

# Ceres

## A Motorized System for Plant Root Research

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# Introduction

- SoyFACE images roots to assess plant health and gather data for gene mapping research.
- There are currently 5,000 stalks of corn, each growing beside an imaging tube.



# Introduction



Can you stick a 10 pound camera 6 feet  
underground and pull it out cm-by-cm  
800,000 times a week?

We can't.

Interns dislike the process.

Objectives

Design

Project Build and Tests

Successes and Challenges

Questions

# Objectives

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# Objectives



1. Autonomous
2. Scalable
3. Low-Cost



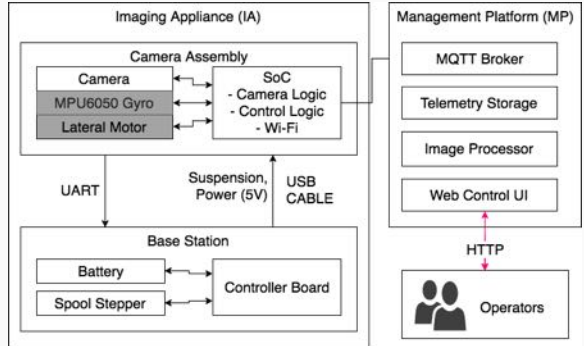
# Design

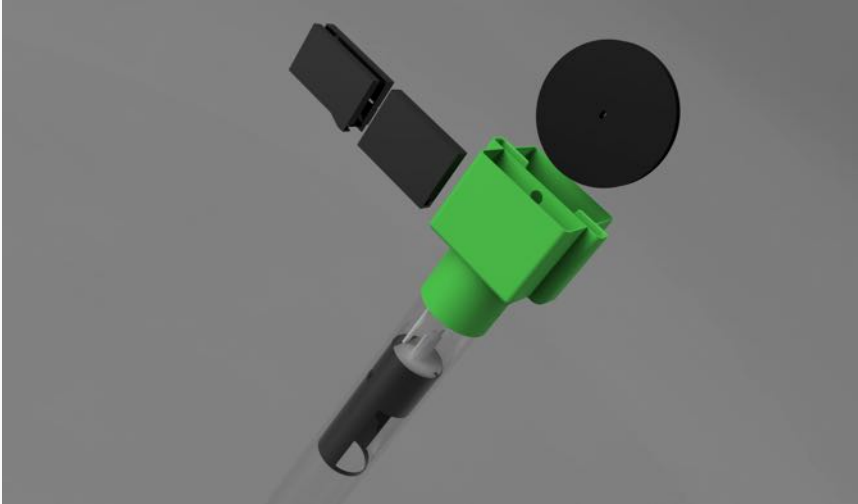
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# High Level Design

