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# Character Design for 3D Printed Zoetrope Visual Style and Character Designs Printability

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**ABSTRACT**
Zoetrope is considered as one of the important inventions in the early of moving image history. Nowadays, using 3D print technology, independent artists are able to create zoetrope that shows the motion effects of a sequence of real 3D Physical objects. There are many kinds of objects that can be printed and displayed in the zoetrope objects, including stylized characters. However, not all 3D models can be proceed using the 3D printer. Many conditions need to be fulfilled to proceed using the 3D print machine. There are many visual styles of a character design that can be printed as animated objects for zoetrope devices. This possibility motivates the author to investigate the correlation between character design visual style, 3D printing process effectivity, and animation appeal of 3D printed zoetrope.

***Keywords:*** *Animation, 3D Print, Zoetrope, Visual Style.*

## 1. INTRODUCTION

Nowadays, 3D print technology is becoming more common and affordable to be accessed by society. Its ability to convert a virtual object to a real physical object has attracted many artists to exploring this technology to create artwork. In the animation industry, 3D printed is often utilized in stop-motion animation production. Other than stop-motion, some independent animators like to use 3D print technology for creating 3D Zoetrope.

In the beginning, Zoetrope was often using a sequence of 2D pictures and mirrors or paper wall to create moving image effects. By utilizing 3D printed and 3D animation software, a 3D animated object sequence can be printed out as Physical objects and displayed as a moving object using a zoetrope mechanism.

To print out as a sequence of physical objects, a 3D model of character has to fulfill several conditions. In this paper, the authors investigate the relationship between an animated character's visual style and its ability to be printed effectively displayed on the zoetrope device.

## 2. LITERATURE REVIEW

### *2.1. 3D Printed Zoetrope*

3D print technology exploration has been done by several artists to be implemented in the 3D zoetrope animation. The objects which animated using the 3D printed technique are varied from abstract to realistic objects or characters.

Zoetrope is one of the early animation invention, found by William Horner in 1843 [1]. In the early invention, this device comes with a rotating drum shape part with some slits. Throughout the slits, animated moving pictures effects can be seen by the audience. Later, in 1887, Etienne-Jules Marley tries to develops zoetrope by adding 3D objects inside of it [2].

3D print technology is often utilized in the animation industry to produce 3d printed objects for stop-motion animation. Laika Entertainment initiated this utilization in their movie, Coraline in 2008 [3]. Nowadays, as it becomes more affordable than before, independent artists and studios start to use 3D print to moving images artwork, including 3D object zoetrope. Unlike early models, modern zoetrope is often equipped with a strobe light as an alternative to a drum part with slits [4].

### *2.2. Visual Style Framework*

In the character animation practice, the visual style is one of the crucial aspects that need to be settled in the pre-production process to deliver a story to the audience. Sloan [5] cited Scott McCloud's framework, which divides the visual style of character design into three directions: photographic, Abstract, and Symbolic.

According to McCloud, every character design tends to go one of these three directions.

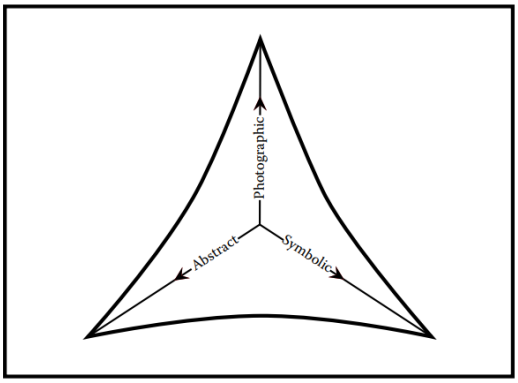


**Figure 1** Visual Framework of Character Design

### *2.3. Printable 3D Model*

To be able to proceed in the 3D printing machine, some conditions need to be implemented in the 3D model, such as closed polygons, clear manifold area, and connected components. An appealing sequence of animated 3D models, which does not fulfill these conditions, may reduce the animation effect quality when it proceeds into a 3D printing machine and animated in a zoetrope device.

## 3. RESEARCH METHOD

This research involved students from the "Animation Production "subject of the Film Department at Universitas Multimedia Nusantara. There were three chosen stylized character design with similar visual style and different complexity level created by different students:

- Bear by Fransisca represents a simple symbolic style;
- Alin by Agnes Amelia represents a simple semi photographic symbolic style;
- Pastel by Brian Pratama represents a more complex semi photographic symbolic style.

