“THE LONE ANDROID SHORT PREVIEW”: THE EFFECTS OF CEL SHADING IN 2D ANIMATION

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This report is submitted in partial fulfillment of the requirements for the Bachelor of [Computer Science (Interactive Media)] with Honours.

FACULTY OF INFORMATION AND COMMUNICATION TECHNOLOGY
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2021

DECLARATION

I hereby declare that this project report entitled

"THE LONE ANDROID SHORT PREVIEW": THE EFFECTS OF CEL SHADING IN 2D ANIMATION

is written by me and is my own effort and that no part has been plagiarized without citations.

STUDENT : _____ Date : 21/6/21
(AHMAD AMMAR BIN FAIZULNUDIN)

I hereby declare that I have read this project report and found this project report is sufficient in term of the scope and quality for the award of Bachelor of [Computer Science (Interactive Media)] with Honours.

SUPERVISOR : _____ Date : 12 SEPT 2021
([DR. MOHD ADILI NORASIKIN)

DEDICATION

This page is dedicated for the people who had help and support me through the entire process of bringing this project to its completion.

ACKNOWLEDGEMENTS

I would like to give my gratitude and appreciation to those who have helped me along the way. To Dr. Mohd Adili Norasikin who has gave me the guidance as well advice to this project. It is because of him that I was able to finish this project on time.

Furthermore, I would like to give my heartfelt thanks to both my parents who have help support my entire education financially even though the troubles faced during the covid-19 pandemic going on at the time this project was developing.

And finally, to my friends in the Piggievern Discord server who have support me emotionally and mentally by using their time to have chats together and helping me let loose occasionally. Thanks for hearing my rant guys!

ABSTRACT

"The Lone Android Short Preview" is a 2D-based animation that showcase a short preview of a planned animated short about an android waking up to a post-apocalyptic earth with no memories of what happened. The focus of the project is to research on the effects of cel shading in 2D animation. Cel shading has been a common method for many artists as well animators in their works as means to provide the illusion of dimensions and realism. However, it is common knowledge that cel shading is not often used by animators since they find the method to be too time-consuming and are just satisfied with the use of the base color. Therefore, the purpose to develop this 2D-based animation is to collect data on how cel shading effects the process of 2D animation and how it effects the visuals of the animation entirely. In this project, the animation will be created by using Clip Studio Paint EX, and Adobe Premiere Pro.

ABSTRAK

"The Lone Android Short Preview" adalah animasi 2D yang memperlihatkan pratonton pendek dari animasi pendek yang dirancang mengenai seorang android yang bangun pada bumi pasca-apokaliptik tanpa kenangan tentang apa yang berlaku. Fokus projek ini adalah untuk meneliti kesan cel shading dalam animasi 2D. Cel shading telah menjadi metode umum bagi banyak seniman dan juga animator dalam karya mereka sebagai alat untuk memberikan ilusi dimensi dan realisme. Namun, sudah diketahui umum bahawa cel shading tidak sering digunakan oleh animator kerana mereka menganggap kaedah ini terlalu memakan masa dan hanya berpuas hati dengan penggunaan warna dasar (base color). Oleh itu, tujuan untuk mengembangkan animasi 2D ini adalah untuk mengumpulkan data tentang bagaimana cel shading mempengaruhi proses animasi 2D dan bagaimana ia mempengaruhi visual animasi sepenuhnya. Dalam projek ini, animasi akan dibuat dengan menggunakan Clip Studio Paint EX, dan Adobe Premiere Pro.

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LIST OF ABBREVIATIONS

FYP	**-**	**Final Year Project**
2D	**-**	**Two Dimensional**
3D	**-**	**Three Dimension**
PC	**-**	**Personal Computer**
CPU	**-**	**Central Processing Unit**
GPU	**-**	**Graphics Processing Unit**
KyoAni	**-**	**Kyoto Animation**
SOP	**-**	**Standard Operating Procedure**

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Chapter 1: INTRODUCTION

1.1 Introduction

The shading process of an animation is mostly done on the animation production and post-production stage of the 2D animation production. In general, shadings are mostly done after the entire animation is finished with all the frames applied with their base colors and outlining, this is called the cleanup animation. After finishing the cleanup animation, the production team will sit down and plan out how the lighting of the animation is applied particularly in the direction of the light for each animation scene.

Shading comes in play to illustrate the existence of light and to show the illusion of dimensions and realism for 2D animation. After planning the lighting for the animation scene, animators will then apply shading using the basic concept of light and shadows. Which is an object's shadow should be located on where the light does not cover the object and vice versa for the object's highlight.

Although 2D animation does not have the same automatic shading options as its 3D counterpart, shading can still be achieved although can be quite tedious. Which brings us to cel shading. Cel shading in general has been used in 2D animation because of how simple it is on giving the animation a 3D look. Thus, achieving its goal on showing the illusion of dimension and realism for the animation (Juha 2020).

1.2 Problem Statement

As simple as it sounds, cel shading is not often used by animators nowadays because of how tedious it is. In reality, the idea of applying shading to a frame-by-frame animation can be quite time consuming. As stated before, 2D animation does not provide automatic lighting as its 3D counterpart since the animation is done on a 2D plane. The process itself requires the animators to have an understanding on lighting and dimension to give their animation a more realistic look. Because of this, animators tend to stay away from shading their animation and leave with the base color only.

1.3 Objective

Objectives of this project are as follows:

1. To investigate the cel shading to the 2D animation production process
2. To develop a 2D story-based animation with the application of cel shading
3. To evaluate the rendering time of using cel shading in 2D animation

1.4 Scope

The target audience of this project is localized to animation enthusiast or anyone who is interested in learning 2D animation in general. Since the animation does not involve any voice acting, no subtitles are required. Furthermore, the entirety of the animation does not contain any adulterated scenes. Thus, making it suitable to be viewed by anyone from any age group.

1.5 Project Significance

This project aims to study on how to approach and apply cel shading to 2D animation. The findings of this project will redound to many animators, especially young animators, on how cel shading is implemented and will affect their own 2D animation. Furthermore, it allows them to have a better understanding to how cel shading works in terms of technical aspect such as layer management and the time it takes to render

scenes when it is applied. Thus, implying to young animators on what the will have to confront when it comes to the application of cel shading to their animation.

1.6 Conclusion

To conclude, this chapter covers the project topic “The effects of cel shading in 2d animation” with the objective and goal of the project. The project will follow the activities schedule which are listed in the Gantt Chart and milestone that proposed in the proposal to ensure the project can be carry out on time within the period. In the next chapter, the literature review and project methodology will be conducted.

CHAPTER 2: LITERATURE REVIEW AND PROJECT METHODOLOGY

2.1 Introduction

This chapter will discuss about the research of the related topic about cel shading in 2D animation. Besides that, this chapter also recover the project methodology to show the procedure or process of the project development and the requirement such as software and hardware.

2.2 Literature Review

2.2.1 What is Cel Shading

From my perspective, Cel Shading can be simplified as a shading technique of applying shadows and highlights to an animation. This is mostly due to the idea that cel shading is mostly used by artists to give their works the characteristics of dimensions and lighting.

Cel shading is stated Juha (2020) as an art style of non-photorealistic rendering designed to make animation look three dimensional by creating flat colors on top of base color, making it look three dimensional while stile still keeping that 2D effect in it. Aside from that, McKella (2019) wrote that cel shading is a shading technique used in cartoons and comic books. The basic idea of this technique is that artist shade and highlight with chunky, simplified colors rather than the subtle gradients we see in real life. Both definitions differ from each other, but the concept is the same. Cel shading in general is a simplified shading technique used by most artists and animators to achieve a 3D look for their works.

The term cel shading pays it homage from the medium that traditional animation was drawn on which are celluloids or cels for short. There have been arguments regarding on how the term itself should be spelled out. Both Juha (2020) and McKella (2019) emphasize on the matter by stating:

> *This celluloid is traditionally used for painting within 2D artworks, and the name cel shading came from shortening the name down. So while it could have been cell shading, it's not. It's called cel, not having the second l-letter in it.* (Juha, 2020)

> *Quick history lesson: Cel shading, commonly misspelled as "cell shading," is named for celluloids, which are clear sheets of painted acetate used in classic 2D animation.* (McKellla, 2019)

Cel shading is common when it comes to modern animation. Particularly anime, which is Japanese animation. Animation companies tend to not only use cel shading but expand it to the extent of making technique as an artform itself. One of the most well-known company that practice this is Kyoto Animation or KyoAni. When looked into, the beauty of all of their works contributes to not only their way of storytelling but also their way of using cel shading heavily in them to the point that it is considered as their style of animation. We can see an example of their works in Figure 2.1 and Figure 2.2.