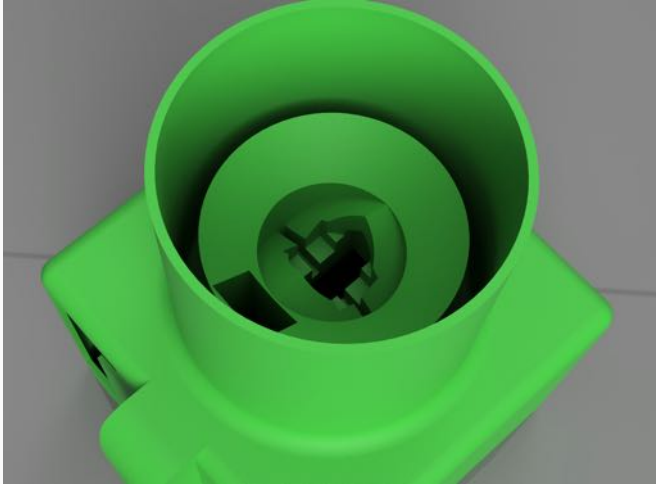
## 3 Major Components

- Management Platform
- Camera Assembly
- Base Station

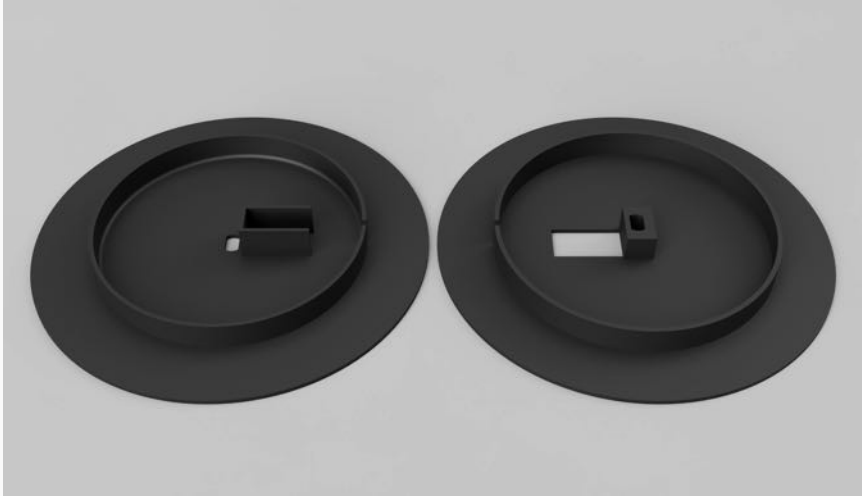




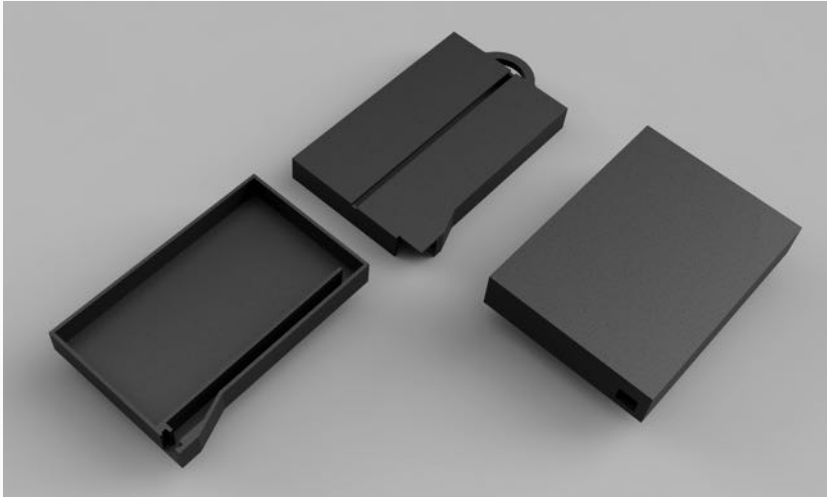
**Figure 1:** Main Components



**Figure 2:** Homing Mechanism



**Figure 3:** Spool Design



**Figure 4:** Removable Battery

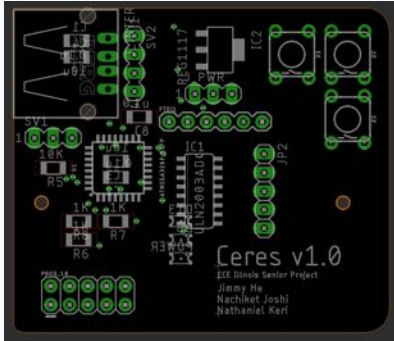


Figure 5: Base Station PCB

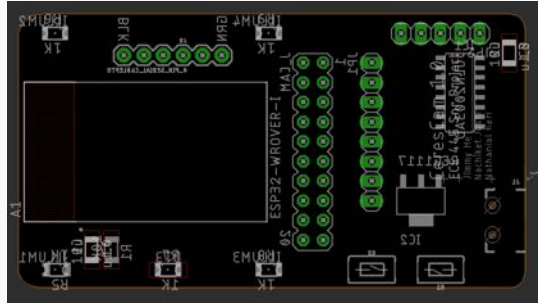
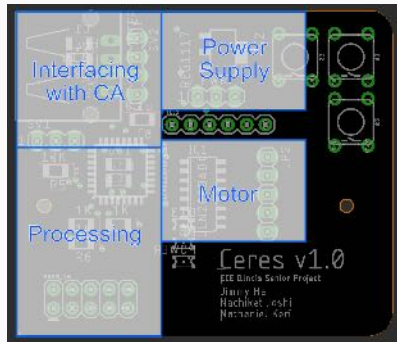
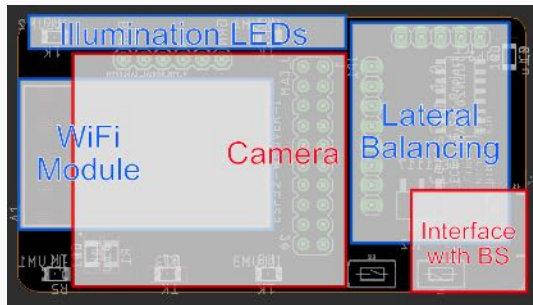


