Harvard University Extension School
Master of Liberal Arts in Digital Media Design
Capstone Report
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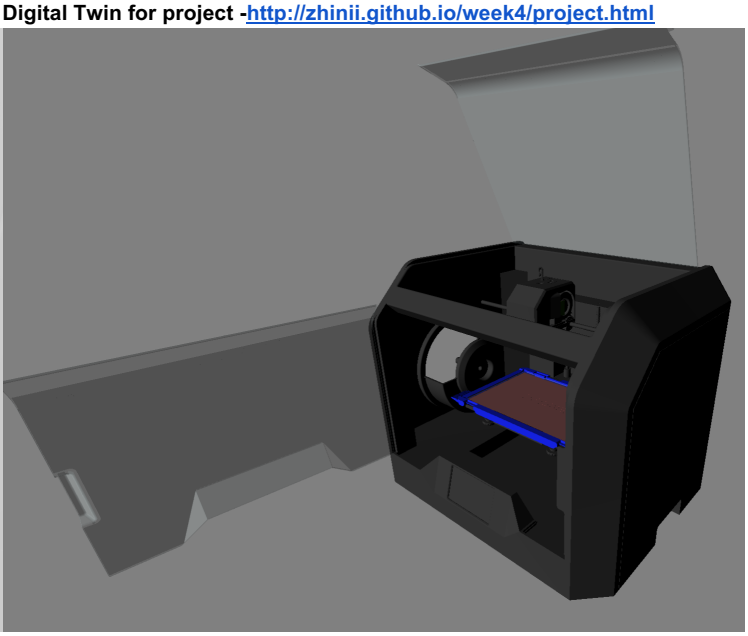
Part 1 - Project Overview

This project is titled ‘digital twins’. The intent of this project was to create a digital replica of a physical object. The object chosen for this project is a 3d printer, Dremel 3d45. Using this digital replica, instructions on how to repair the 3dprinter would be developed with the intent to create a clear an engaging set of instructions. The presentation of this replica would be accomplished by taking 3d models of the equipment and rendering them in a web browser. This model would be in an interactive scene that users could control. The instructions are provided in a sequential step by step method where users can choose the task and which step they’d like to view.

Dremel 3d45 - https://digilab.dremel.com/products/3d45

Digital Twin for project -http://zhinii.github.io/week4/project.html



Audience & Goals

This project was primarily built for the lab staff at the Graduate School of Design. The GSD has 120 of these 3d printers in their facilities. The heavy use of the equipment requires regular maintenance. The project goal was to take my understanding and expertise of the physical hardware, capture it and present it in a format that is easily accessible to the graduate students who help maintain this equipment.
Currently Dremel provides 2d text documents[1] for these repair processes. This project has taken and repurposed these documents and integrated them with the 3d model. The hope is that presenting the machine in a 3d environment will add clarity to the repair processes, which will enable users to more easily perform necessary maintenance on the equipment.

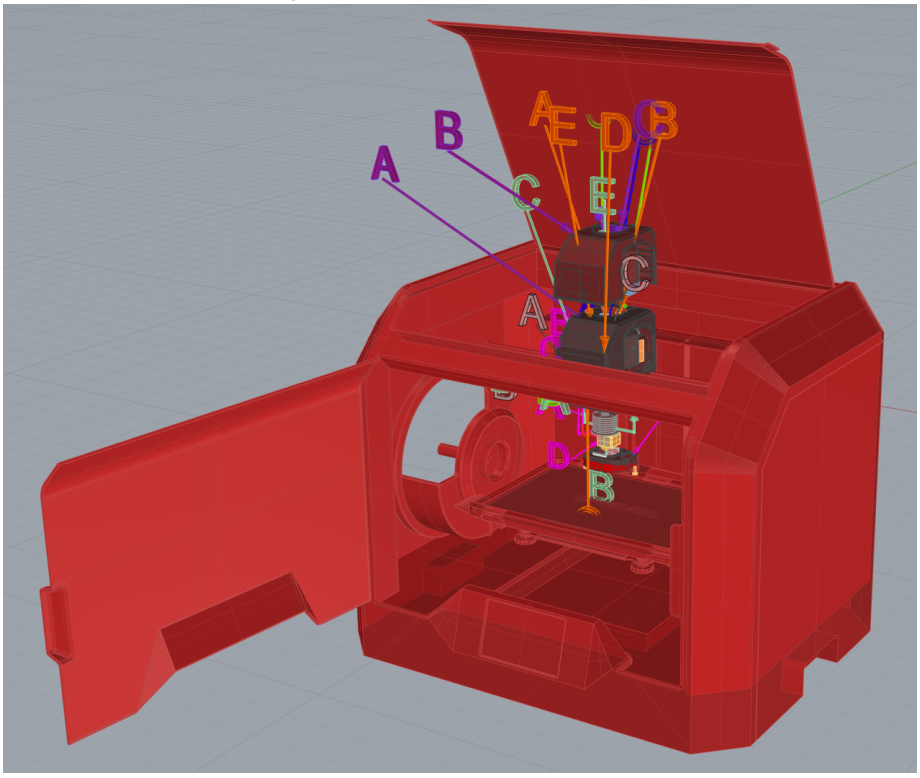
[1]Dremel instructions on printhead replacement.
https://shop.dremel.com/content/3Dserviceparts/3D45%20Nozzle%20Assembly%20Replacement%20How-To%20Guide.pdf

Part 2 - Technology & Process

This project required the use of several technologies, they are as follows:

The 3d representation was prepared in Rhino, a 3d modeling program. Bosch Tools, the company that designed and manufactured the 3d printer provided the digital files of the printhead assembly of the printer. The rest of the machine was modeled based off of the physical printers that exist at the GSD. These files were combined in Rhino. Materials properties and colors where applied to the different components in Rhino, i.e. plastic covers matched, screws having a different finish etc. Arrows and labels were modeled to identify specific components. These also had a specific color applied to them so they could easily be identified in the 3d model by the viewer. These arrows and labels were ordered to match with the text instructions in each step, being labeled A, B, C etc.