Figure 2.1: A scene in Hyouka (An Animation Made By KyoAni) Utilizing Complex Cel Shading

Figure 2.2: A poster of Violet Evergarden(An Animation Made By KyoAni) Using Complex Cel Shading

Judging from these statements and applications by a professional company, cel shading can be simplified as a technique of applying a simple shading of shadows and lighting to animation. Not only that, but it can also be an art form for animations if used in a complex manner.

2.2.2 How Cel Shading is achieved

It is crucial to understand how cel shading can be achieved. This is due to the idea that shading plays a major role in giving life to your animation.

Nicca (2017) states that there are many advantages to cel shading which are:

- Low difficulty level
- Does not take a lot of time
- Easily applied and changed
- Easily adapted to other coloring styles

However, it does come with the caveat that the artist or animators must understand color theory, and light and shadow values. Based on the article by Nicca (2017), one

must decide the light source when sketching, it is through that one can do their shading accordingly. Figure 2.3 showcases how Nicca(2017) manages her Cel Shading to her artwork.

Figure 2.3: An Illustration by Nicca (2017) showcasing how she manages Cel Shading beforehand

Aside from that many animators will also need to understand the technical sides of software that they used. Particularly in layer management.

Cel shading art form is achieved through the practicing the use of layer type settings and its capabilities. This is mostly due to each layer type brings a different result of rendering colors. Such as multiply, highlight, etc. Furthermore, managing how layers are organized in their works. One of the most commonly idea used organization is making what appears first as the first layer. In most situations, this would be the outline of the animation. Then followed with the details and coloring. Figure 2.4 shows an example of layer management done by an artist.

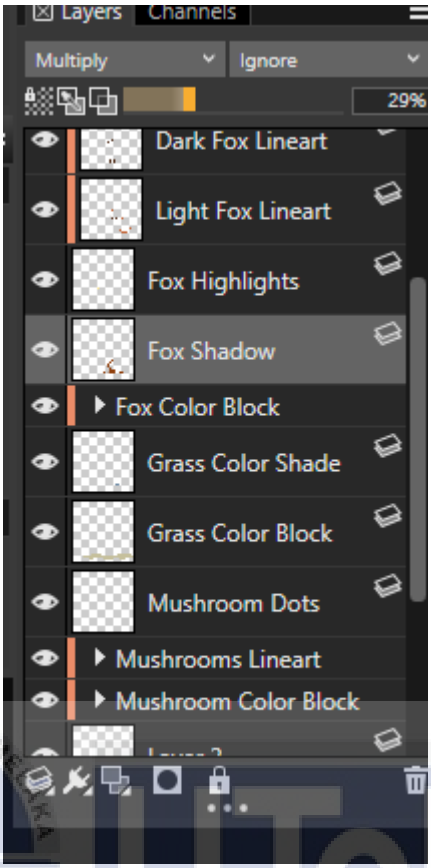

Figure 2.4: Example of Layer Management

In conclusion, cel shading can be achieved if one has good grasp in light theory by fully understanding how light directions effect the shadings of a 2D drawing or drawing. Furthermore, it is necessary for an animator to understand on layer management when it comes to cel shading as well understanding each layer type settings. It is through this knowledge, animators are able to render better shadings, or cel shading in this situation, for their works.

2.3 Project Methodology

For this project, development process is done by phases. The phases are as listed:

i. Literature Review

Research is very important for every project. This is so that the knowledge gained can be a guideline for the production of the project. Secondly, it helps with gaining an understanding to help improve the production for the animation.

ii. Requirement Analysis

As usual, analysis is required at the start of any project. For this project in particular, analysis is done to identify the requirement of developing the 2D animation. Many things were needed to be considered such as:

- The objective of the animation to be developed
- The software required for the animation
- The duration of the animation
- Storyline of the animation

iii. Design

In the design phase, activities involved in designing conceptual model and flowchart of the animation. For this project, character design as well as the storyboarding are to be the main focus.

iv. Development

For the production phase, the production process of the animation is in the works. For this project, development for the animation will be conducted. Key items such as backgrounds, keyframes, base color, etc. will be handled in this phase.

v. Testing

For this phase, any information and knowledge gained during the research phase will be implemented to the product. This is to see whether the wanted effects is as expected. The second significance for the testing phase to be applied for this project are to set a target as well limits to the project's expectation

2.4 Project Requirement

2.4.1 Software Requirements

1. Clip Studio Paint Ex
2. Adobe After Effects
3. Adobe Premiere Pro

2.4.2 Hardware Requirements

1. Animation Workstation (PC)
2. Drawing Tablet

2.5 Conclusion

In conclusion, one must approach cel shading carefully for it to be applied to their animation. Based on the literature review, cel shading can be an artform when done correctly. There are many things that needs to be considered when it comes to cel shading particularly color values and layer management.

CHAPTER 3: ANALYSIS

3.1 Introduction

The analysis chapter provides a more in-depth look of the requirements needed for the project in order to have a deeper understanding of how the project development goes along the entirety of the semester it is conducted. Information regarding the requirements needed is based on testing the capabilities of the workstation used and animation software tested. All requirements for the project will be listed down to give assistance needed for the project development phase.

3.2 Requirement Analysis

3.2.1 Project Requirement

- **User Analysis**

As mentioned in Chapter 1, the target audience of the animation are those who are animation enthusiasts as well those who likes watching animation shorts in general. There will be no age limit for the animation since it does not contain any adulterated scenes whatsoever. However, application of cel shading should be kept in mind as it is the main focus of the entire project. With that in mind, an animation with cel shading will be expected by the audience. Especially those who will evaluate the project.

- **Technical Analysis**

The technical part of a project is also crucial for the project as it is the comprise of important instruments that will bring the animation to life which are the hardware and software. Upon stating this, it is undeniable that certain technical issues will come up during the development process of the animation. For example, hardware failure as well software errors. In addition, methods of overcoming such situations will be required.

With that said, further research on the topic will be needed as to achieve the end product being published in time. Furthermore, it also plays an important role in the rendering time of the entire animation. This is mostly due to the capabilities of certain workstations in rendering being affected by its hardware and the software used. To counter this problem, online forums and YouTube video gives the right amount of information required to overcome the situations stated despite it being regarded as ineligible and incompetent by formal institutions.

- **Resource Analysis**

Due to the ongoing pandemic at the current moment this report is written, many educational institutions are closed in order to abide the Standard Operating Procedure (SOP) that was issued by the Malaysian Government. Therefore, academic resources and references are limited and can only be acquired through the use of internet.

Although, searching for formal resources can be quite difficult due to the internet having many suggestions on certain topics. Therefore, vigilance is required to find the correct resources and references for the project. Particularly for its report writing.

3.2.2 Software Requirement

They are various software available in the market when it comes to the development of 2D animation. The choices of software used for the project is based on how suitable

it is to work on as well its effectiveness in the development. For this project, there are two types of software in particular, which are:

- **Animation Editing Software**

  i. Clip Studio Paint Ex

  Clip Studio Paint Ex is a drawing software developed by Celsys Inc. and plays a major role in the animation drawing process. Its capabilities in giving the user the use of brushes that are found on drawing software in its animation mechanics allows more freedom in the animation drawing process. Especially to those who are familiar in those type of softwares. Figure 3.1 shows the interface of Clip Studio Paint Ex.

Figure 3.1: Clip Studio Paint Ex Interface

  ii. Adobe After Effects

  Certain scenes in the animation requires the use of typography. With that said, Adobe After Effects is the most suitable software for the job given its capabilities in motion graphics.

  iii. Adobe Premiere Pro

  Adobe Premiere Pro plays an important part in combining as well as editing each scene that have been drawn.

- **Documentation Software**

  i. Microsoft Word

  All documentations for the project are done using mostly Microsoft Word, a text document editing software by Microsoft.

  ii. Microsoft PowerPoint

  Any presentation used for the project is uses the capabilities of Microsoft PowerPoint.

3.2.3 Hardware Requirement

- **Workstation**

A workstation is a special computer designed for technical or scientific applications. That said, for this project the minimum requirement for the workstation to render the animation and edited footages of the scenes are:

- 64-bit dual core 2Ghz CPU with SSE2 support
- 4GB Ram of Memories
- NVIDIA GeForce 400/ AMD GCN 1st Gen
- GTX 970 GPU
- 1280x768 Screen Resolution

- **Drawing Tablet**

A drawing tablet is a special hardware used to allow the capabilities of drawing digitally by simulating the action of writing or drawing on paper. Although instead

of using paper, a drawing tablet uses a specialized pad and stylus that are able to sense pressure.

3.3 Animation Analysis

3.3.1 Framerate

The animation uses mostly 12 frames per second for each scene. This is to allow better and faster rendering time. Furthermore, this will decrease workload as I am working with lesser frames. However, this frame rate does come with an issue which is the animation having less details and fluidity of motion in the animation.