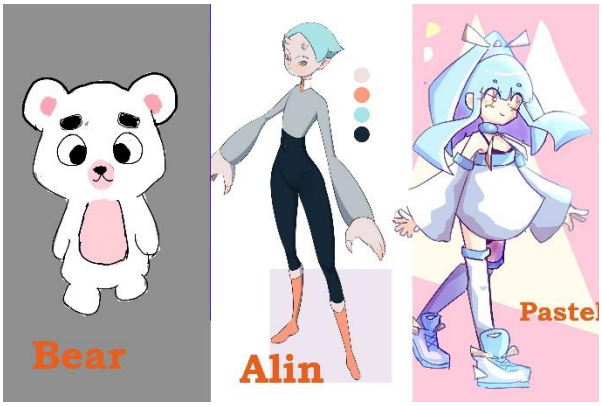


**Figure 2** Visual Character Design Concept With Different Complexity

These character concepts were modelled and animated using Maya software. There will be three steps of process undergoes after the final 3D animated file is created.

- Step 1: Breaking down the animated 3D digital models into 18 frames 3D model in obj file format. Inspect the printability of 3D models and do the repair process if needed using Autodesk Meshmixer software
- Step2: Making G-code file for the printing command using Slicer software.
- Step 3: Print and clean up the character, and put the objects in Zoetrope disk.

During executing these three steps of processes, observation will be conduct to see the relation of the visual style and the effectiveness of 3D printed zoetrope production. In step 1, the observation will be focused on how many problems will be found on each character. Inspect feature in Autodesk Meshmixer allows users to see common issues in 3d models for the printing process, including the hole in the mesh, non-manifold area, and separate components. In Step 2, the observation will focus on comparing the character design concept and the output simulation. In Step 3, the result of each 3D printed character sequence's animation will be observed to see if there any significant appearance consequences in the moving object's effect.

## 4. PROCESS

### *4.1. Step 1*

After students finished doing 18 frames animation of their 3D characters, the mesh objects were selected in each frame to be converted into 3D models with OBJ format files. Next, Each of the OBJ files was imported into Autodesk Meshmixer and run the inspect command to see if it contains problems. There are three types of possible issues that can be shown in Autodesk Meshmixer:

- Hole in the mesh which showed using a blue sphere.
- Non-manifolds area shown by magenta spheres.
- The disconnected components which pointed out in red spheres.

After problems were found, the auto repair feature was used to fix the models and export them into STL format files.

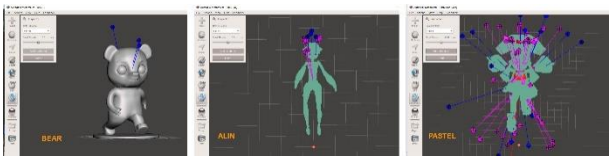


**Figure 3** 3D Model Problems Comparison

The 3D models of Bear characters show the least problems; each model of each frame has only three holes in the mesh at the head area. The Alin characters have more issues than the bear characters. There are four holes in the mesh of the head and four non-manifold areas of the head. Two other manifold areas also appear in the stomach area of characters. The Pastel character shows the most problem compare to the other two characters. Almost every part of the characters shows a problem; disconnected parts also appear in this 3D model. Total there are 14 mesh holes, 32 open-manifold areas, and two disconnected components.

### *4.2. Step 2*

In Step 2, each of the 3D models repaired and converted into STL format files is processed in the Slicer software. In this software, the 3D objects are sliced down into Cartesians coordinates information of many layers and combined with other commands to operates the printer before converted into G-code files. In this Slicer software, the user is able to see the simulation of the printing process, including the preview of the printed object result.

In this step, the preview of printed models is compared with the visual of each character concept. The observation is focused on the differences in visual appearance by observing part details and silhouettes. Observing part details is conducted to see the consistency between the character concept and the printed model. While observing the silhouettes is meant to see the character's abilities to show an appealing and informative animation.


**Figure 4** Printed Bear Character Preview

From the preview of the Bear character in Slicer software, it shows that the 3D printed version has a high similarity compared to the character's concept design. There is no missing part shown in the preview of the printed object. However, the silhouette of the 3D printed Bear character's preview seems a little bit blocky and not appealing in some angle. Moreover, the running cycle animation also cannot clearly have shown from the silhouette.


**Figure 5** Printed Alin Character Preview

Like the Bear character, a preview of the 3D printed Alin character shows a high similarity to the character's concept design. There is also no missing part shown in the preview of the printed object. However, the silhouette of the preview of the 3D printed Alin character looks more appealing. The running cycle animation also clearly shows good staging.

