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Lorena Mitchell for
Jerry Waite, Ed.D., University of Houston

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Stop Motion Animation and 3D Printing: Does it Improve the Process?

Lorena Mitchell • For Professor Jerry Waite, Ed.D. • University of Houston

Abstract

This paper will examine one particular animation style, Stop Motion Animation, by describing the process by which it is done and how the process can be made more efficient. There will also be a brief discussion on why the need for efficiency is important, as compared to 2D and 3D animation. The purpose of this study is to determine whether 3D printing can improve the overall character creation process in Stop Motion Animation for independent creators and become viable for educational use.

Introduction

Animation, whether it be 2D, 3D, or stop-motion, can be done through a variety of processes adapted to fit each style. Popular animation techniques for 2D and 3D animation include the use of hand drawings, digital drawings, digital modeling software, and even motion capture software.

Stop-motion animation requires a more arduous process for creating completed projects, because sets and characters must be built physically rather than through software, but some companies are turning to 3D printing to speed up the process. Most arguments for which technology is best depends on the style of animation being produced, the budget of whomever is producing the project, and the content creator's personal aesthetic preferences. Laika, an Oregon based stop-motion animation company, utilizes 3D print technology to optimize their workflow of the character creation process for their feature-length films.

What is the issue?

While a major studio could afford to integrate the use of a 3D printer into their character creation process, it is unclear whether the same technique is feasible on an individual basis or even in a classroom setting. Potentially, makers could save money on the purchase of materials and redirect time spent sculpting character pieces to other parts of the filmmaking process. The use of a 3D printer could allow for more consistency and could potentially help makers produce more professional looking animations.

There are 15 programs nationwide that teach students about stop-motion animation utilizing traditional techniques. The problem with these programs is that that they are so specialized that they limit their appeal to the potential candidate pool of students interested in this animation style to a select subgroup of individuals. Certain educational programs, mainly engineering and medical, are already taking advantage of 3D printing as a teaching tool. Educators should be looking for ways to broaden the interest of their programs to potential students, and the introduction of the use of 3D printing for animation could certainly spark more interest.

Terminology

There are a few terms that will be repeated throughout this essay. These terms are clearly defined below.

- **Armatures** for stop-motion animation are defined as "a skeleton type frame used to give support or rigidity to clay or other malleable material [that] will normally have ball and socket or hinged joints or readily bendable joints in the case of a wire armature to mimic the joints (elbows, knees, neck etc.) of human or animal figures" (Stop Motion Central Clay Animation - The Basics, n.d.).
- **Puppets** in stop-motion animation are "characters with human-like qualities that directors can pose freely and more easily to show different movements" (Chandler, 2013).
- **Stop-Motion Animation** "(also called stop frame animation) is animation that is captured one frame at time, with physical objects that are moved between frames" (Introduction to Stop Motion Animation, 2017).

Literature Review

Stop motion animation has been around nearly as long as traditional filmmaking, dating back to 1897, when the first stop motion film, *The Humpty Dumpty Circus*, was produced (Matthews, 2015). French artist and cartoonist Emile Cohl originally introduced stop motion animation to America. Cohl used a combination of his own drawings, handmade puppets, and other inanimate objects to create his works, with his most notable film being *Fantasmagorie* (Mendoza, 2011). Lotte Reineger created the first full-length animation film *The Adventures of Prince Achmed* in 1926 (predating Disney by almost 10 years), using a paper cutout technique.

There are several other techniques used to create puppets for stop-motion animation. A common puppetry material to use is clay (seen in the *Wallace and Gromit* and *Gumby* series), which is every easy to manipulate. One of the major issues with working with this material, however, is that it cannot be handled for long periods of time. In addition, it deteriorates under the lighting on the film set. In these cases, Claymation animators use a material called plasticine instead (Aardman Animation, 2015). Tim Burton's puppets commonly featured clockwork functions that would change the character's facial features (Chandler, 2013).