3.3.2 Story and Environment

Overall, the animation gives a sense of curiosity with the story that it is given. The flow for all scene works well together for the exposition of the story. The same can be said true for the background used for each scene. Which plays a major role of showing how cel shading effects the animation story wise and environmental wise.

Since I intend that the animation to have no voice lines whatsoever, the viewers can describe the story from the environment of each scene and freely expand it with their own imagination.

3.3.3 Character

The character of the story, though silent, does his role very well in conveying how the audience feel when watching the animation, which is curiosity. Since the character is an android with its memory wipe, it somehow relates the audience when understanding the surroundings the story is set in.

3.4 Project Schedule and Milestones

The project schedule and milestone document are important to draft before the start of the project. Without planned time management, the project might not be completed on

time. It is also act as a guidance to estimate the project flow and progress. The project schedule and milestone are as described in the following Table 3.1 and Figure 3.2:

Table 3.1: Table of Project Milestones

Key Milestones	Start Date	End Date
Pre-production - **Research** - **Scripting** - **Storyboarding** - **Animatic**	March 9th 2021	April 12th 2021
Production - **Voice over** - **Graphic Elements Creation** - **Animation**	April 13th 2021	June 15th 2021
Post-production - **Editing** - **Rendering and Compositing**	June 16th 2021	June 24th 2021

- **Final Output**		
Final Output		June 25th 2021

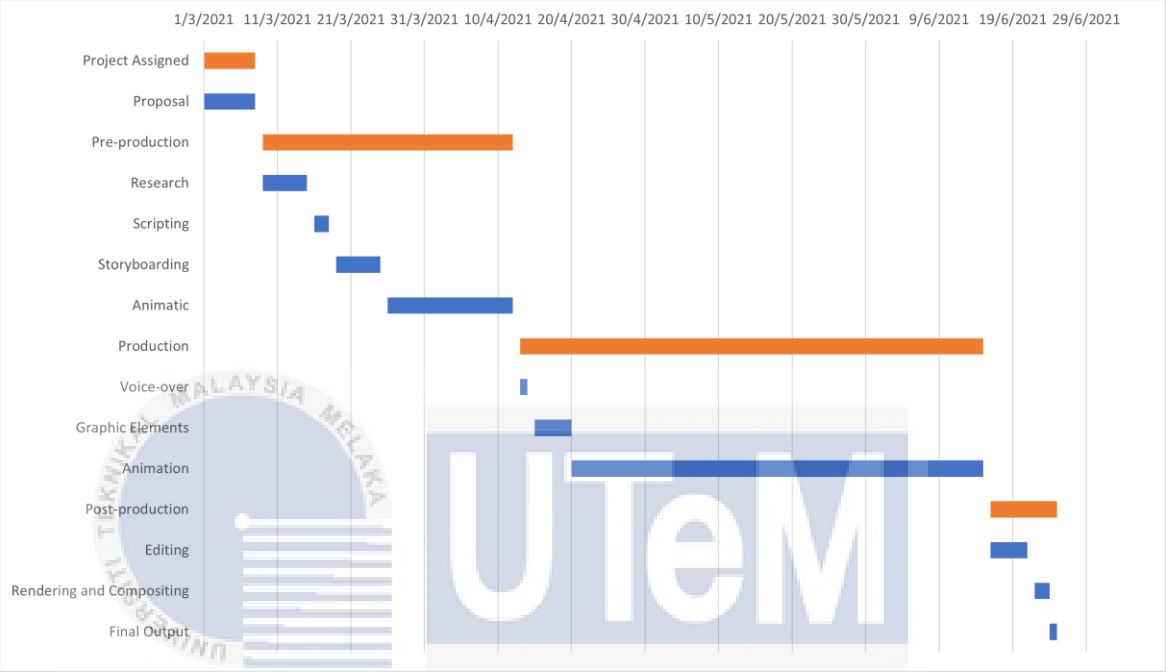

Figure 3.2: Graph showcasing project Milestone

3.5 Conclusion

In conclusion, requirement analysis is important for the project development before the beginning of the production. The analysis shows an overall view of the hardware requirement of this project which concerned throughout this project. The hardware and software requirement need to be analyzed to prepare the material to conduct the project. The project schedule and milestones are also analyzed from the initial idea to the whole development process in PSM 1. In the next chapter, the project will proceed to the design.

CHAPTER 4: DESIGN

4.1 Introduction

The project development emphasizes on the regulation in each phase that involved. This will ensure that the project will be more meaningful for the target users. In this chapter, the design details for the project will be defined. Design is about a solution that meets the requirements and has been analyzed. The design defines the result of the analysis, preliminary design and the result of the detailed design. This chapter is to enrich the storyline and the main characters.

4.2 Preliminary Design

4.2.1 Storyboard Design

Storyboards are important tools used by many animators, or many artists in general, as it presents a rough draft of what each of the animation scenes would look like. Each scene will be planned out with rough sketches in the storyboard to give a representation on how the sequence of scenes would play out. Animators would then create a rough draft of the animation, or animatic as they are called. An example of an animation storyboard can be seen on Figure 4.1.

Figure 4.1: A storyboard of a scene in Gorillaz Feel Good inc Music Video

As easy as it sounds, the process of storyboarding can be quite difficult as it requires a good amount of planning for each scene. This is due to how the scenes affect each as well the entirety of the animation. In summary a well thought story is the key is important for how the animation story flows and captivating the audiences.

For this project, the storyboarding starts off with the basis that any animators should know. And that is to come up with a story. The story for this project revolves around an android that awoke in a post-apocalyptic future. As such, a script was written to plan how the storyboarding of each scene will play out. Figure 4.2 shows a part of a written script done for the project.

Our story starts off in a desolate city. Curiosity begins to rise as to what cause such a sight. Skyscrapers no longer reached the clouds like they used to. Building blocks either destroyed or decayed as the years aged them.

However, not all is gloom as it seems. Instead, the destruction is compensated with varieties of flora and fauna. Large greeneries cover the debris and is inhabited by odd-looking creatures but nevertheless have the same features of the lifeforms that we know of.

Birds still have wings but instead of two they have four of them. Jellyfish would float in the air instead of water. Flowers of the same species would pop out with different variety of colors. The list just keeps on going.

That said, whatever is going on here indicates something significant. The presence of evolution from the common creatures can only mean one thing. And that is whatever happened here, happened a very long time ago.

That said an anomaly can be seen within the debris of the destroyed buildings. A pod that what one can assume can only be seen in the Sci-fi films. The pod itself was producing a looping beeping noise indicating that it is malfunctioning or something of the sort.

As the beeping noise stop, the pod opens and what seemed to be a human boy, that is if you can call him human if it were not for the glowing blue lines coming down from his eyes. When the ‘boy’ rise from the pod, he took in the sight in front of him.

However, he did not show any expression that emotes happiness, sadness or shocked whatsoever. Instead, what bore on his face is more of a robot-like curiosity. After catching the sight in front of him, the ‘boy’ felt something within the palm of his right hand. Noticing that it was in closed grip the entire time, he opened his right hand only to find a USB drive….

Figure 4.2: Part of the Script written for the project Animation

After writing the story, the project continues with drawing the storyboard for the animation. The storyboards can be seen in Figure 4.3.

Figure 4.3: Storyboards created for the project Animation

Note: Certain scenes may vary from the storyboard as the project development continues.

4.2.2 Character Design

A character design is crucial when it comes to animation. This is due to the characters being the focus of the story. Especially the protagonist and main characters. During

development, the projects plan on creating a child character as it the story revolves around curiosity. In a way, it relates to all age groups as it represents the child-like curiosity during their youth. All characteristic of the main character in the story are as listed below:

- Child
- Boy
- Is curious about his surroundings
- Robot like features

After listing the characteristic, inspiration for the character would be searched. As a result, the project finds that the best inspiration for the character design is Astro boy, a character designed by Osamu Tezuka, a Japanese illustrator and manga artist. Figure 4.4 shows an illustration of Astro boy.

Figure 4.4: An illustration of Astro Boy by Osamu Tezuka

Aside from Astro boy, the project also finds inspiration in the game Detroit: Become Human by Quantic Dream compony. Particularly the way they differentiate their android and human characters in the game. In the game, androids are shown to have a colored ring at their temple. The color would change colors based on the androids condition. For example, in Figure 4.5 the ring is colored blue meaning that they are

stable and Figure 4.6 the ring is colored yellow indicating the android is facing an increased activity or strain.

Figure 4.5: An Android in Detroit: Become Human game have blue ring on her temple. Indicating she is in stable condition.

Figure 4.6: The same Android having a yellow ring. Indicating that she is facing increased activity or strain.

With both of the illustration and game being an inspiration in the character design of the project, the character can now be drawn based on them. Figure 4.7 showcases the concept art for the character used in the animation.

