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Study of Laika's Facial Expression Mechanism System for Stop-Motion Animation Puppet Through Knock-Down Strategies on Home-Scaled 3D Printer

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Abstract

The growth of 3D printing has been rapid over the decades. Laika is a United States-based animation production company, and the pioneer of 3D printing technology in stop-motion animation. Laika uses this technology in their production pipeline for making stop-motion puppets in most of their films, including their latest films, Kubo and the Two Strings (2016). Due to limited access and information of details of Laika's facial expression, communities and fans of animation have tried to conduct experiments with their own 3D print, using footages of behind-the-screen processes from Laika studio. This paper explores facial expressions for creating stop-motion puppet using an affordable home scale 3D printer. Using limited technical information collected from documentation video from Laika as well as referring to articles written by stop-motion enthusiasts, this fan-based research ignites creativity to overcome the barriers of technology and access through strategies in producing affordable 3D print stop-motion animation.

Keywords: Stop-motion animation, 3D printing, facial expressions.

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1. Introduction

The motivation to conduct research in Laika's facial expression mechanism system for stop-motion animation puppet was driven by two reasons. First, it was triggered by the fact that Laika is a company that is known best for producing films utilising high-end 3D print machine for their puppet's faces and use them in all of their films. Second, the limitation in finding detailed information about the structure of Laika's expression system and curiosity about whether it is possible to reproduce a similar system and implemented on any character using an affordable home-standard 3D printing machine. Thus, the main objectives of the study are to collect detailed information about Laika's facial expression structure and to investigate the possibility of reproducing this system using a home-scale 3D printer.

2. Literature review

3D printing technology has rapidly developed over the decades. In this digital era, its ability to translate a design or model that only virtually exists over real physical objects is able to change the way how people manufacture objects.

2.1. 3D printing

According to Brand (2014), 3D printing is an additive manufacturing, which translates a computer model into a physical object by dividing the computer model into separated physical layers that stack on one another to build the final form. Brand (2014) mentions that according to the method, there are four common types of 3D printing: photopolymer (transform liquid to solid), granular (transform granular powder to solid), lamination (cutting of thin material and recombine into new form), and fused deposition modelling (building up layers of melted plastic).

2.2. 3D printing in animation industry

According to the timeline of stop-motion animation history explained by Priebe (2011), it is likely implied that Laika studio was the first stop-motion animation company that successfully used 3D printing technology in their pipeline to produce Coraline (2009). It is mentioned that 3D printing technology was utilised to print as many as 15,000 faces to make 250,000 facial expressions by the replacement animation technique. The same technique was also practiced by Aardman studios when creating Film Pirates! Band of misfits (2012), then followed by other Laika's film such as Boxtrolls (2014) and Kubo (2016). Besides its utilisation for facial expression, there were some Indie studios that used 3D printing machine to print a whole character for replacement animations such as DBLG studios with their film: Bears on Stairs (2014) and the Chinese Indie Studio, which produced Box Man (2014) (Yekti, 2017).

2.3. Stop-motion animation

According to the scholar Jane Shadbolt (2013), stop-motion is an animation technique involving the physical process of rearranging miniatures frame-by frame, which considers scale, perspective, construction materials, sets and character performance. Purves (2010) points out how animators manipulate physical things to be able to move in a real space, light, focus and depth become the main attractions of stop-motion animation.

2.4. Replacements animation

According to Priebe (2007), replacement animation is one of the strategies of the stop-motion animation method. Instead of building objects to be manipulated on each frame, it uses several different versions of a puppet or an object to be used on each frame. It is derived from the logic

behind hand-drawn animation, where the animator consistently makes a slightly different drawing from the one before on each frame (2010). The earliest person who believed in using this replacement technique for stop-motion puppet's face was Howard S Moss, who did the animation for The Mo Toy Comedy in 1917 (2010). Another recently made film also known to use this replacement faces technique in their film was The Nightmare before Christmas and James and the Giant peach (Priebe, 2010).

2.5. 3D printing technology utilisation in Laika Studio

Priebe (2010) mentions *Coraline* as the first film in which rapid prototyping was utilised for stop-motion animation. Coraline was produced by Laika Studio, a stop-motion animation production company located in Portland, Oregon, USA. It is also mentioned that in making *Coraline*, Laika used rapid prototyping technology for printing out 3D computer models for replacement animation and props using resin materials. Priebe (2010) states that by using this technique, Laika was able to combine the smoothness of computer graphics and the stylised stop-motion set. In his book, Priebe (2010) mentions that each character in the Coraline film could have about 15,000 faces and up to 250,000 facial expressions. To make more different combinations in expression, Laika divided the face part into two different parts: upper and lower.