The newest technique for stop-motion puppet creation is 3D printing, as seen in films such as *Coraline and ParaNorman.* A model of the character with varying facial expressions is created on a computer, and then these different versions are printed out to use on the puppet's body (See Figure 1). Laika collaborated with Stratasys, a 3D printer manufacturer, and used their 660Pro printers to produce nearly 12,000 faces for all of their puppets in *Coraline* (Sciretta, 2012). They also used a color 3D printer to create over 30,0000 faces for *ParaNorman* and eliminate painting from the production time after previously using Maya, a 3D modeling software, and a non-color printer for previous projects (Laika Studios, 2015). Their most recent film, *Kubo and the Two Strings,* also featured the first fully 3D printed armature for their Moon Beast character, seen in Figure 2 (Armstrong, 2016).

Figure 1: These are a few of the jaw pieces used for Norman's character in Laika's ParaNorman (Heater, 2012).

An important distinction to look at when considering the use of 3D printing for stop-motion animation is to look at how much this equipment costs. Stoopid Buddy Studios, creators of *Robot Chicken*, had used EnvisionTEC's 3D printers before, but had never owned one in-house (Crouse, 2015). The price for the type of 3D printer used by Stoopid Buddy Studios costs between $100,000 and $250,000 (EnvisionTEC, 2016). The printer was specifically designed for printing materials at a high volume, which would be a benefit to an animation studio looking to save on time. Similarly, the printers that Laika uses are also costly, with the Stratasys 660Pro retailing at $100,000 minimum, and full-color J750 model retailing at about $300,000 (Aniwaa Pte. Ltd., 2016).

Figure 2: These are some examples of 3D printed characters from Laika's Kubo and the Two Strings. The Moon Beast (suspended) has the first fully 3d printed armature (Logan, 2016).

Method

The purpose of this research is to determine whether or not the use of 3D printing could improve the character creation process for independent artists and add value to an educational program using a method similar to the process that Laika uses. To conduct this research, one full character was built with faces created in the traditional method using clay and an alternate method in which the faces were created in 3D software. The same armature was used for the character, as a constant. The files for the faces were sent to 3D printing companies, and then a cost analysis was conducted to determine which method (clay versus 3D) is more effective. The methodology used in this research is as follows:

- Purchase all necessary materials to sculpt character faces and build an armature from scratch;
- Sculpt the clay faces and build the armature;
- Utilize Maya software to sculpt faces and create 3D printer-friendly files;
- Send 3D files off to print companies and get quotes for prices to print;
- Calculate material costs using both methods;

Procedure to Create Sculpted Faces using 3D Printing

First, a series of sketches of the character is required before any sculpting can begin. These should include front and side-profile views of the character's face and a full body sketch of the complete character (Figure A2-1). The sketches of the face should also be to the scale of the character in real life. When sculpting faces by hand, the clay should be sectioned into pieces that are equal in size to the faces drawn in the original sketch.

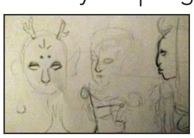

Fig A2-1: Initial Character Reference

Wellesley College has a detailed tutorial for sculpting faces in Maya, which can be accessed online and is titled *Maya 2014 Polygonal Modeling a Female Head*. The steps listed below are a condensed version of that Wellesley College tutorial.

1. Take the sketches of the front and profile views into Photoshop and line up facial features to prep for use in Maya.
2. Insert the images of the side and profile views into Maya, placing one on the X plane and the other on the Y plane in Maya's perspective view (Figure A2-2).
3. Use polygon primitive planes in Maya to begin sculpting half of the face, following the sketches, starting at the eyes and mouth, and excluding the nose (Figure A2-3).
4. Duplicate and mirror the completed facial halves and sculpt a nose, rotating between the front profile view to check the volume of the face (Figure A2-4).

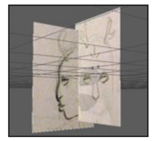

Fig A2-2: Front and profile views on the x and y planes in Maya

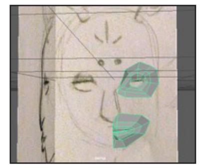

Fig A2-3: Eyes and mouth as starting points

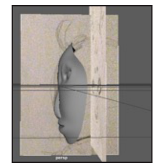

Fig A2-4: Checking the nose against the profile view to make sure that it projects correctly from the face

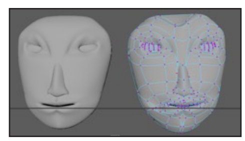

Fig A2-5: Purple dots indicate vertices that can be manipulated

5. Use the extrude tool to shape the back of the head until the face is solid.
6. Duplicate the finished face several times and switch to Vertex mode to manipulate the facial features (Figure A2-5).