Figure 4.7: Concept Art of character for the Animation

4.3 Conclusion

In conclusion, this chapter mostly discusses on the storyboard and character design that was used for the animation. It is important for to develop a storyboard and character design for an animation project. Great and nice design will contribute greatly to letting the audience understand the story. This stage is crucial to identify all elements that are required in the project.

CHAPTER 5: IMPLEMENTATION

5.1 Introduction

This chapter will explain the project implementation for a short story of 2D animation, The Lone Android. This phase includes media creation, media integration, product configuration management, and implementation status. The implementation phase is done according to the study of the previous chapter. The goal of this product implementation is to provide the outline of techniques and elements that have used for developing this 2D animation video. The types of elements productions that are used for developing this 2D animation such as text, graphic, audio and animation such as text, graphic audio and animation will be discussed. The integration process will state about what kind of process that used to develop this animation.

5.2 Media Creation

This part of media creation will cover all the process of media component is created and edited manually and separately before it will be integrated later in media integration part. This process includes production of texts, graphics, audio and animation respectively.

5.2.1 Production of Texts

Most of the text involved in the animation is done in Adobe After Effects. Text is important as it provide information to the audiences to understand the context of the story of the animation. To make sure that the text is readable, the color of the text must

be accordance with the colors used for the background. That said, certain aspects are considered when it comes to the texts used in the animation:

- Font Type
- Color
- Size

With the given aspects, this project was able to finalize the text used in the animation as shown in the Table 5.1 below:

Table 5.1: Font Settings used for the Project

Font Type	Color	Size
Impact	Red	65px
Prestige Elite Std	Neon Green	40px

5.2.2 Production of Graphics

The graphics used in the animation is done in Clip Studio Paint EX. Clip Studio Paint is remarkable when it comes to hand drawn digital drawing due to its fluency with any drawing tablets and the varieties of brushes, provided by the software and its community. A simple production process was used for the graphics used in the animation, as shown in Figure 5.1 below:

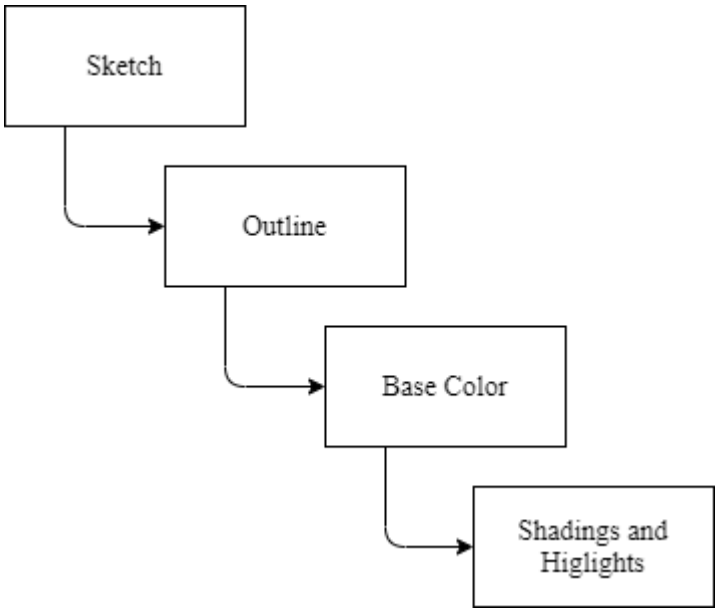

Figure 5.1: Flow of Graphic Production for Project

Below shows Table 5.2 which showcase the outputs for each production process:

Table 5.2: Table Showcasing Graphic Production Outputs

Production Process	Output
Sketch	

Outline	
Base Color	
Shading and Highlights	

5.2.3 Production of Animation

In this part, the environment is created according to the storyboard that already done in pre-production phase. Once that is finished, the project then goes on with initial sketch of a scene in the production phase. The initial sketch, which can be seen in Figure 5.2, gives the idea of how the scene is played out by being the starting frame and shows the environment it was set in.

Figure 5.2: Initial Sketch of a scene

Movement in the scene is then sketch in another layer. These movements will be provided with keyframes as well guideline so it can be referenced to create in-between frames. Figure 5.3 and Figure 5.4 showcases the use of keyframes for the Animation development.

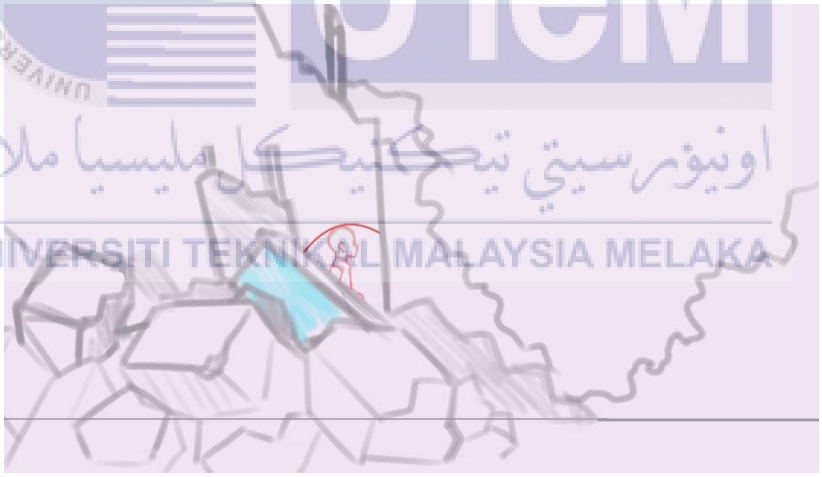

Figure 5.3: Sketch of Keyframes in Animation

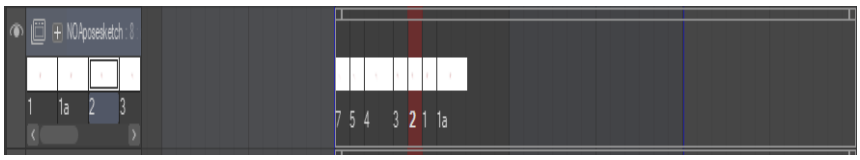

Figure 5.4: Showcase of Frame management in Clip Studio Paint EX

Following the same principles as the graphic production process, which can be referred on **Table 5.2**, the animation process then follow suit with the outlines and base color, then continue with adding the shadings and highlights in the post-production phase.

Once finished, all scenes will be rendered and combined using Adobe Premier Pro. The file with the compiled scenes will be published in MP4 format.

5.3 Media Integration

Media integration part explains about how all the media components were integrated to each other to make this product useful and functional. The integration files between text, graphics, and animation will interact to this part.

In summary all graphics and animation of the scenes are drawn and rendered using Clip Studio Paint EX. All textual contents of the animation is created and rendered using Adobe After Effects. Once finished they are compiled into a video in Adobe Premiere Pro and is rendered to MP4 format. A simple representation for this flow can be seen in Figure 5.5.

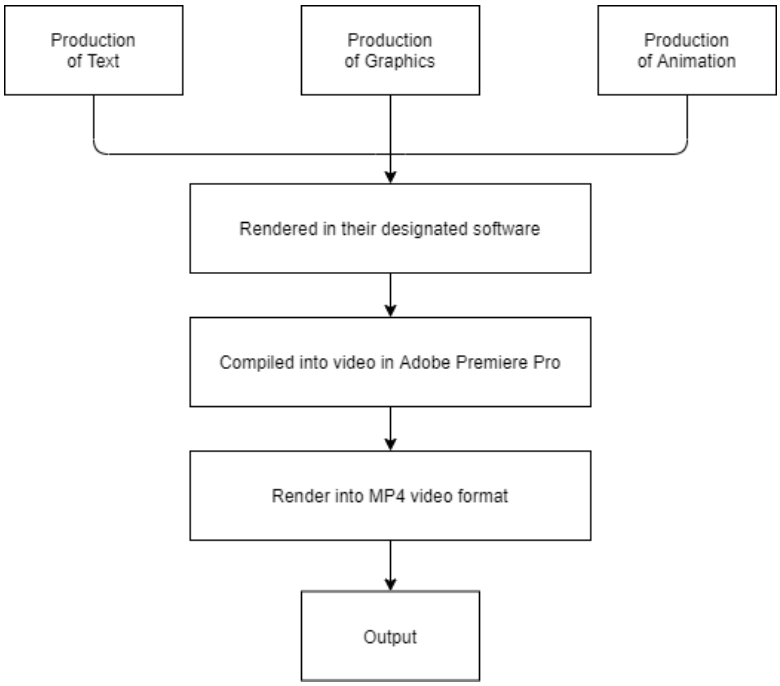

Figure 5.5: Flow of Media Integration for project

5.4 Product Configuration Management

Product configuration management will discuss about the configuration environment setup and version control procedure. In this part, the configuration environment setup and the version control procedure will be briefly described

5.4.1 Configuration Environment Setup

The main platform for developing this 2D animation is mostly done in Clip Studio Paint EX. Other than that, Adobe After Effects also plays a role in creating specific scenes of the animation. Once finished, all the scenes are compiled into MP4 video format in Adobe Premiere Pro.

