3D Printing Error Detection System

Team E1
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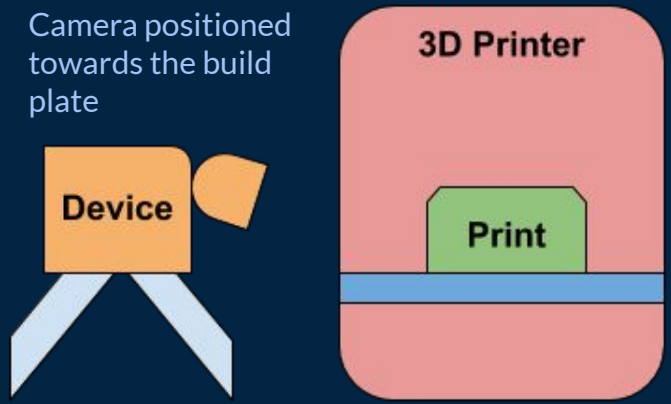
Closing the Loop on 3D Printing

- Status Quo:
  - Printers are open loop devices
  - Standard printers have no built in error detection
  - Current camera systems are “dumb” - simply for human monitoring
- Our device will monitor active 3D prints
- Will detect errors as they occur, and alert users

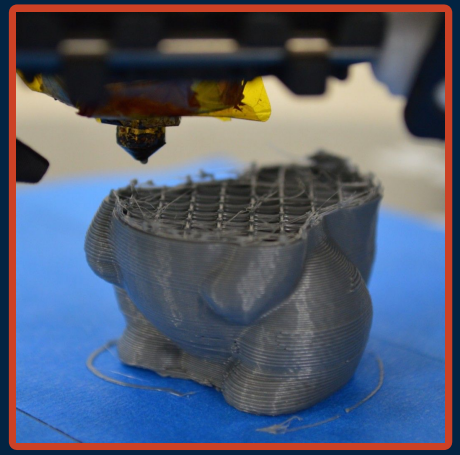
Camera positioned towards the build plate

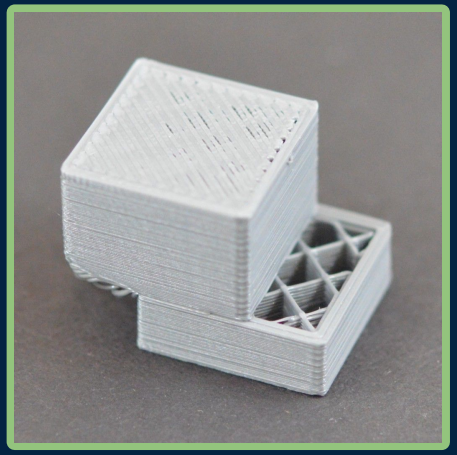


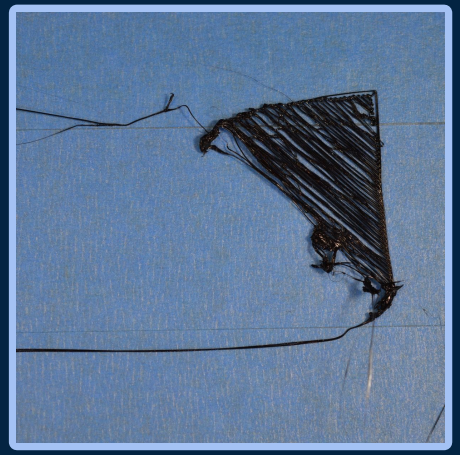
Error Classes

Key Target Error Types:

- Extrusion stops mid-print
- Layer shifting
- Failing to adhere to the print bed
- “Hairball”







Software Component

- 3D render function to translate g-code into 3D model
- Initializing the two to match up in size / dimensions
- Performing edge detection on live images of the active print
- Comparing the edge detection to the 3D render
- If error occurs → notify the user

Software Requirements

Error check upon completion of each layer, or each second	• Implementation specific • Based on known g-code and printer speed, device will know when each layer is complete • If layers finish too fast, device will resort to error checks every second
Accuracy of error detection	• 70-75% detection rate • Will develop custom confidence threshold • Will poll users/makers
Error occurs and error is discovered	• Based off of frequency of checks • Error should be discovered and reported within 5 checks (~0.5 mm)