3. Research Methodology

This research uses knockdown strategy, whereas the author studies the mechanism system of existing facial expression, which involves 3D printing as a tool to produce it, by finding information of the parts and its function, and then reproduces the system and applies it to a character using affordable home-scale 3D printer. The author uses facial expression mechanism system used by Laika as the case of study since Laika is known as the pioneer of the stop-motion animation company that utilised 3D printing technology and succeeded in producing four full feature stop-motion animation films.

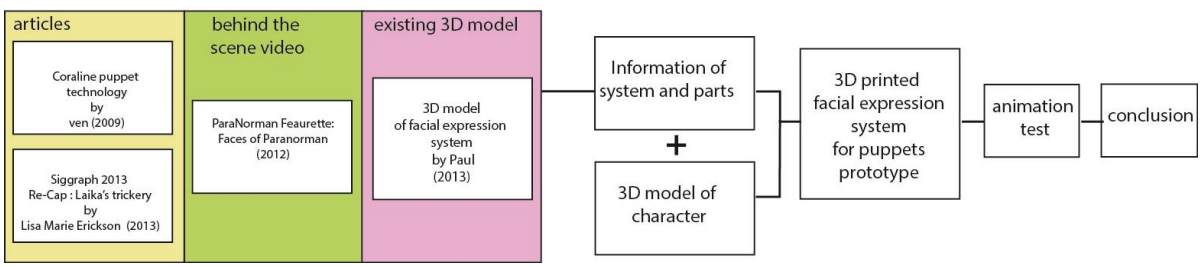

Figure 1. Research method diagram

This research is conducted by generating information from two articles, and behind-the-scene video as the main secondary source. All information from these secondary data combines with the information gathered from the experiment as the primary source using existing 3D models of the facial system and 3D model of character. The first article is Coraline puppet technology, written by Sven based on his experience observing real puppets shown at the Coraline premiere screening in 2009. The second article is Siggraph 2013 Re-Cap: Laika's trickery, written by Lisa Marie Erickson. In the second article, Erickson writes about her insight/opinion about the Laika puppet mechanism based on information that she had gathered from 'The seamless fusion of stop-motion and visual effects technologies in Laika's feature films' seminar presented by Laika's practitioners, who were responsible for Laika's puppet making. Behind-the-scene video was retrieved from YouTube titled: ParaNorman Feaurette: Faces of Paranorman' (2012). Similar to the article by Erickson, this video showed information interviewing four important sources from Laika: Georgina Hayns, Creative supervisor from

Puppet Fab, Morgan Hay and Kingman Gallagher as the Rapid Prototyping Leads dan Bryan Mcleans as the Creative Supervisor.

The next step is to make a real 3D printed facial expression system. The 3D model of the system was downloaded from www.stopmotionanimation.com. This model was shared by Demian on February 2016 in a forum discussion titled 'Paranorman Eyes'. The purpose of doing this experiment is to get real experience in assembling and operating the facial expression system, so it can give more understanding to the system and the function of each parts. All the secondary and primary information about the system is then applied to a character. The author uses a 3D model of a character bought online. It is a 3D model of a woman character that comes with a complete facial controller, and ready to be animated digitally.

4. Laika's Documentation Observation and Study

4.1. Coraline puppet technology (2009)

In the article titled Coraline puppet technology, Sven (2009) mentions that there are two types of mechanical systems applied in the characters of the Coraline movie. The first system is a mechanical system called Hollow resin skull*, the second is* snap-on faces*.* The hollow resin skull system is applied on some characters such as The Father and Other Father. In this system, the main structure of the head and the face were built from the resin material which is connected to small metal parts that have a function to animate the facial skin part made from silicone material, such as eyebrows, mouth, etc. (Sven, 2009). While *snap-on faces* system, which is applied to the main characters, Coraline and Wybie, were designed to accommodate the replacement-animation method in the animation process. This system utilised 3D printing technology to produce the small parts of the structure as well as the faces itself. Sven (2009) points out that according to what he saw, in this *snap-on faces* system, the face part is divided into two different parts, the forehead part and the rest of the face below the corners of the eyes and bridge of the nose.

In this article, Sven (2009) also explained more details of the *snap-on faces* system. Sven (2009) mentions that several 1/16" diameter neodynium magnets were attached to each part of the faces. He also argues that the eye parts consist of the eyelids part that could rise and lower, and the eyeball part which is attached to the skull using ball capture plates located on the back side of the eyeball. Other important thing about the *snap-on faces system* explained by Sven (2009) is the neck connector. He mentions that there is a squat cylinder connector part at the bottom of the head. From his observations, he concludes that it can be used for holding the square telescoping rod as the neck structure, which can prevent the puppet from rotating around accidently.