5.4.2 Version Control Procedure

The version control produce is the process of managing the version of the products. There are two types of versions which is Alpha and Beta version. The entire

version comprises of some testing procedures that the testers attempt to execute several operations to identify and analysis the reaction and result of the test. Before starting each task on the scenes, the correct configuration setup also must be done with the software. It is important to make sure that the final output has produced perfectly.

Table 5.3 and Figure 5.6 below shows the configuration settings in Clip Studio Paint EX.

Table 5.3: Table of Clip Studio Paint EX Scene Configuration

Software	Configuration
Clip Studio Paint EX	I. Width: 1920 II. Height: 1080 III. Resolution: 300ppi IV. Frame Rate: 12

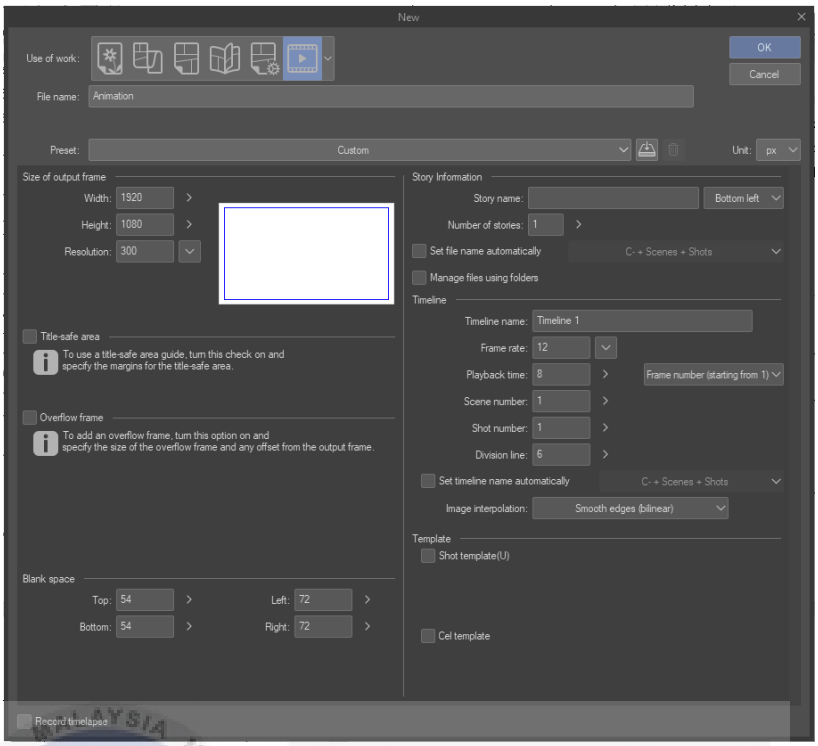

Figure 5.6: Settings Window of Clip Studio Paint EX for Scene Configuration

Table 5.4 and Figure 5.7 below shows the settings used in Adobe After Effects:

Table 5.4: Table of Adobe After Effects Stage Configuration

Software	Configuration
Adobe After Effects	Stage Composition: I. Type: Composition II. Size: 1920x1080 III. Framerate: 29.97 IV. Resolution: Full

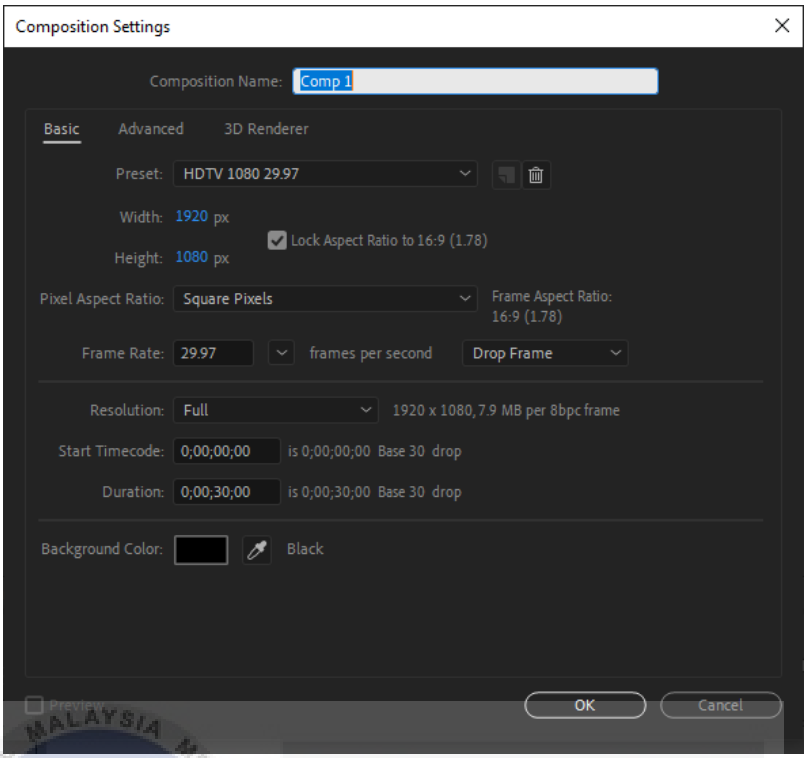

Figure 5.7: Composition Settings Window for Adobe After Effects

Table 5.5 below shows the configuration used for video compilation in Adobe Premiere Pro:

Table 5.5: Table of Video Configuration in Adobe Premiere Pro

Software	Configuration
Adobe Premiere Pro	Sequence Presets: I. Preset Name: HDV108024

i. Alpha Version

This alpha version part where the product is tested by a developer in order to ensure the project is free from errors. The developer is responsible to overcome

the error before the product is released to the end users. During the development, this project has done 5 versions for Alpha version testing. Table 5.6 elaborates each version of the project.

Table 5.6: Table of Project Version

Version	Description
Version 1	Illustrate and create the character, environment, camera angles and related graphics
Version 2	Editing the product
Version 3	Finalize all the animate part and improve

ii. Beta Version

For beta version, the testing is done for end user after the alpha testing is done. The user must be a target user in order to make sure that the error is really occurred during the test, this beta version is released using a booth at a public place so that developer can find many users. The error that may occur then will be repair and the golden master release.

iii. Golden Master Release

This part will be the end and final where the product has been perfectly tested and ready to be released of presented with full functionality and potentials. It is considered very stable and expected to be free from bugs.

5.5 Implementation Status

Implementation status is to track the progress of the activities to complete this 2D animation project, The Lone Android. Table below show the implementation status, which there is listed down in the general components task in the overall implementation phase of the project.

5.6 Conclusion

As a conclusion, this chapter has discussed and explains the implementation phase of this project. This includes the detail overview of the development process, the media creation, media integration, product configuration management, and implementation status. The next chapter will discuss the testing process of the project that includes test plan and test implementation in detailed.

CHAPTER 6: TESTING

6.1 Introduction

This chapter describes the testing for the project and its results. The project testing phase is conducted so that developers can observe significant outcomes for their projects. This chapter consists of test plan which includes test environment, test schedule and test strategy. All of which will be discussed further in the chapter.

6.2 Test Plan

6.2.1 Test User

The project requires no user testing since it is mostly focusing the aspects of animation process. The project utilizes the workstation used as described in **3.2.3**. The software used for the animation, which is Clip Studio Paint EX, will also be used for the testing.

6.2.2 Test Schedule

Due to the limited resources and the time, it takes for Clip Studio Paint EX to render, the testing phase might take a couple of days to finish than it was planned. To overcome this, each scene for the animation will be done and rendered separately.

6.2.3 Test Environment

All testing will be done in a closed-office environment. Testing implementation will be done inside the workstation with the Clip Studio Paint EX which is the software used for the project.

6.3 Test Strategy

One of the objectives of this project is to evaluate the rendering time for animations that are implemented with cel shading. For this project's animation, various settings will be adjusted to see the differences in rendering time. While at the same time, see if the quality of the animation is still suitable for viewing. All the actions stated is done to find the suitable setting requirements to render the animation.

6.4 Test Implementation

As stated before, all tests for the project will be carried out using Clip Studio Paint EX. For this phase, one scene of the project animation will be rendered with different settings five times to find the suitable settings for the remaining scene. Each test results will be calculated for their average values to be compared. The different settings for the scene rendering are as follows, GPU Usage, resolution, and image interpolation. Each rendering for each different settings will be recorded as well to come up with an efficient solution for rendering.

6.5 Test Data

Below is the checklist of the rendering settings for the project. The test will be conducted targeting the render settings shown in the checklist.

