot with Tactile Feedback" (Chen, Ziling. et al.). Local researchers will continue to use this system to support research in plant genetics after demonstrating it causes no damage to plant specimens & does not introduce any bottlenecks to existing facility data collection.




Future Steps

Before sale of the system outside of Purdue University affiliated laboratories, design refinement must continue. Some examples being explored currently include:

- Electric Height Adjustment
- Multifunctional End-Effector
- Optimal End-Effector Placement Algorithm
- Improved Portability of System

After the system is improved, the next goal is to lower the cost of production & begin marketing to other universities with similar phenotyping programs. If successful, partnering with corporations for their research endeavors will allow further revenue opportunities alongside technology maturation.

In Partnership with Purdue ABE Plant Sensor Lab & LeafSpec LLC.

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