Software Testing & Verification

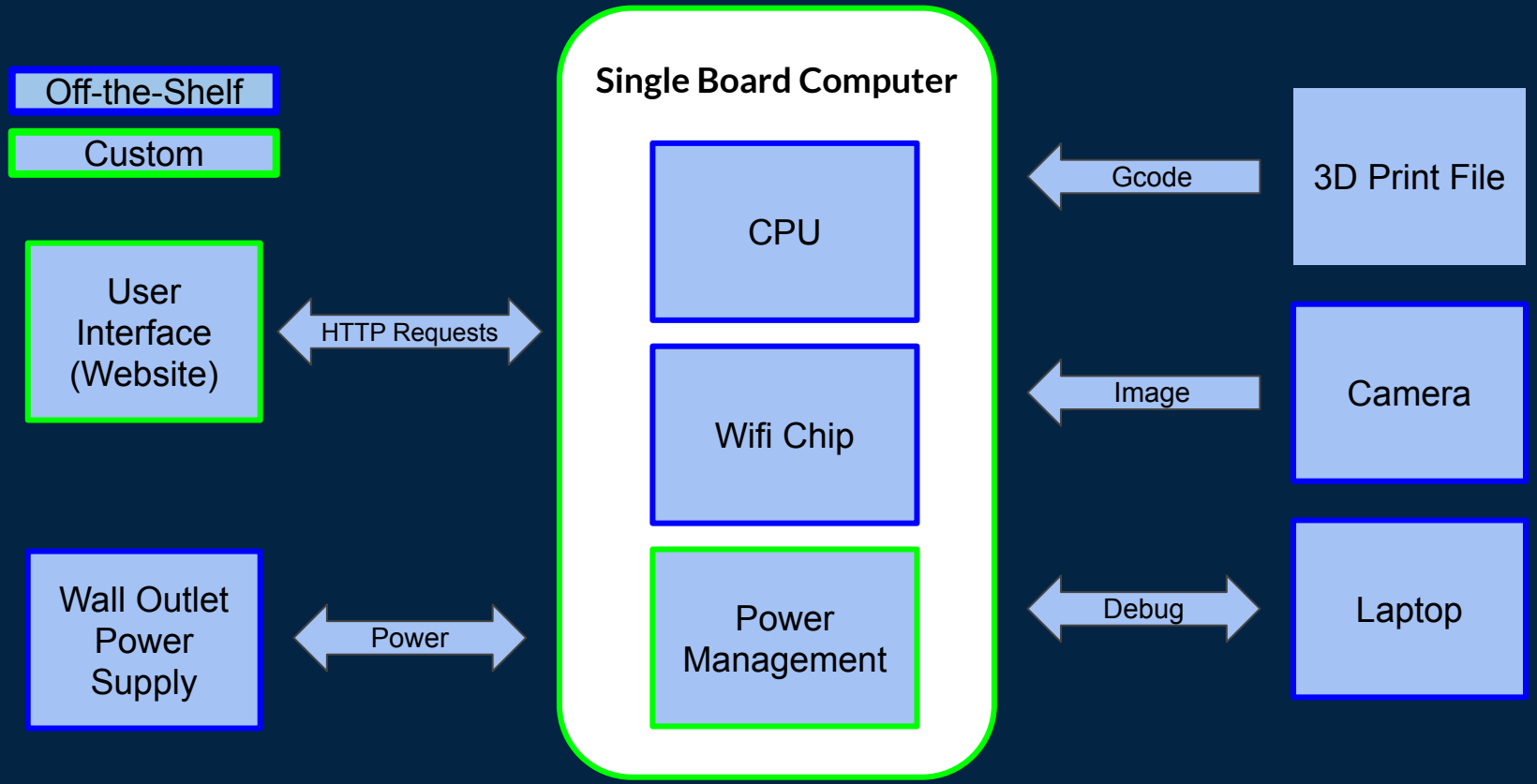
3D Printer System

- Compare g-code based model to original model
- Compare g-code based model to actual prints
- Test edge detection on active prints
- Purposely create faults to test error detection
- After integration with hardware -- repeat last 2 tests

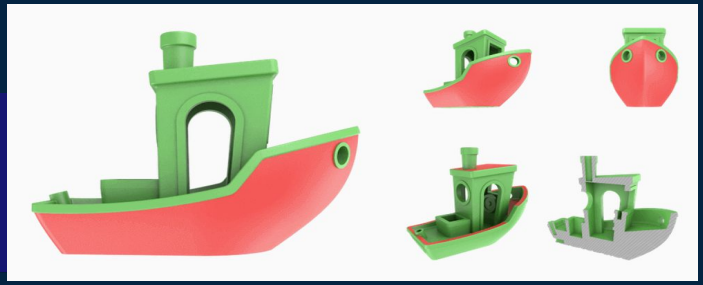
User Experience

- Test user reception of different commands/statuses from the system
- User testing for intuitiveness of setup and use

Hardware Component



Hardware Requirements



Device must be able to run for at least 6 hours un-interrupted	• 6 hours is the average time to complete a test print
SBC area within 6 x 3 inches	• Based on the size of iPhone 11 Pro for ease of use
Device must weigh less than 4 lbs	• Based on the weight of the Macbook Pro 15”
Camera view covers a 8.9L x 6.7W x 6.7H inches build plate	• Based on rough average of dimensions from three target printers: ° Dremel 3D40: 10L x 6W x 6.7H inches ° Ultimaker 3: 7.8L x 8.5W x 7.9H inches ° Makerbot Replicator+: 8.9L x 5.7W x 5.9H inches