Table 6.1: Testing Phase Checklist

	Rendering Settings
1.	**Image Interpolation Setting**

	- Smooth Edges (Bilinear)
	- Hard Edges (Nearest Neighbour)
	- Clear Edges (Bicubic)
	- High Accuracy (Average Colors)
2.	**Resolution Settings**
	- 1280 x 720
	- 1920 x 1080
3.	**GPU Settings**
	- With GPU
	- Without GPU

The data results that we will be focusing on this testing phase will be the time taken for each test to render the scene of the animation.

6.6 Test Result and Analysis

6.6.1 Image Interpolation

The image interpolation will be the testing the rendering the animation with different image interpolation settings. Image interpolation is the general term for the techniques used in image synthesis to generate intermediary pictures between two images. To put it simple, it is the process of how a software generate in-betweens for frames, be it animation or an image. For this test, this project will be focusing on the

rendering time for each image interpolation settings that has already been prepared by Clip Studio Paint in default. Which are:

- Smooth Edges (Bilinear)
- Hard Edges (Nearest Neighbour)
- Clear Edges (Bicubic)
- High Accuracy (Average Colors)

The **Figure 6.1** below shows the gives a detailed definition of each interpolation setting by Clip Studio.

Smooth edges (bilinear)	This method blends the colors of neighboring pixels to create smooth outlines (boundaries between colors). However, outlines may become blurred depending on the image.
Hard edges (nearest neighbor)	When interpolating the image, the pixels in the image are duplicated. Since the colors are not affected by neighboring pixels, outlines (boundaries between colors) remain sharp. However, outlines may become jagged depending on the image.
Clear edges (bicubic)	This method blends the colors of neighboring pixels to create smooth outlines (boundaries between colors). This method results in stronger outlines compared to the [Smooth outline (bilinear method)] setting. However, white noise may appear around outlines depending on the image.
High accuracy (average colors)	The average colors of the original pixels are strictly calculated and contained for each pixel after the transformation. Scaling up makes the line sharper and scaling down makes the line smoother. Even detailed lines can be transformed smoothly when scaling the image down. However, this method can result in blurred outlines and can take a long time to process depending on the image.

Figure 6.1: Detail Definition on the Image Interpolation settings prepared by Clip Studio

Past research has been done by on the time it takes to render using three of the settings. A study made Hasan (2017) was able to come up with the results in **Figure 6.2**, which showcases that the time rendering using the nearest neighbour setting is less than the Bicubic and Bilinear settings.

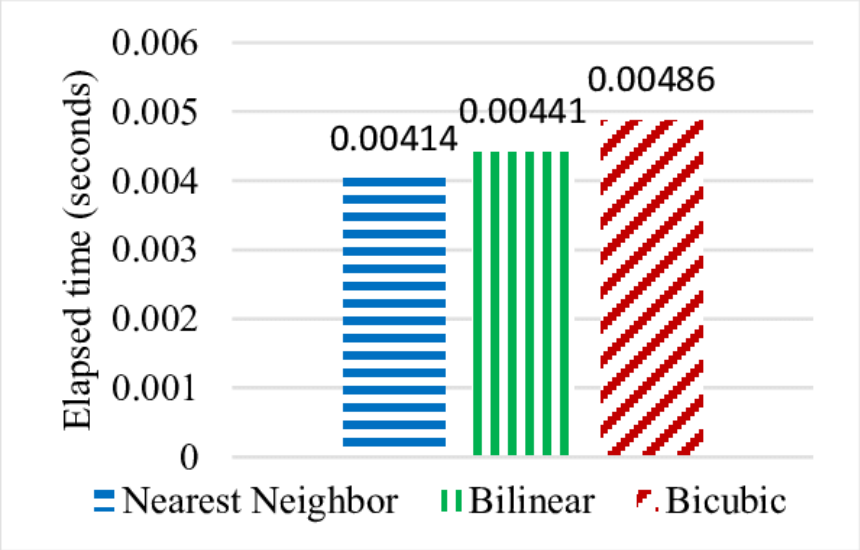

Figure 6.2: Research on the Execution time comparison between Nearest Neighbour, Bilinear and Bicubic by Mohammad Shahidul Hasan(2017)

Based on the paper, it is stated that due to the Nearest Neighbour setting being the simplest setting it is evidently the fastest.

Aside from that Dianyuan (2015) also conducted a test regarding image interpolation which result in the findings on **Figure 6.3**.

Interpolation Type	Subjective Feelings	Image Contour	Overall Evaluation	Processing Time (seconds)
Nearrst_ Neighbour	obvious mosaic phenomenon	Not clear	Worst	5
Bilinear	blur, not sharp	not clear, serrate phenomenon	Poor	6
Bicubic	fuzzy, sharper	serrate phenomenon has improved	Better	8
B-Spline	relatively clear, sharp	Edge becomes clear, serrate phenomenon disappeared	Good	17

Figure 6.3: Evaluation made by Dianyuan (2015)

Based on the figure, we can see a patter that the results are somewhat similar to Hasan (2017). Being that the nearest neighbour setting being the least in processing time and the one with the highest processing time being the Bicubic setting.

6.6.2 Resolution

For this test, the selected scene for this test will have different resolution settings when rendered. The purpose of this test is to see if there is any differences in the rendering time when it comes to changing the resolution of an animation which has been applied cel shading. An animation resolution plays a role when it comes to displaying 2D animation since it is the very dimension size of the animation in terms of its pixels and how tall and wide the animation will be. For this test, the resolution used will be as follows:

- 1280 x 720
- 1920 x 1080

6.6.3 GPU

Each setting will be done with the option of being rendered with or without the GPU's assistance. Since the roles of GPU in modern animation has increased with rendering. This project will observe how much time can the GPU reduce when it comes to rendering animation specifically 2D animation.

6.6.4 Overall Results

The following are the overall results of the testing phase with each of the settings taking account.

Table 6.2: Table of the Average Rendering Time (mm:ss.00) of Testing Phase

1280 x 720 Resolution		
	With GPU	**Without GPU**
Smooth Edges (Bilinear)	00:01.57	02:56.65
Hard Edges (Nearest Neighbour)	00:02.19	02:59.47
Clear Edges (Bicubic)	00:02.08	03:17.59
High Accuracy (Average Colors)	00:01.12	01:02.70
1920 x 1080 Resolution		
	With GPU	**Without GPU**
Smooth Edges (Bilinear)	00:02.49	03:02.37
Hard Edges (Nearest Neighbour)	00:03.00	03:09.64
Clear Edges (Bicubic)	00:02.84	03:33.67
High Accuracy (Average Colors)	00:01.73	01:30.15

