Automatic Brain Segmentation for 3D Printing - Phase 4

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Group B1

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Our Team

Mechanical Engineers

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Problem Statement

- Create a personalized brain model from an MRI scan
- Make the process from MRI scan to brain model nearly fully automatic
  - Only a single input needed from the customer
- Print 3D model to help doctor/surgeons have an accurate visual aid when explaining the patient's brain ailments or upcoming surgeries
- Create 3D models to serve as gifts/souvenirs for patients receiving brain-related treatment

Goals and Objectives

- Goals have shifted from focusing on making a model with two materials in order to allow for a better visual of the inner parts of the brain
- Now one material is going to be used and the focus is on optimizing the software that will be created to make the process fully automatic
- Time permitting, further development on the output of the process will be done

Phase 3 Feedback

Phase 3 Panel Feedback	Solutions/Responses
Why do the brains need to be personalized?	Long term goal is to be able to print with two materials to help display abnormalities of different peoples brains
How are you guys going to deal with the long delay of printing out the brain? Can you make it hollow?	Brain models are very complicated and do take time given that accuracy is an important feature. Hollow models would aid in this sense but upon attempt there were structural issues when doing this.
Is the additional quality check after Meshlab necessary?	While it may not be essential to the process it is an extra precautionary step the group wants to limit the issues
How are you going to automate the process?	Will be discussed below for Beta Prototype

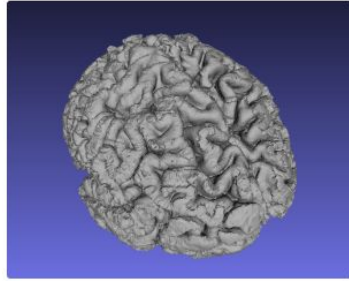# Alpha Prototype Design

Pipeline Design
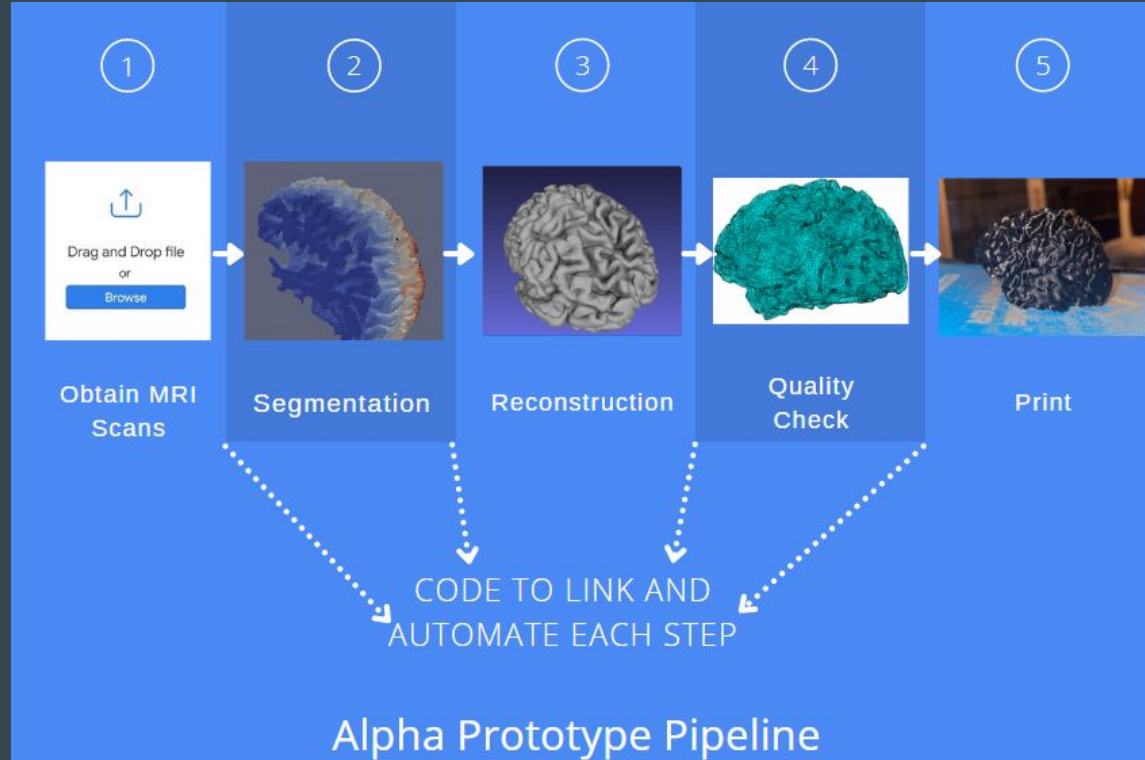
Alpha Prototype Testing: Overview