4.2. Siggraph 2013 Re-Cap : Laika's trickery (2013)

In the second article titled Siggraph 2013 Re-Cap: Laika's trickery, Erickson (2013) wrote some information based on the 2013 Siggraph conference that she had attended. This information included the technology that was utilised in the process of puppet making and animation process, and also general information about facial expression animation in the Paranorman film. Erickson (2013) explained that replacements animation is the main technique used to animate the mouth, eyebrows and other parts. She also explained that most of these parts were produced using 3D printing technology. The total amount of 3D printed faces are more than 40,000 pieces, and able to make half a million combination of facial expressions. Erickson (2013) also mentions that each of the face parts was painted manually by a painting artist.

In this article, Erickson (2013) also explains the technology behind the process of making stop-motion puppet for Laika. The Zcorp 3D printer machine which uses powder material is utilised by Laika for economical purposes, although it took many steps in the finishing process. Besides the 3D printer itself, she mentions some software included in the making process, such as Autodesk Inventor for

designing some mechanical parts of the puppet's structure. She concluded that the 3D scanner was also used to get information about the physical character sculpture objects, before processing into the final 3D model using topogun and Zbrush software.

4.3. ParaNorman Feaurette: Faces of Paranorman (2012)

This video gives information based on the interview of practitioners involved in the process of making facial expression animation for Paranorman films. The information collected from this video is actually similar to the second article written by Erickson, since the interviewees were the same people who were presenting the 2013 Siggraph: Laika's Trickery conference. This video was able to provide additional information about the process of making puppets for Paranorman films. It was mentioned in this video that the total amount of puppets is 300, which involves 77 gallons of Super Glue, 8,000 Lbs of printing powder, 2 gallons of white resin, 66,400 magnets, 729 sheets of sandpaper, 25,000 purple gloves and 5000 X-acto blades.

Figure 2. Information about Laika's puppet faces making process from video: ParaNorman Feaurette: Faces of Paranorman (2012)

Source: http://popcornposts.blogspot.co.id/2013/08/siggraph-2013-re-cap-part-1-laika-s.html

4.4. Experimenting using existing 3D model by Demian (2017)

After having a good understanding about the parts involved in facial expression and its function, the next step is doing experiments to get the real experience about how each part is supposed to work. This experiment also measures the capabilities of the home-scale 3D printer to produce the same mechanism used by Laika. In this experiment, the author uses 3D existing 3D model, downloaded from www.stopmotionanimation.com and created by Demian. This experiment using fused deposition model 3D printing machine called minibot manufactured by Creality 3D. The material has been used in this experiment is polylactic acid filament.

Adjustment of the original 3D model scaling was made due to the capabilities of the printer. It needs to be scaled up because some parts have a dimension that does not fulfill the minimum requirements to be printed with minibot 3D printer.

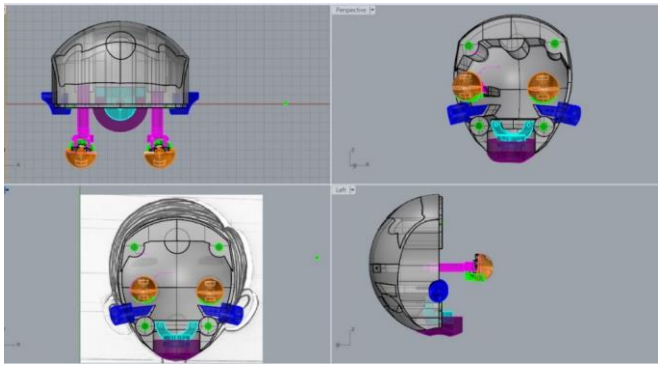

Figure 3. Original eye mechanism 3D model by Demian

Figure 4. Head structure printed with creativity 3D minibot 3D printer

The printed parts were really helpful to mapping the category of the parts. From these 3D printed objects, combined with information gathered from articles and behind the scenes video, the author made a categorisation of the parts structure and information about how it works. Overall, the head structure can be categorised into four main structures: skull, eyes, ears and neck connector. Other additional information about the size of the magnets helped the author to understand the right location for the magnets in the overall structure. From these experiments, the author also concludes that most of the parts it belongs to the eye structure, which consists of six different parts on each side.

