Plumbus creation through the use of 3D scanning, FDM printing and laser-cutting

BSc-5

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1 Introduction

The goal of the project was to create a 3D printed plumbus – a fictional household item from the Rick and Morty universe – by 3D scanning at least 5 common, physical objects. The scanned files needed to be fabricated using a Fused Deposition Modeling (FDM) printer along with a base for the object by the method of laser-cutting.

A plumbus has 5 distinct parts for which 5 real world items have been selected:

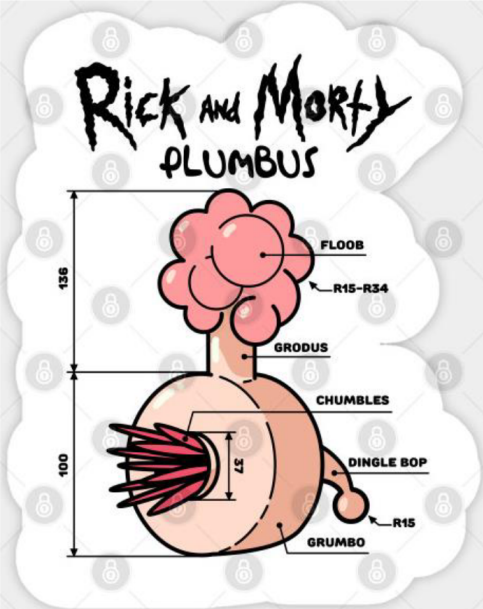


Figure 1: Labeled image of a plumbus with rough dimensions.

- Floob → microfiber cloth ball
- Grodus → toilet paper roll core
- Chumbles → brush bristles
- Dingle bop → microfiber cloth cone
- Grumbo → toilet paper roll

Objects were chosen from common cleaning supplies to reflect some of the uses of the plumbus.

2 Scanning

The first step in creating the plumbus was to acquire the geometries of the selected objects.

First, the objects had to be prepared to fit the exact needs of the project. For some, such as the paper tube, it meant creating additional, more detail-rich texture while for others it meant modifying their shape and adding a mounting option to allow scanning on all sides. Most of these modifications were made with the use of rubber bands.

The first method of 3D scanning was to attempt photogrammetry with mobile devices. The main issue encountered was the impossibly long upload a processing times of the apps[1]

[1]Apps attempted were Polycam, Modelar and CamToPlan.

that we tried. Blaming the server-based processing, the use of *Meshroom* was attempted for stitching individual images into a 3D scene, but it also abandoned due to its extreme hardware and storage requirements.

Finally, a decision has been made to use specialized scanning hardware. The scanner used was the *EINSTAR VEGA hand scanner*, provided by our professor. With its display and on-device processing, it proved to be fairly user-friendly, but several issues also presented themselves.

Figure 2: The UI of the EINSTAR VEGA gave valuable information such as the optimal distance to the scanned object as well as areas that still need more definition.

Issue	Solution
Scans would not initiate / not recognize an object's presence.	Starting scans from the pedestal used (chair) and only after initialization moving up to the desired object.
When scanning the hanging ball, the chair leg obstructed the view to the object.	Switching to a detailed scan reduced the working distance.
Some objects, mainly those of paper, lost tracking easily.	Adding dots on the exteriors seemed to facilitate tracking by adding distinct features for texture based tracking.

Table 1: List of issues faced with the actions taken to tackle the problem.

2.1 Scan cleanup

The 3D scanner provided the models in STL format. Although the slicer program used, which would turn the model into machine instructions for the 3D printer, would accept the format, the scans also included features of the objects' surroundings. To remove those and to place the individual parts in their final positions in respect to the whole, each scanned object was imported into Blender. Blender is a free and open-source 3D computer graphics software tool with a few clear advantages over traditional computer aided design (CAD) software which served the project's needs well:

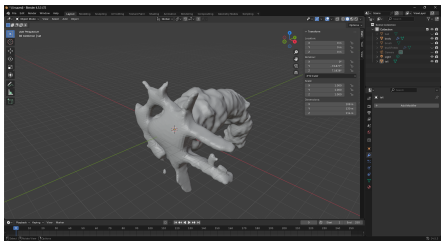
- It features an advanced polygonal modeling system, allowing for easy vertex manipulation. The meshes generated by the scanner also consist of polygons.