Figure 6: Camera Assembly PCB



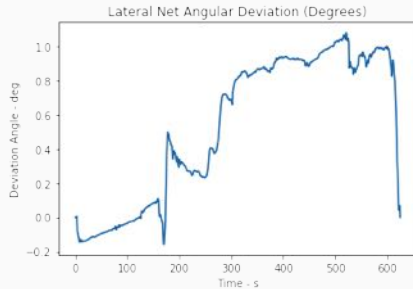
**Figure 7:** Base Station PCB



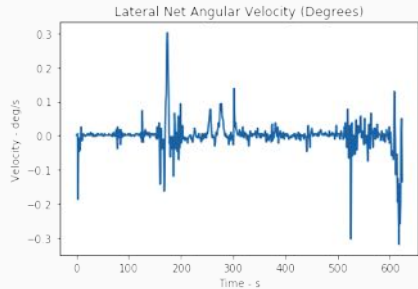
**Figure 8:** Camera Assembly PCB



## Lateral Balancing - Not Included

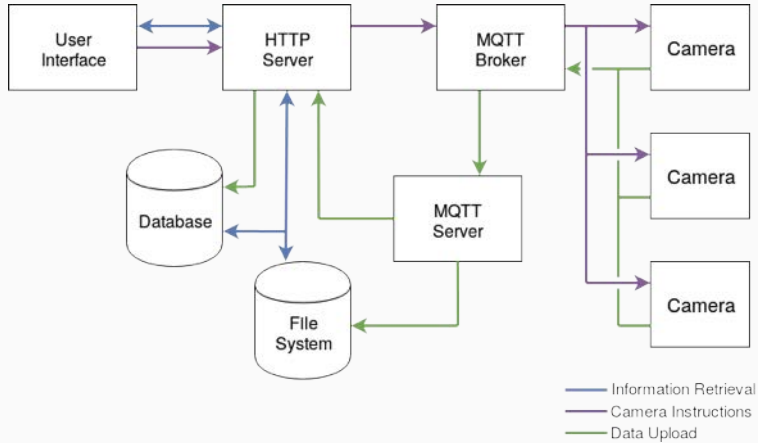


**Figure 9:** Lateral Deviation



**Figure 10:** Lateral Velocity

# Management Platform Dataflow

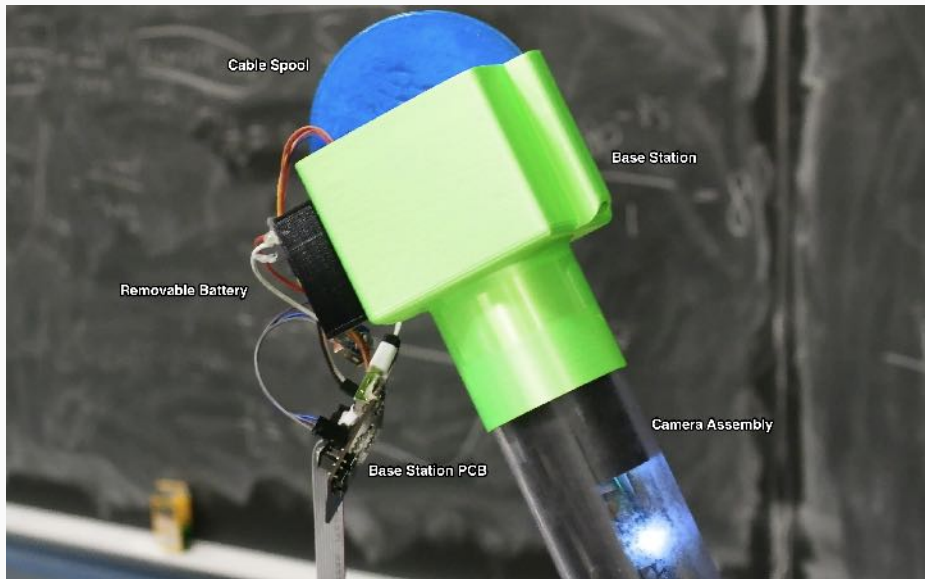


**Figure 11:** Management Platform Dataflow

## Project Build and Tests

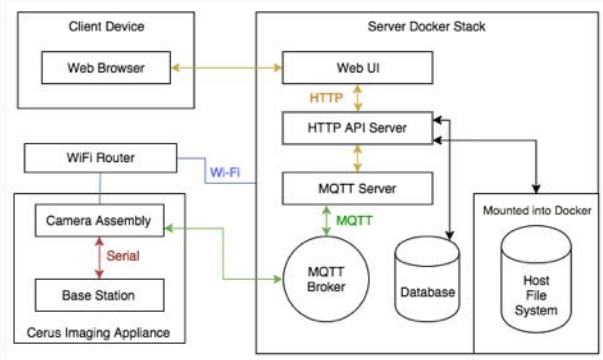
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# Walkthrough



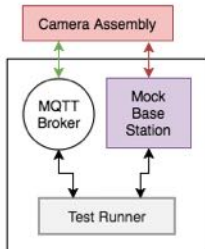
# Final Product

- Management Platform is shipped as a self-contained Docker Stack
- Enclosures of the Imaging Appliance are 3D printed
- Imaging Appliances are manually assembled glued into the enclosure

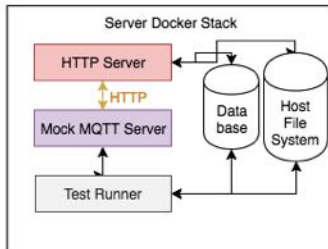


# Unit Tests

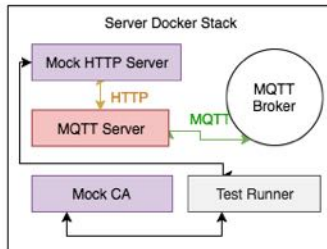
**CA Testing Setup**



**HTTP Server Testing Setup**



**MQTT Server Testing Setup**



- Components tested individually and independently
- Behavior of the remaining system simulated by a Python script