Screen capture of 3d model in rhino with annotations



Once the model was complete it was exported as an obj file with an associate mtl file. These were then converted to glb files[2]. The reason for the conversion is that glb compress the 3d files into the smallest file type for web rendering[3]this is desirable in a web environment where users will be accessing and viewing these in a web browser. The
By using a smaller file type, pages will load quickly. Viewing the model in a browser was chosen, because accessibility is highly desirable. This enables anyone with an internet

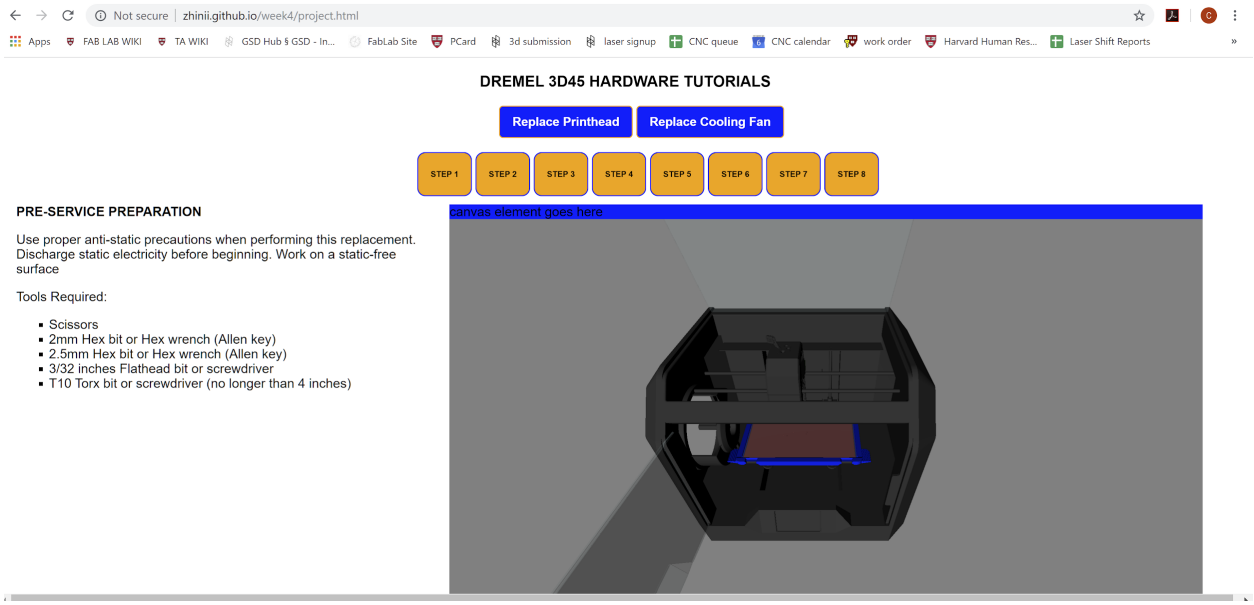
[2] Obj to glb conversion tool - https://github.com/AnalyticalGraphicsInc/obj2gltf
[3] Explanation of glb file format - https://wiki.fileformat.com/3d/glb/

connected device (laptop, tablet, phone) access to this project. This enables the largest number of users.

The library three.js[4] was used to render the glb files in the web browser. This library included functions for scene navigation via a mouse as well as an API to generate lighting for the scene. This library leverages html5 canvas element to achieve these functions.

The instructions that Bosch Tools produces were converted formatted using html and css and presented via a show/hide function from a list of steps. This allows the user to navigate at their discretion.

Screenshot of web interface - steps and instruction panel on left, 3d model on right



[4] Threejs website - https://threejs.org/

Part 3 - Results & Conclusion

The primary goals of the project where accomplished. A digital duplicate was created, rendered in a browser, users can interact with it and the 3d model reveals information about the object.

The questions which are harder to quantify are:

- Is this an effective delivery method of instruction?
- Is the interaction intuitive and clear for users?
- Does there need to be additional annotations beyond the 3d model and text?

I believe more research and development into human/computer interaction would be useful. Understanding how users intuitively perceive a 3d environment, especially for those who don't have experience navigating or interacting in this type of environment. I didn't address animations or including animations in this project, but it seems like a logical accompaniment. Tween.js[5] seems like a js library that could work well with three.js in accomplishing this.

I believe this project is a necessary precursor to developing full AR/VR environments. It contains the basic ingredients that exist in those types of environments (3d models, interactive 3d scene, navigation of the scene). Presenting in this format enables users to access this sort of presentation without the expensive equipment that is necessary for AR/VR. By building and training users in this environment now, the transition to AR/VR will be much easier when the cost of the equipment necessary to engage those environments is lowered enabling larger populations of users to utilize that technology.

I intend to continue my exploration in this method of representation. I believe this is the most effective way, aside from in person instruction, to represent and train/teach hardware and the potential for distance/remote courses that require a hardware component (robotics, arduino etc) seems clear. Further investigations will involve incorporating animations.

The biggest hurdle for a large scale deployment is that everything has to be programmed. Creating a simple web interface where users could drag and drop 3d models into the browser and add annotations to the 3d models would enable a larger scale adoption of this method of representation.

[5] https://createjs.com/tweenjs

Project Repository

This GitHub repository contains work done for this project. Work is documented in a weekly fashion with a new folder for each week. Included in the repository is the status update/reports.

https://github.com/zhinii/capstone