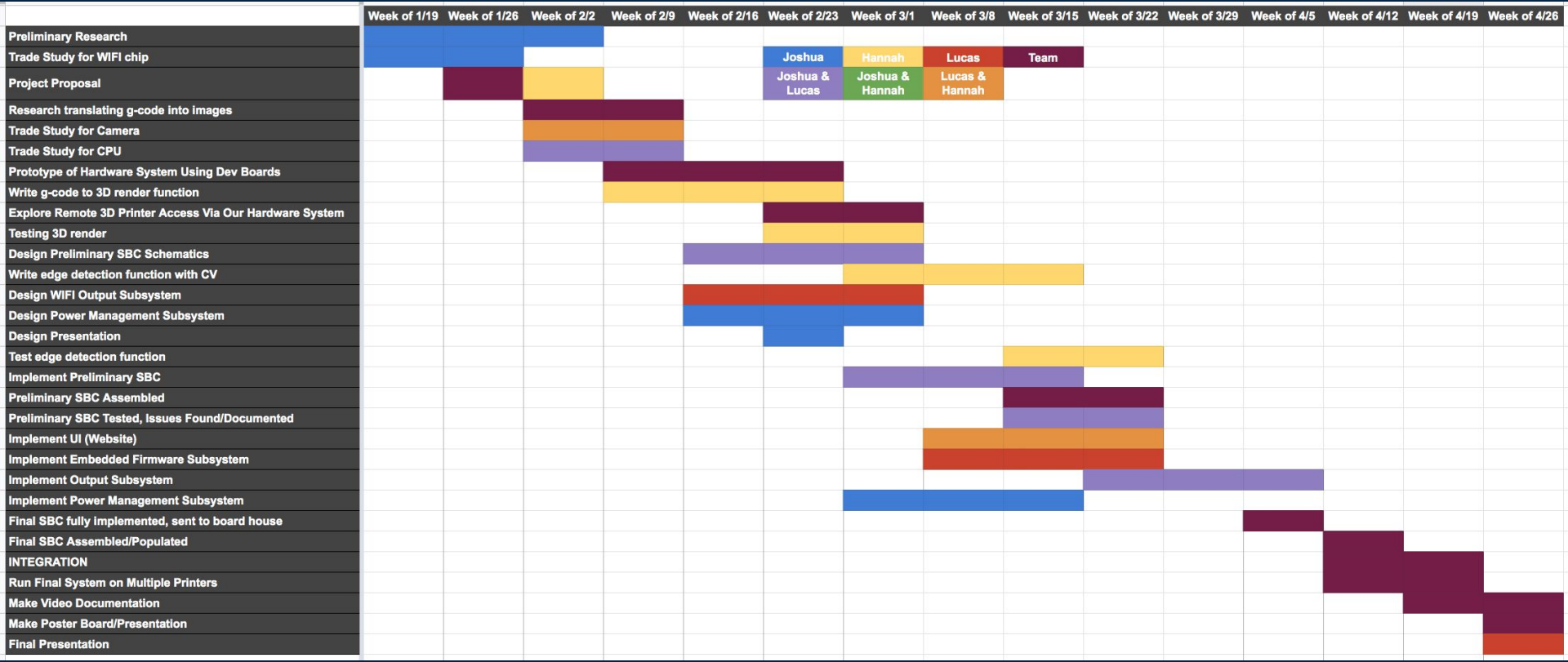
Hardware Testing and Verification

- Test power consumption via meter and current shunts
  - Including power consumed by camera
- Develop watchdog system to monitor power, temperature, and heartbeat on the SBC
- Survey end-users for weight, size, and usability constraints
- Ensure computer vision algorithm successfully runs on SBC
- Develop WIFI communication test plan
  - Send commands back and forth fast enough to stress test system

Division of Labor / Areas of Knowledge

- Hannah: Signals / Software
  - Computer Vision
  - Image Processing
- Joshua: Hardware / Software
  - PCB Design
  - Custom-Designed SBC
  - Embedded Systems & Power Management
- Lucas: Hardware / Software
  - Embedded Systems & Firmware
  - 3D Printing / Rapid Prototyping
  - Custom-Designed SBC

Schedule & Gantt Chart



Some Fun Stretch Goals

- Sense additional error types such as warping, stringing, oozing, and layer separation
- Automatically sense camera orientation and distance via integrated accelerometers and IR range finders
- Sense extruder overheating
- Build out a custom 3D printer that better has our camera-based error detection system baked in