- Testing of smoothing in MeshLab
  - What parameters of smoothening are most desirable
- Testing of materials
  - Prints done in past were made from PLA, can the model be enhanced from resin
- Testing the size of the print
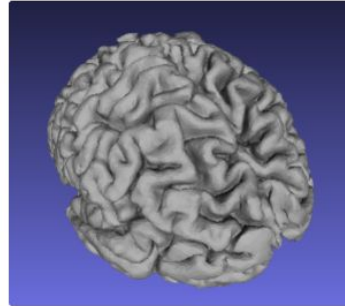 - Prints were done in a 1:4 and 1:2 ratio

Alpha Prototype Testing: Model Quality Control

- Numerous models were placed into MeshLab to improve the model quality
- Commands used in Meshlab:
  - Flatten Visible Layers
  - HC Laplacian Smooth
  - Quadric Edge Collapse Decimation

FreeSurfer output without corrections in Meshlab

After corrections in Meshlab

Alpha Prototype Testing: Material Comparison

- PLA
  - Printer: Flashforge Finder
  - Pros
    - Cost: $20/print
    - Easy to load into printer
    - Durable
  - Cons
    - Visible layering
    - Support material needed
   - Rigid exterior

- Resin
  - Printer: Phrozen Sonic Mini 4k
  - Pros
    - Smooth
    - Very good with small details
    - Water washable
  - Cons
    - Cost: $30/print
    - Less Durable than PLA
   - Printer must be refilled mid-print

Alpha Prototype Testing: Print Quality Comparison

- The Resin model is much better overall
- The model looks smooth and cohesive
- PLA model did not meet our standards
- Parts of the PLA model didn't print correctly
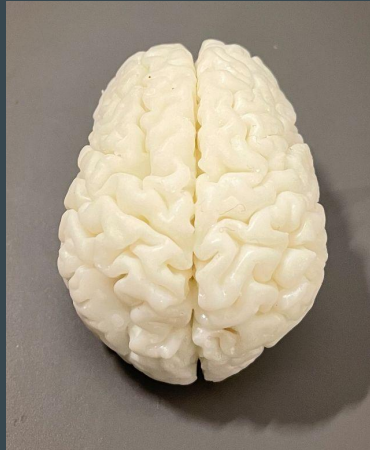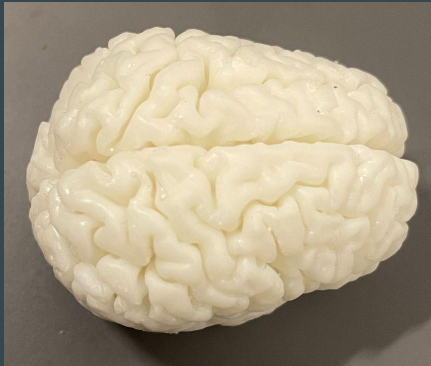
Alpha Prototype Testing: Sizing Comparison

- The two models seen below are resin prints from the Phrozen Sonic Mini 4k
- The smaller model is 1:4 volume ratio of the full sized brain (25%)
- The larger model is 1:2 volume ratio of the full sized brain(50%)
- These pictures below show that both our 3D printer, and material can produce high quality prints of various sizes
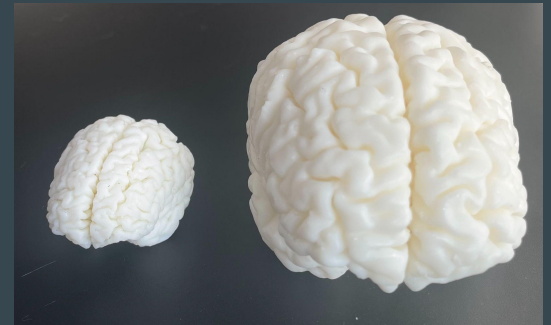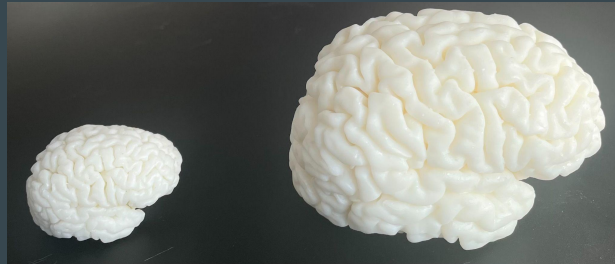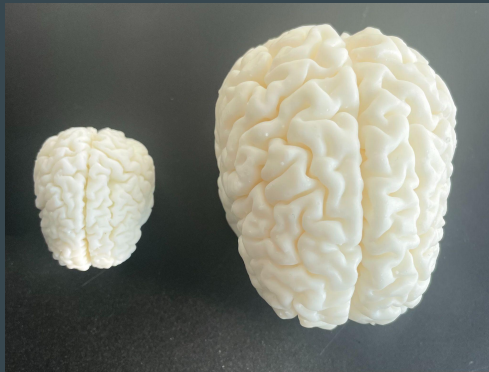
Alpha Prototype Design - Future plans