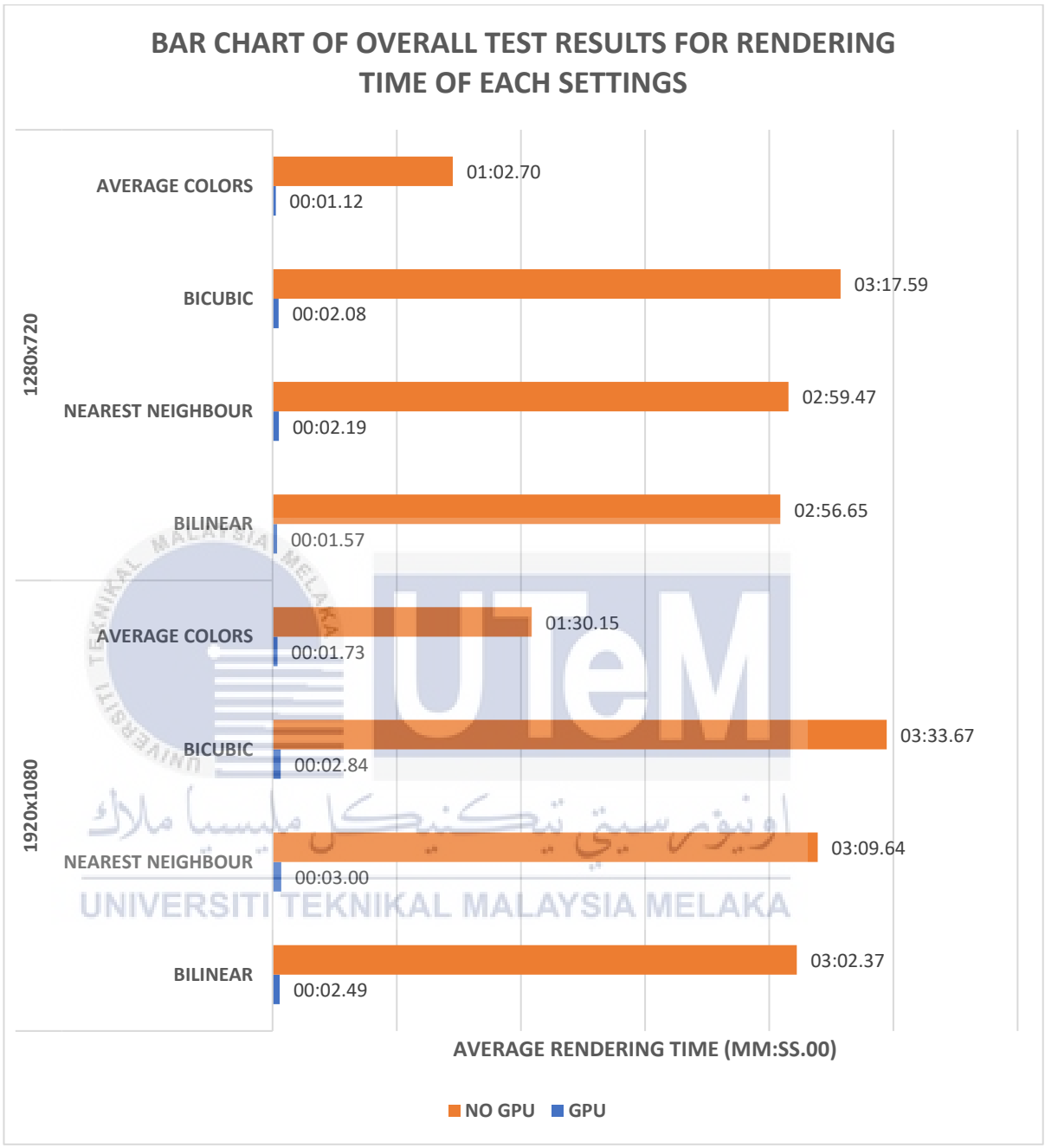

Figure 6.4: Bar Chart of the Average Rendering Time (mm:ss.00)

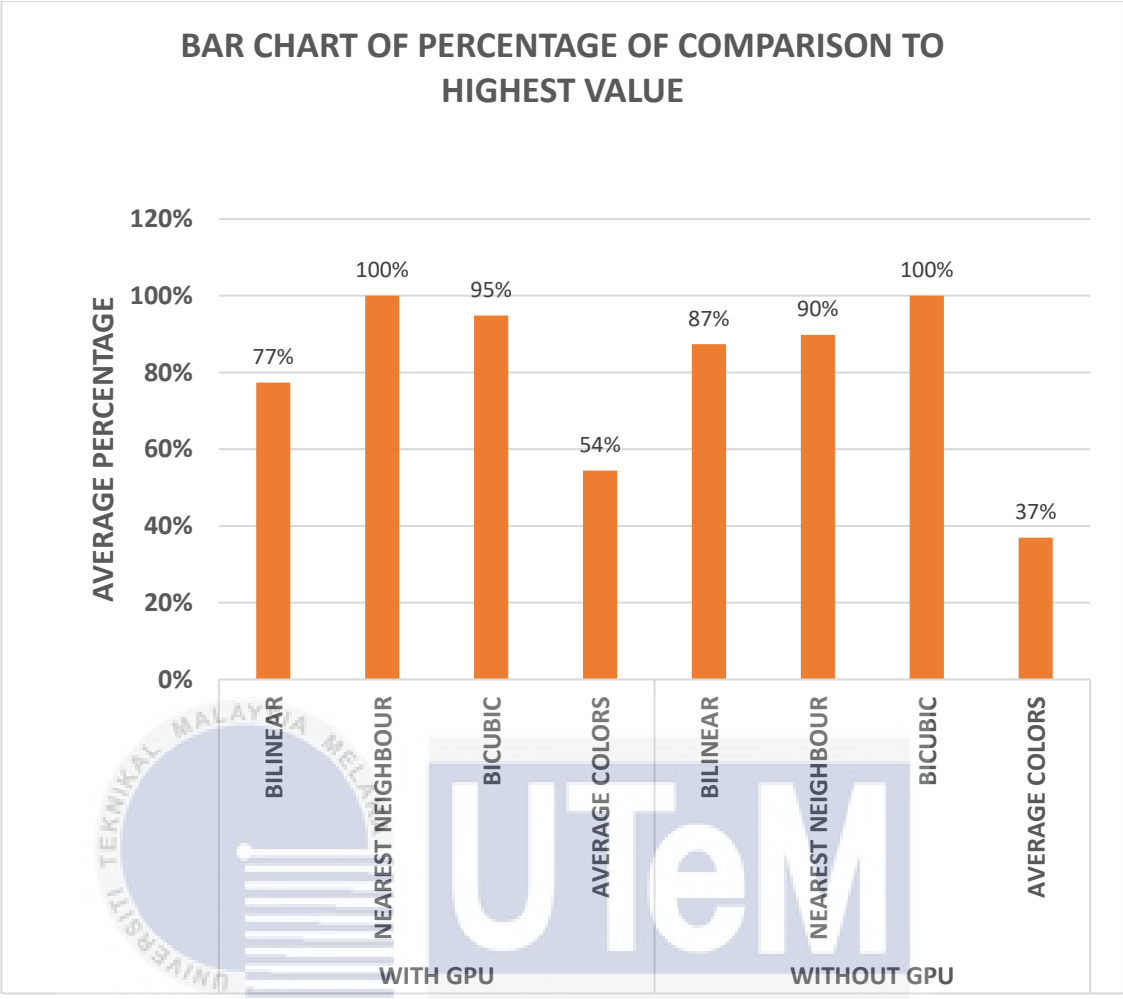

Figure 6.5: Bar Chart of the Percentage of Comparison to the highest time rendering value for each Image Interpolation setting

Judging from the overall results from **Table 6.2** and **Figure 6.4**, we can see that the image interpolation with least amount of rendering time is the High Accuracy setting. With a crucial amount of 1-2 seconds saved compared to other settings when rendering with a GPU and 2 minutes saved when rendering without a GPU. Aside from that we can see that there is a big amount of time reduced when it comes to rendering the animation using a GPU.

Based on the overall results, the gap between the average rendering time for both resolution is small by only a few milliseconds when using GPU rendering and around 20-30 seconds without GPU rendering. On the other note, we can see that there is a large gap between using GPU and without GPU rendering by a decent amount of two minutes. Here we can conclude that the animation resolution plays a small part in the

rendering time for 2D animation that has been applied cel shading. Aside from that, we can the similarity between the Image Interpolation Test and Resolution Test when it comes to gap of using GPU rendering. Where we can conclude that by using GPU can help tremendously with decreasing the rendering time.

Overall, it is determined that by using the average colors image interpolation settings, the rendering time was able to reduce under the average of 60% than the other image interpolation settings. Furthermore, the use of a GPU helps tremendously with decreasing the rendering time with the average of +95% throughout most of the rendering. However, when it comes to the effects of resolution, the project finds that by decreasing the size of the resolution only led to small percentage to decrease the rendering time. Which is about 4 – 8% when compared.

6.7 Conclusion

To conclude, this chapter describes the efforts when going through the testing phase. The testing phase is an important phase to the development of this project. All the data gathered have provide a huge help with achieving and understanding one of the objectives for this project. However, there are few possible improvements that can be done in future work based on the strength and weakness of the project. The next chapter will provide a better description of the aforementioned.

CHAPTER 7: PROJECT CONCLUSION

7.1 Observation on Weaknesses and Strengths

Like many projects, 'The Lone Android: Short Preview' may seemed well done to some viewer but it does have its own weaknesses. Particularly in its development and testing phase. The purpose of this chapter lies in describing on said weaknesses as well as strength of the project.

7.1.1 Difficulties Faced

They were many difficulties discovered faced in the development of this project. These difficulties are deemed to be weaknesses that will need improvement in the future to fulfill the requirements needed. The weaknesses are as follows:

i. Equipment

During the development of the animation, the only equipment used to draw the animation on the computer was a drawing pad. Although it is helpful when it comes to drawing, it is quite difficult when it comes to creating an animation. This is because it requires to work on the same scene with many frames. Which can be quite straining for the hands and may lead to carpal tunnel syndrome.

ii. Storytelling and Staging

One of the main issues to the animation would be the context to the storytelling and staging every scene properly. Although it is still a short preview it does not hide the fact that certain scenes to the animation feels somewhat disconnected.

iii. Pandemic Difficulties

During the entirety of the project, the Covid-19 pandemic was still going on. Students are obligated to stay at home. Therefore, implying that balancing coursework and house sitting can be a challenge since it is very tiring.

7.1.2 What the Product was able to fulfill

i. Animation

Scenes for the animation respectfully follows some of the principles of animation. Rather than being a slideshow animation, body motions and movements of the character in the animation can be seen. Thus, showing the effort that goes in the animation.

ii. Multimedia Elements

The project animation contains the multimedia elements to provide better content. Elements such as text, graphic, and animation were integrated within the animation.