**Figure 6** Printed Pastel Character Preview

Pastel as the most complex character among all three shows the inconsistency of model similarity compared to its character concept. As the consequences of disconnected components that already predicted in the Autodesk Meshmixer software, printed objects' preview shows that this character printed result will have missing parts: hair accessories, necklaces, and shoe accessories. However, while some details are missing, the 3D printed result preview still shows an appealing silhouette with a good staging which clearly indicates that the character is running.

### *4.3. Step 3*

In Step 3, each of the G-code files of 3d models is executed using a 3D printer machine. In order to fit with the Zoetrope disc created in this project, each character printed object will have a dimension that no more than 7 cm in height. Although all the character shows no problem after the repairing process in the preview, it

turns out that only one character's 3D model was succeeding in the printing process.

**Figure 6** 3D printed characters on Zoetrope disc

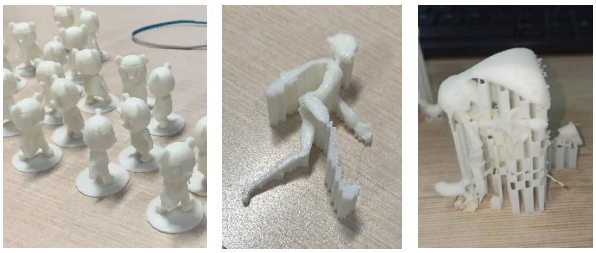

**Figure 7** Printed Character Result

frame were printed along the process, and most of the body mesh was missing. Other than the thin dimension at the several areas of the model, the loose parts also seem heavily affected by the unsuccessful printing process.

## 5. ANALYSIS

After observing the characters' process and comparing one to each other's, the results show correlations between visual style and printing process effectiveness and animation appeals.

The Bear character, which represents a simple, symbolic style, is considered the most effective character to proceed with 3D printed. It can be seen from how the preview shows no missing parts, and it only shows three mesh holes in the inspection process. However, the Bear character is considered the model that will show the least appealing aspect, such as having blocky silhouettes and bad staging.

On the contrary, Pastel characters, as the most complex character designs, come as the most ineffective characters to be printed using 3D printers. It has 14 holes in the mesh, 32 open-manifold areas, and two

**Table 1.** Character Design and Printing Process Comparison

| Character | Mesh Problems | Model consistency | Silouettes | Staging |
|---|---|---|---|---|
| Bear | 3 mesh holes | No missing parts | Blocky | Bad |
| Alin | 4 mesh holes<br>4 open-manifold area | No missing parts | Dynamic | Good |
| Pastel | 14 mesh holes<br>32 open-manifold areas<br>2disconnected components. | 3 missing details:<br>Hair accessories<br>Necklace<br>Shoes accessories | Dynamic | Good |

Eighteen frames of Bear characters' 3D models were successfully printed without any missing part. They are also a minimum effort of the clean-up process needed for the printed model. Overall, regarding the printing process, the simple visual style applied to the Bear character, giving a bigger chance for the printing process's success.

For the Alin character, each of the frames was only about 80 percent having been printed. The right side of the legs was not printed correctly and resulted in a broken part. This unsuccessful printing process seems to be related to character design, which has a thin dimension in the leg part.

As already predicted in the Autodesk Meshmixer, the Pastel character shows most printing process problems. This problem still occurred even though the repairing process was already applied. Only several parts of each disconnected components. Moreover, this character becomes the only character that has missing details when it proceeds with the 3D printer. Despite the complexity and the problems that show during the printing process, Pastel characters show the clearest staging and dynamic silhouettes amongst three characters.

Alin represents a combination of photographic and symbolic character but not as complicated as Pastel. Within its position in the visual style frameworks, Alin character shows more problems than the bear characters, but still indicates much fewer issues than Pastel character. In total, Alin only has four mesh holes and four open-manifold areas without any disconnected components. Alin character printed model preview also shows no missing parts. Considered as the character 3D model with few problems, Alin characters still able to offers a precise staging and dynamic Silhouettes.

## 6. CONCLUSIONS

After observing the printing process of three different characters for Zoetrope animation and comparing to each visual concept, it can be concluded that:

- The visual style and the complexity of the character concept have affected the printing process's difficulties for animated zoetrope objects. A character with a photographic style element and has more complexity level will have higher possibilities to have more problems during printing.
- The visual style and the complexity of the character concept has affected the appeal and staging of the zoetrope character animation. A character with a photographic style element and higher complexity has possibilities to show more appealing animation.

However, there are more visual styles that are not tested in these experiments. Thus, in the next research, it will be better if it is conducted using the same characters with a different style, which shows more visual style representation in the McCloud characters style framework.

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