- Add quality control by writing code that checks model surface for holes
- Print using clear resin material and compare with our other models
- Explore ways to get the cost of resin down
  - Buying in bulk
  - Modifying the infill percentage
- Print a 1:1 full size brain model

Beta Prototype Design

Overview

- Implement raw quality check code
- More accuracy with second surface
- Two interfaces: customer and employee
  - User friendly
  - Automate the pipeline processes
  - Turn code into a tangible product and open up ability to monetize the project

Beta Prototype Plan

Customer Interface

- Primarily to upload MRI scans they want to models of
- Integrated into project website
  - Convenient and informative
- First page will have an introduction and button to get started
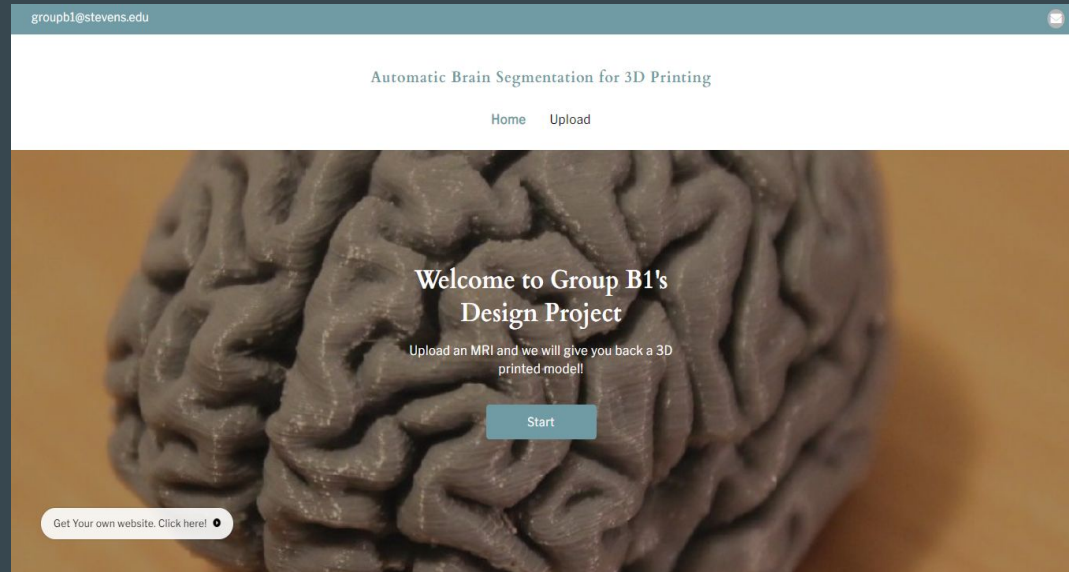
Beta Prototype Plan

