# 3D Printing Error Detection System

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#### **Project Summary - Rescoped**

- Monitor active 3D prints, detecting errors as they occur, and alert users of potential errors
- Errors to Detect:
  - Extrusion stops mid-print
  - Failing to adhere to the print bed
- Target Printer: PrintrBot Simple Wood







#### System Requirements Review



#### **Process Flow**

- From g-code of print, we create 3d models of the print at each different z-layer
- At the end of printing a layer, the camera takes a photo of the current state
- Compare the two images to check for errors



# Solution - Overall System:

- Descoped to a single custom mount for the raspberry pi camera: M1
- Raspberry Pi runs OctoPi (a custom version of the Raspbian OS without a desktop)
- Connects to 3D printer via microUSB
- Connects to OctoPrint web command through WIFI







#### Solution - G-Code Modeling

- Parser combs through g-code for movement commands (G0 and G1) and separates them into x, y, and z coordinate arrays
- Plot rotated model at different layers
- Mask out grid lines from python's plotter







#### Solution - Edge and Error Detection:

- Match corresponding points between image and 3D model
- Project 3D model to image plane
- Find edges on image and projected 3D model
- Compare using Hausdorff distance
  - Using this distance metric because it is suitable for template matching



# A Series of Unfortunate Events:

- Printer broke
  - Design fault on Rev F4
    PrintrBot boards
  - Mosfet input takes 12V without any resistor in between
- Laptop exploded
- Printer broke...again



Your computer restarted because of a problem. Press a key or wait a few seconds to continue starting up.

Votre ordinateur a redémarré en raison d'un problème. Pour poursuivre le redémarrage, appuyez sur une touche ou patientez quelques secondes.

El ordenador se ha reiniciado debido a un problema. Para continuar con el arranque, pulse cualquier tecla o espere unos segundos.

Ihr Computer wurde aufgrund eines Problems neu gestartet. Drücken Sie zum Fortfahren eine Taste oder warten Sie einige Sekunden.

問題が起きたためコンピュータを再起動しました。このまま起動する場合は、 いずれかのキーを押すか、数秒間そのままお待ちください。

电脑因出现问题而重新启动。请按一下按键,或等几秒钟以继续启动。

# Fixing the Printer:

- SOP-23-3 package NPN BJT replaced the mosfet
- Original Mosfet was internally shorted
- Probe not producing enough voltage to flip BJT







## **Design Trade Offs**

- Software:
  - Point Cloud vs. Blob vs. Edge Detection
- Hardware:
  - Stereo cameras vs. single camera
  - TOF vs no TOF
- Design Goal:
  - Generalized vs. Specific target printer



Ultimaker 3 tourse

Ultimaker -



Figure 5. Extracted blob from blue object on printing-bed.



Figure 6. Blue object on printing-bed.





#### Metrics and Validation Plan and Results

- Method: Programmatic Error
  - Load faulty g-code into parser / renderer and get series of images
  - Load correct g-code into parser / renderer and get series of images
  - Compare the two using error detector to see if errors are caught



#### **Project Management**

- Project broken down into key areas
  - G-code
  - Edge detection
  - Error detection
- Implementation and testing was severely impacted by quarantine/remote work situation
- Design was also impacted by technical issues
- Overall team cohesion suffered

• Additional time was eaten by unexpected hardware debugging

Lucas Joshua Hannah Led LeH JeH Team	Week of 1/19	Week of 1/26	Week of 2/2	Week of 2/9	Week of 2018	Week of 2/23	Week of 3/1	Week of 3/8	Week of 3/15	Week of 3/22	Week of 3/29	Week of 4/5	Week of 4/12	Week of 4/19	Week of \$25
Course Logistics												-			
Proposal Presentation			Distriction.			1000									
Design Presentation						Joshua			-						
Write Design Paper						learn			a construction of the						
Statement of Work (Rescope)									Joshus						
Make Video Documentation															Team
Final Presentation														-	Lucas
Final Demo				-						1				-	_
Tasks Accomplished															
WIFI Module Trade Study	Joshus								2						
Implemented camera location optimizer				Joshua		-									
Research camera views				Joshua											
Besigned Power Regulation Subayatem				Joshua											
Trade Otudy on TOF Rangefinder Lasers				J+L	-										
60 Card Reader Trade Study					Joshus										
Getup Ultimaker3: researched/accessed camera						Joshua									
Microprocessor Trade Study						Joshua									
Confirmed Camera/Lenses Trade Study with Equations						Joshua									
Re-Do Trade Study on TOF Rangefinder Lasers															
Implement Print Point Glood (PPO)								Joshus							
OctoPrint Plugin Development								Joshus							
Write edge detection function with HSV mask									-	Joshua					
Implement Print Error Func (using Hausdorff)											Joshua		(optimized)	-	
Implementing 3D-2D Pose Estimation/Projection														Joshus	
Research translating g-code into images															
Trade Study for Camera															
Trade Study for Camera Lenses						1									
Design g-code visualizer (block diagram, documentation)															
Design edge detection (block diagram, documentation, etc.)				J+H		e 11									
Write g-code parser function				-							LHH			11	
Write g-code visualizer (full 3D model)															
Write g-code visualizer (sliced 3D model to projected 2D image)											-				
Create falty g-code renders															
Set Up OctoPrint with PrintrBot						Lucas									
Research OctoPrint Plugin Development						Lucas	2							20.2	
Set Up OctoPrint Plugin Development Environment						Lucas									
Design pi-cam mount											Luces			2	
Explore Device Positioning on 3D Printers				Team							Luces				
Explore Remote 3D Printer Access				Team							Contraction of the			Lucas	
Debug 3D Printer Problems						4			1			Luces		Lucas	
Explore TouchUl Plugin Native Interface													Luces		