7.2 Suggestions for Improvement

This section provides the suggested improvement needed on making the animation better. They are a few ways in achieving these improvements which are:

i. Better Equipment

It is suggested by professionals that when it comes to animation, it is better to use a digital drawing tablet. This is due to them providing a more upfront view when it comes to drawing the animation rather than working separately on another screen with their hands operating the drawing pad. Although it does not stop them from facing carpal tunnel syndrome, it does provide less strain for the animators and artists.

ii. Improved Storytelling

As stated, there needs to be an improvement for the context to the animation. Scenes will need to be able to provide enough information to be able to connect with each other. Just because the animation is only around 1 – 2 minutes, it does not mean that good storytelling cannot be achieved.

7.3 Project Contribution

As stated in the objectives of this project, this project's mainly focuses on the technical parts of applying cel shading in 2D animation as well with providing data on the rendering time. With that being said, plays a role in providing the new animators and animation enthusiast on understanding more on cel shading in 2D animation and be a guideline for them to applying them.

7.4 Conclusion

In conclusion, the project was able to achieve its objectives by providing the information required as well producing an animation in fulfilling its criteria. The project can be used as a guideline for newbie animators and show enthusiasts the workaround to cel shading in 2D animation. Although it may look simple, cel shading can be quite difficult to achieve due to the processes it goes through and without proper understanding, the appeal that they are looking may not be attain.

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APPENDIX A

RESULT OF AVERAGE RENDERING TIME FOR IMAGE INTERPOLATION AND RESOLUTION TEST

RESOLUTION: 1280x720

IMAGE INTERPOLATION SETTINGS: Smooth Edges (Bilinear)

	GPU Usage	
Test Number	**With GPU**	**Without GPU**
1	00: 01.15s	02:57.02s
2	00:01.45s	02:55.34s
3	00:01.35s	02:57.65s
4	00:02.01s	02:56.23s
5	00:01.89s	02:57.02s
Average (mm:ss.00)	00:01.57s	02:56.65s

IMAGE INTERPOLATION SETTINGS: Hard Edges (Nearest Neighbour)

	GPU Usage	
Test Number	**With GPU**	**Without GPU**
1	00: 02.12s	03:00.10s
2	00:02.34s	02:59.32s
3	00:02.23s	02:59.12s
4	00:02.10s	03:01.50s
5	00:02.17s	02:57.29s
Average (mm:ss.00)	00:02.19s	02:59.47s

IMAGE INTERPOLATION SETTINGS: Clear Edges (Bicubic)

	GPU Usage	
Test Number	**With GPU**	**Without GPU**
1	00: 02.34s	03:20.12s
2	00:02.13s	03:19.40s
3	00:01.78s	03:15.23s
4	00:02.12s	03:14.30s
5	00:02.05s	03:18.90s
Average (mm:ss.00)	00:02.08s	03:17.59s

IMAGE INTERPOLATION SETTINGS: High Accuracy (Average Color)

	GPU Usage	
Test Number	**With GPU**	**Without GPU**
1	00: 01.45s	01:11.32s
2	00:00.98s	00:59.65s
3	00:01.12s	01:00.30s
4	00:01.03s	01:03.26s
5	00:01.02s	00:58.98s
Average (mm:ss.00)	00:01.12s	01:02.70s

RESOLUTION: 1920x1080

IMAGE INTERPOLATION SETTINGS: Smooth Edges (Bilinear)

	GPU Usage	
Test Number	**With GPU**	**Without GPU**
1	00: 01.61s	03:02.61s
2	00:02.74s	03:01.54s
3	00:02.70s	03:02.54s
4	00:02.54s	03:02.75s
5	00:02.85s	03:02.42s
Average (mm:ss.00)	00:02.49s	03:02.37s

IMAGE INTERPOLATION SETTINGS: Hard Edges (Nearest Neighbour)

	GPU Usage	
Test Number	**With GPU**	**Without GPU**
1	00:02.95s	03:10.30s
2	00:03.21s	03:08.25s
3	00:02.82s	03:09.45s
4	00:03.83s	03:09.98s
5	00:02.18s	03:10.23s
Average (mm:ss.00)	00:03.00s	03:09.64s

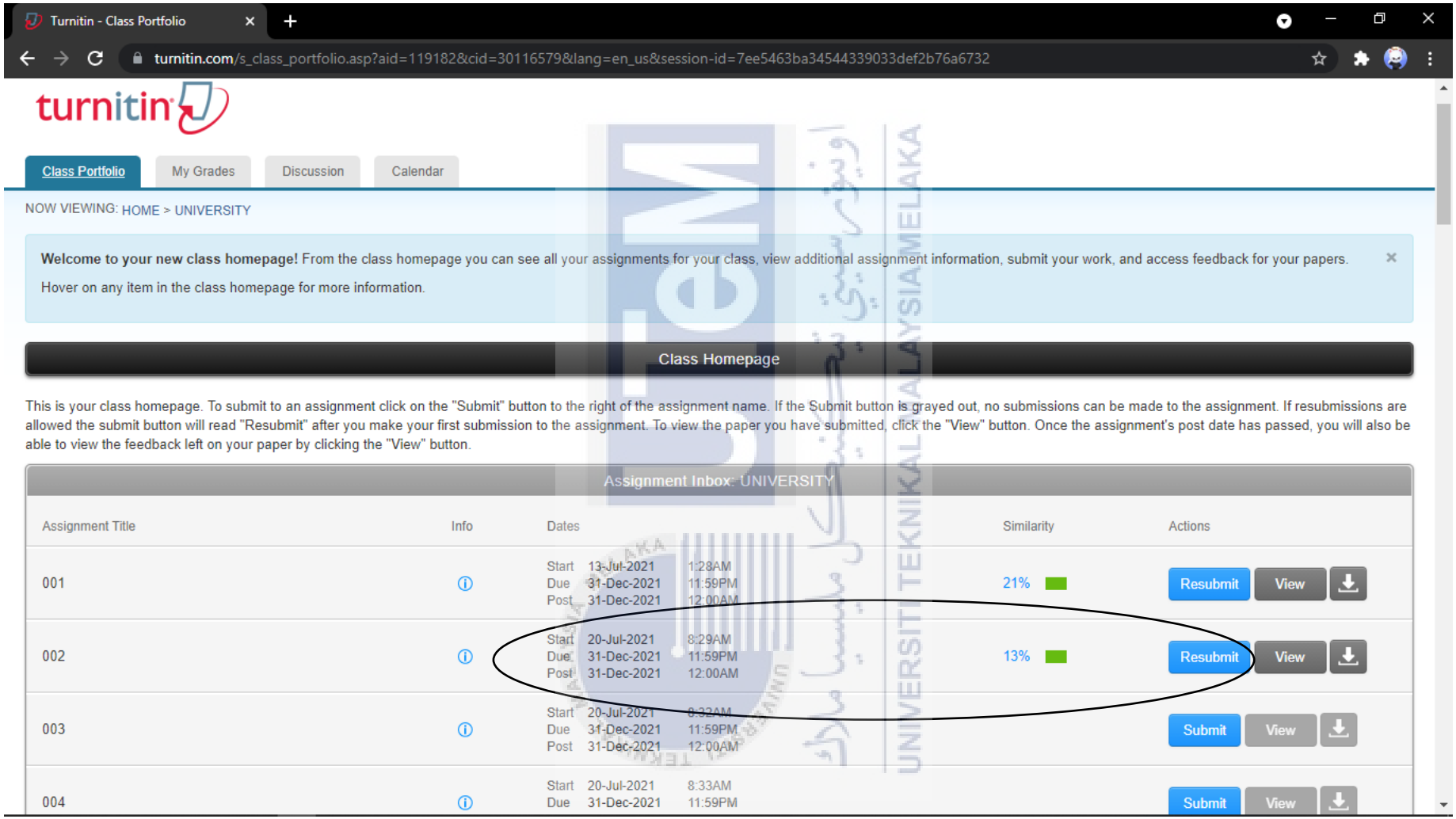
IMAGE INTERPOLATION SETTINGS: Clear Edges (Bicubic)

	GPU Usage	
Test Number	**With GPU**	**Without GPU**
1	00:02.97s	03:39.32s
2	00:02.77s	03:24.20s
3	00:02.71s	03:28.43s
4	00:02.85s	03:43.12
5	00:02.92s	03:33.29s
Average (mm:ss.00)	00:02.84s	03:33.67s

IMAGE INTERPOLATION SETTINGS: High Accuracy (Average Color)

	GPU Usage	
Test Number	**With GPU**	**Without GPU**
1	00:02.06s	01:31.23s
2	00:01.73s	01:28.32s
3	00:01.65s	01:30.56s
4	00:01.55s	01:32.89s
5	00:01.65s	01:27.75s
Average (mm:ss.00)	00:01.73s	01:30.15s

APPENDIX B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Info
Dates
Similarity
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