Customer Interface

- Second page allows user to upload MRI
- Last page for thanks, displaying progress, and notifying about updates
- Aims to be quick, easy to navigate, and aesthetically pleasing
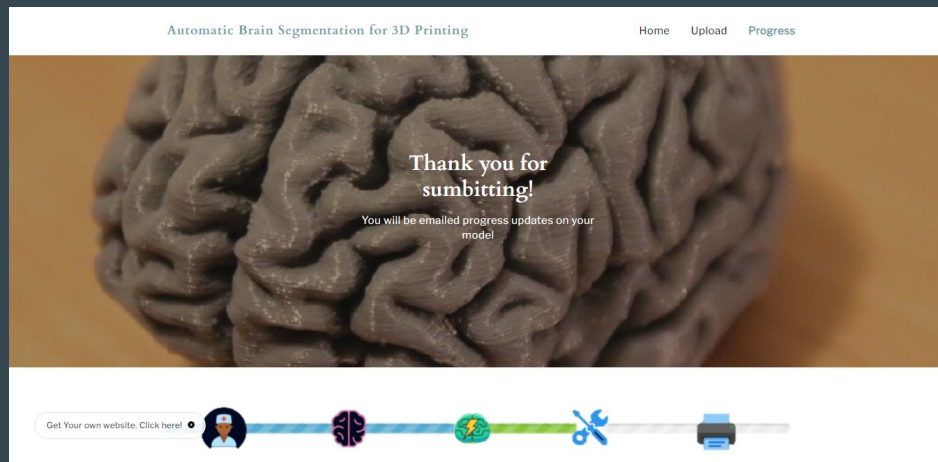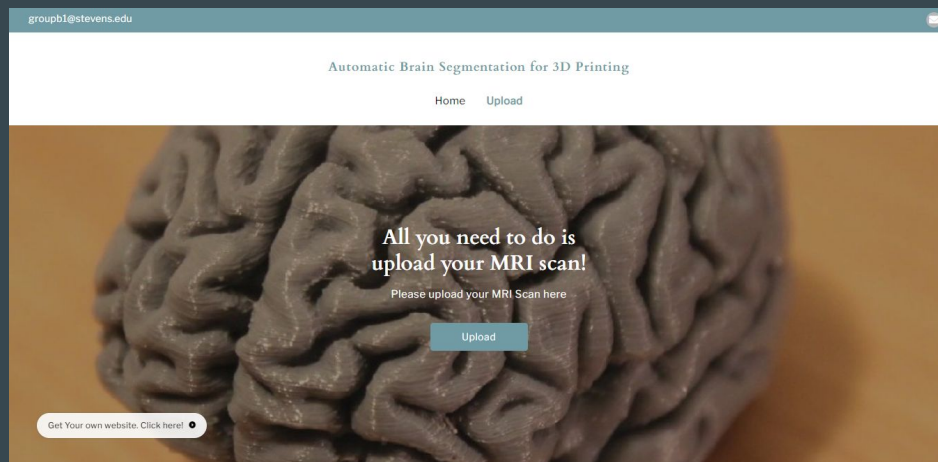
Beta Prototype Plan

Employee Interface

- Much more code/function intensive
- Import button that send MRI scan through each stage of the pipeline
- Progress and time remaining for each step
- References for software used in pipeline
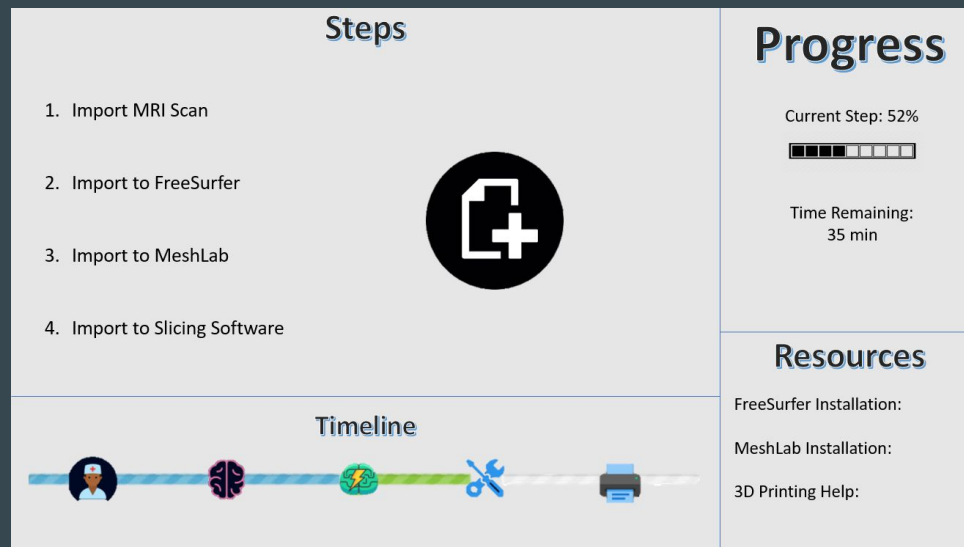
- Straightforward and as easy to navigate as possible