Table 1. Laika's puppet face mechanism system and parts information categorisation

Information	Article: Coraline puppet technology (2009)	Siggraph 2013 Re-cap: Laika's trickery (2013)	Paranorman Feaurette: Faces of Paranorman (2013)	Experimenting on existing 3D model by Demian (2017)
Source/Author	Sven	Erickson	Hayns, Hay, Gallagher and McLeans	Demian
Movie title	Coraline	Paranorman	Paranorman	-
Material used	Plastic	Powder	Powder	-
Eyes structure	Squashed spherical shaped, separated eyelids part	separated eyelids part	-	Three eyelids parts, a half-sphere shaped part eye ball
Ears	Attached	Separated, no movement mechanism	-	Separated, no movement mechanism
Neck connector	Squad cylinder shaped	-	-	Squad cylinder shaped
Face attaching system	1/16" Neodimium	Eight cylindrical magnets	Eight cylindrical magnets	Four cylindrical magnets

4.5. Implementing system to 3D model character

The next step is implementing the system into a character. In this step, the author uses the existing 3D model character bought online, which has the face controller feature. Some adjustments were applied both in the head structure model as well as the 3D character model, such as rescaling the model, adjusting the proportion of the eyes structure, separating and modifying face polygon of the face, etc.

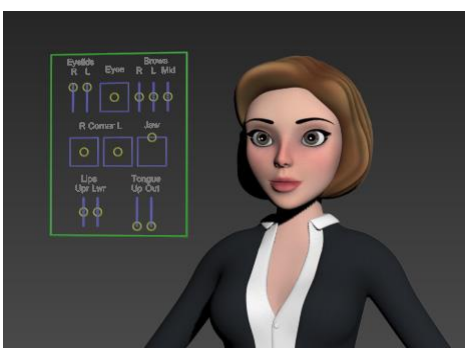

Figure 5. Existing 3D model character

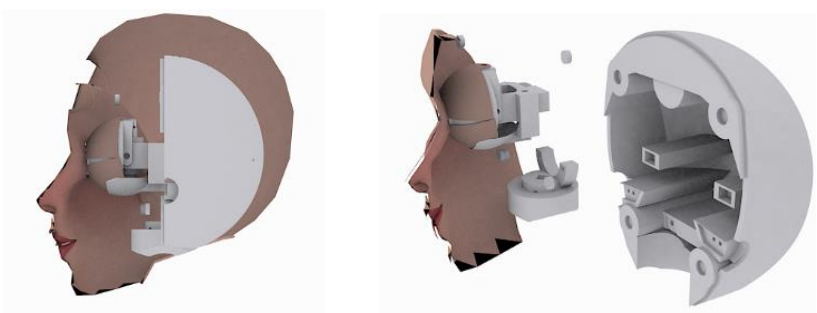

Figure 6. Adjusting 3D model of the character and head structure

4.6. Animation test

The animation tests were conducted by doing 4-second animations of a character head moving along following flying objects around her. The animation of the facial feature of the character was done on a digital platform. There are 48 faces printed using minibot 3D printer. The purpose of the animation test is to validate the process of implementing the Laika's facial production system using home-scale 3D printer.

Figure 7. Complete set of puppet's head mechanism

5. Analysis

After all the head structure, and all the faces part were printed and have a finishing touch before it was assembled into the final prototype, these objects are handed to the animator to be processed according to the animatic storyboard. The result gives a measurement to the process of implementing Laika's facial system to a character using a home-scale 3D printer. The indicator of the analysis is based on three aspects:

- Eye movement animation.
- Since most parts in Laika's facial system belong to the eye structure, it is considered to the main indicator of this experiment analysis. The implementation is considered as a success if the animator is able to make the eye movement animation similar to the animatic storyboard.
- Face attachment process.
- The implementation is also considered a success if the animator can easily change the face into another on each frame.
- Overall animation result.
- It also considered as a successful production if the movement in the animation looks fluid and shows minimal error, especially the faces position.

The overall result shows that the learning process and implementation of the system were successfully executed. The animator was able to produce animation with the eye movement that followed its animatic storyboard. The face part changing process was also considered a success since the author encounters no issues in the animating process. Overall, the animation looks similar to the animatic storyboard; there are no significant errors while positioning the faces on each frame.

6. Conclusion

The author concludes that it is possible to reproduce Laika's facial expression system to any characters using the home-scale 3D printer with some adjustment. During the research, the author learned about how each part was designed to produce the world class stop-motion animation like Laika's film. From this research, the author also realised that in stop-motion animation film which utilised 3D printing technology for their facial expression animation production, the face replacement system cannot be separated from the digital animation process.

The process of gathering information made the author learn that there is an alternative for creating a facial expression system besides the snap-on faces system or 3D replacement animation system.

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