The armature was built by following the basic shapes from the reference sketch. One piece was used for the head neck and torso. Two more long pieces were used for the limbs, and smaller sections of wire were used to secure the pieces together. The aluminum foil was used to build volume in the torso and limbs. After covering the wire to a desired volume, the fabric was measured, cut, and glued over the armature.

Results

Using the methodology previously described, four faces were sculpted by hand using air clay and four faces were digitally sculpted in Maya. To keep the process as consistent as possible, both sets of faces had the same facial expressions: neutral, happy, sad, and mad. The same armature (Figure 5) was used as a constant in the experiment.

Important Factors

Figure 5: This is the final armature created for the character.

One of the biggest issues that came with sculpting the faces by hand was keeping the overall features (such as eye, face, and nose shapes) consistent throughout each piece. The clay faces, seen in Figure 3, were measured initially using a ruler. However, the amount of clay used per face varied depending on whether mistakes had to be corrected and because of the changing facial expressions. The faces sculpted in Maya (Figure 4) were more consistent because the neutral facial expression could be copied several times, and then manipulated as needed into the other expressions without impacting the overall features.

Additionally, a student version of Maya was used to conduct this research. Because the software is free to students, the cost of the software was not calculated into the overall results. Online 3D printing companies require the use of specific file types in order for their software to be able to calculate a quote for the order. The best file type to use is .STL. As of the 2016 version, Maya does not support the ability to export to this file type, so MakeXYZ's online file converter was used to create the correct files.

Figure 3: These are the four hand sculpted faces prior to painting.

Figure 4: These are the four faces created using Maya software.

Calculations

Figure 6 details the differences in cost using traditional methods versus using 3D printing. After the manipulations were made to the faces created in Maya, the files were sent to 25 online 3D printing companies that use an instant quote service, as listed in Appendix 2. These quotes were then averaged to find out printing costs. Quotes that would skew the average were removed from the calculations, resulting in an average quoted price of $13.94 for the four faces. Conversely, it cost $12.29 to create the faces using clay.

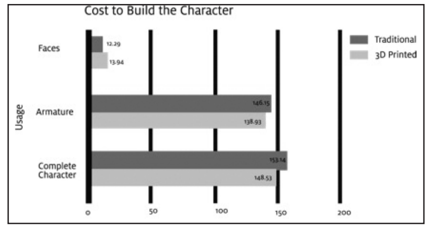

Figure 6: This table is a cost comparison between the prices for a character using clay faces versus those created in Maya.

There was a $7.22 price difference in the armature using the 3D method versus the traditional method because of the additional cost of clay needed to mount the faces to the armature. The final fully assembled character using the 3D printed faces also cost less overall than it would using the clay sculpted faces, once the difference for the total material and time difference costs were calculated.

Conclusions

In conclusion, 3D printing can be a feasible alternative to creating character faces in the traditional way. Surprisingly, the overall costs were relatively similar for both methods. The cost of the clay was relatively equal to the cost of the 3D printed face. The slight differences in overall cost arose from the need to purchase fewer materials when using the 3D printed face method.

Using Maya to sculpt faces was also less time consuming than sculpting faces by hand. The air clay requires one to three days to fully harden, depending on the size of the piece and its density. The faces made in Maya required only a few minutes of adjustments between one facial expression and the next.

Recommendations

If this research were to be continued, it is recommended that this process first be repeated with more face pieces and with a short film as the end product, rather than just a completed character. This way, more information can be obtained about turnaround times influencing the speed of the full film-making process.

Because of time constraints and limited knowledge, the faces sculpted in Maya were only done in single color. Future researchers could recreate the process using full color prints; it would be interesting to see how the cost of these pieces would affect the final character cost. It is also worth exploring the color accuracy of the printed sculptures as compared to the desired colors specified in the original file.

Educators should also consider reaching out to printer manufacturers for partnerships. Stratasys has a page specifically targeting educational use, offering lesson plans and connecting schools with local retailers (Stratasys, n.d.). Most of their printers are used in engineering and medical programs. However, because of Stratasys's partnership with Laika, it's proven that these manufacturers are willing to branch outside of the STEM field and into areas of artistic use.

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