Beta Prototype Plan

Server Setup

- Most important part of beta prototype
- Means of collecting, storing, and using submitted MRIs
- Code/Software will all be done here
- Looking into numerous server options, but leaning towards AWS

Beta Prototype Summary

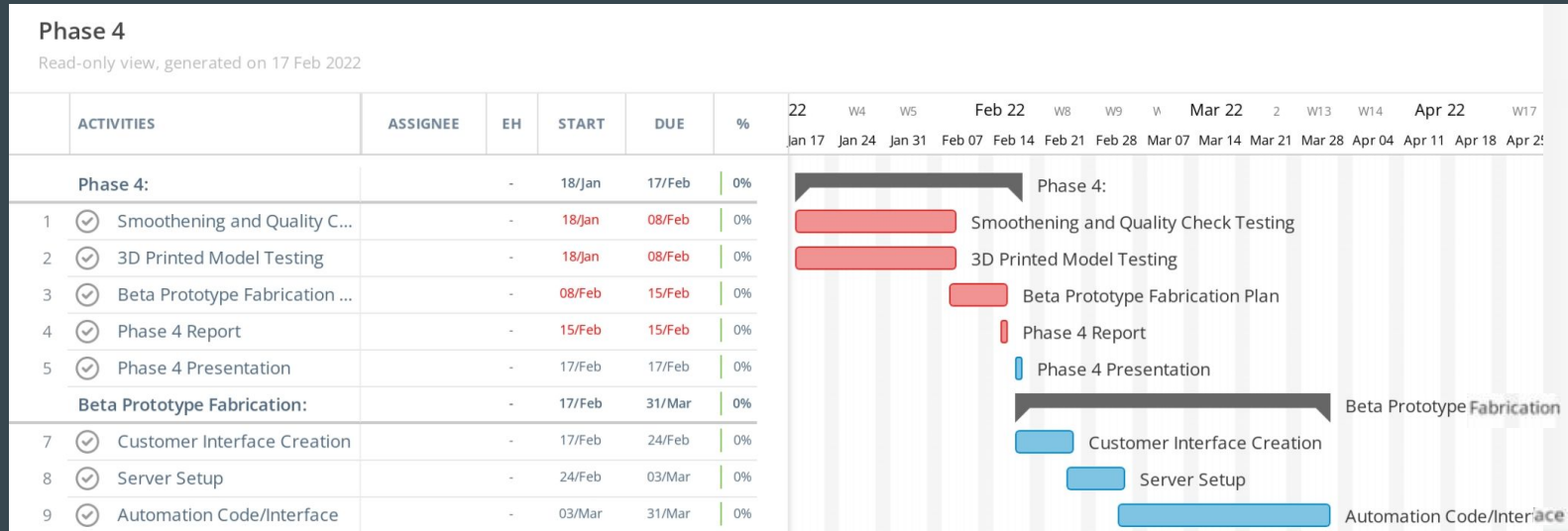| Acquire Customer MRI | → | Arrival of MRI to Server | → | Run MRI Through Softwares on Server | → | Send Finished Model to Printer | → | Print |

- Website

- Code to send file from website to server

- Helper functions

- Code to send finished file to print

Beta Prototype Plan

Timeline

Phase 4
Read-only view, generated on 17 Feb 2022

	ACTIVITIES	ASSIGNEE	EH	START	DUE	%
	Phase 4:		-	18/Jan	17/Feb	0%
1	Smoothening and Quality C...		-	18/Jan	08/Feb	0%
2	3D Printed Model Testing		-	18/Jan	08/Feb	0%
3	Beta Prototype Fabrication ...		-	08/Feb	15/Feb	0%
4	Phase 4 Report		-	15/Feb	15/Feb	0%
5	Phase 4 Presentation		-	17/Feb	17/Feb	0%
	Beta Prototype Fabrication:		-	17/Feb	31/Mar	0%
7	Customer Interface Creation		-	17/Feb	24/Feb	0%
8	Server Setup		-	24/Feb	03/Mar	0%
9	Automation Code/Interface		-	03/Mar	31/Mar	0%

Bill of Materials

BOM Item Number	Description	Vendor	Cost (each)	Quantity	Purchased	Received
1	Black PLA Filament (1 kg)	Micro Center	$15	2	Yes	Yes
2	Natural PLA Filament (1kg)	Micro Center	$19	2	Yes	Yes
3	UV-Curing Resin	Any Cubic	$30	1	Yes	No
4	AWS Storage	AWS	$0.50-$3	1	No	No

Thank You!