- The sculpting tool in Blender allows for more refined adjustment of organic features.
- Although simplistic, there exists a dimensioning system that allows the model to be made with a specific scale in mind. The scaling also transfers to the slicer program.

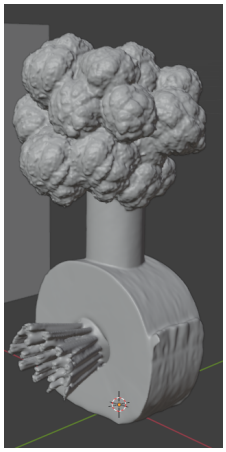
The cleanup and assembly process consisted of the following steps:

1. Remove all unwanted artifacts on each sub-part (i.e. other objects or areas where the scanner lost accuracy).
2. Scale, orient and position the sub-parts.
3. Assemble the plumbus from the sub-parts and join them into a single object.
4. Remesh[2] the object to obtain a more even vertex- and detail density.
5. Scale the object to appropriate scale.
6. Verify all design requirements were met.
7. Export the object as an STL file, ready for printing.

(a) Unprocessed mesh of the paper roll as seen in the web viewer. The object contains artifacts such as the support (under the roll) and scanning inaccuracies (top of the roll).



(b) Imported object (dinglebop), in Blender.



(c) Assembled parts, in Blender.

Figure 3: Steps of the scan cleanup process.

[2]Voxel remeshing is the process of creating new edges and vertices where the model surface intersects an edge of the voxel grid of a specific scale

3 3D Printing

The second major milestone in the project timeline is the creation of a physical object through 3D printing. To achieve this, the STL file was imported into BambuStudio, the proprietary slicer made specifically for the hardware to be used. The final orientation print setting were determined in the software.

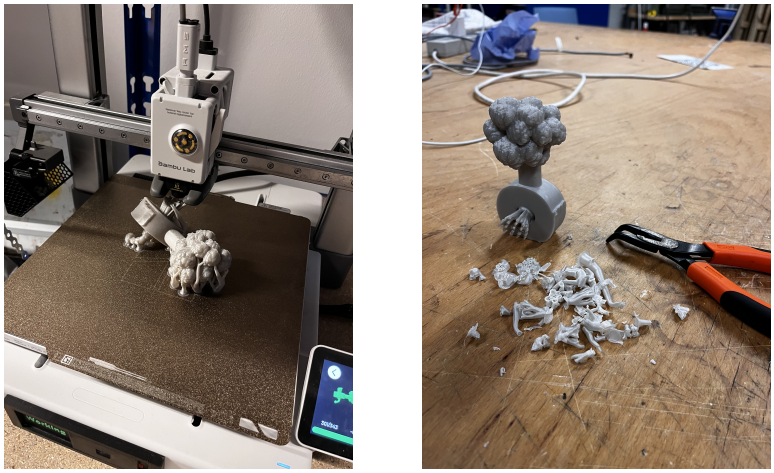


Figure 4: Printing and support removal.

Due to the complex shape of the plumbus, the amount and placement of supports was the guiding principle when placing the object on the build plate. Supports are required when a section of the object cannot be supported by the object itself. The most critical feature in the decision making was the chumbles, as removing supports between the different pillars would have been difficult. According to the previously mentioned considerations, through trial and error, the most favorable orientation was found in which the least amount of support material (waste) was used and the chumbles could be printed without the need of support between each pillar.

4 Laser cutting

The final structural requirement of the project was to create a laser cut base for the plumbus to be displayed in. Additionally, a press-fit tolerance was required between the base and the plumbus.

After several design iterations, the final design features a collar, which mates with the grodus, and four supporting legs. After