- Tests conducted and verified automatically

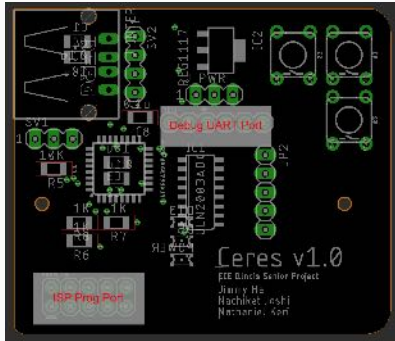


Figure 12: Base Station PCB

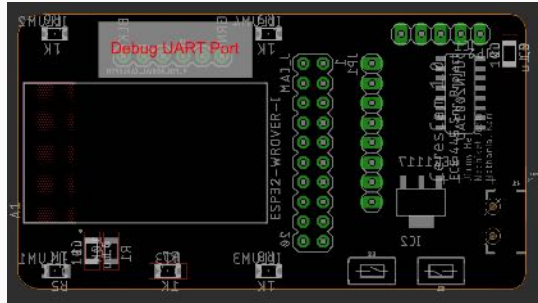


Figure 13: Camera Assembly PCB

## Successes and Challenges

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- Our group was able to effectively work orthogonally with each other.
- We were able to automate everything up until integration.

## Challenges and Solutions

- The end-stop switch would not trigger when we expected it to.
  - We will use an optical switch.
- The stitching algorithm did not work as expected.
  - We will work on image calibration.
- Due to network congestion, the camera assembly took longer than expected to send an image to the management platform.
  - Restructure camera assembly to cache images and sending the cached images after all the images have been taken.
- The camera design was more complex than necessary.
  - Simplify camera design based off our results.

Can you take  
800,000 images a day?

# CERES CAN

Questions?

**Questions?**

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