OPTIMIZING COLOUR RESOLUSION IN 3D MODEL AND ANIMATION FOR FAST RENDERING TIME BETWEEN PC AND MACINTOSH

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Thesis Submitted in Fulfillment of Requirements for the Degree of Master of Science in Faculty of Computer Science and Information Technology
Universiti Putra Malaysia

October 2003

Dedicated to my lovely mum Wan Khadijah Wan Ibrahim
and my wife Norzelawati Asmuin.

Declarations

I hereby declare that this project is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that is has not been previously or concurrently submitted for any other degree at UPM or other institutions.

.....

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Approval Sheet

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Abstracts

This project studied whether the optimizing of colour resolution for the non-photorealistic 3D model and animation can make the rendering process becomes faster than before. 130 frames of short and simple 3D animation were tested. Four types of colour resolution in three categories of screen resolution was applied to the 3D animation, and the result shows that the screen resolution give more impact to the rendering process time compare to the colour resolution. This project also present a comparative study between PC-based and Macintosh-based in the 3D model and animation rendering process. The same 3D animation was tested through the two different platforms which has quitzsimilar in terms of performance and the result shows that Macintosh-based perform better that PC-based in all rendering processes.

MENGOPTIMAKAN WARNA DALAM MODEL 3D DAN ANIMASI UNTUK MENDAPATKAN MASA TERPANTAS DALAM PROSES RENDER MENGGUNAKAN PLATFORM KOMPUTER DAN MACINTOSH

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Oktober 2003

Abstrak

Projek ini ialah kajian bagi mengealpasti tahap optima resolusi warna untuk model 3D dan animasi yang tidak photorealistik. Ini bagi membolehkan proses render menjadi lebih cepat berbanding sebelumnya. Animasi 3D yang pendek iaitu sebanyak 130 frame telah diuji. 4 jenis resolusi warna yang terdapat dalam 3 kategori resolusi paparan telah di aplikasikan kepada animasi 3D tersebut. Keputusan yang diperolehi menunjukkkan resolusi paparan memberikan lebih impak terhadap masa proses render berbanding resolusi warna. Perbandingan antara 2 platform iaitu komputer peribadi dan Macintosh dalam proses render animasi 3D juga telah dilakukan di dalam projek ini. Animasi 3D yang sama telah diuji menerusi 2 platform tersebut di mana ke dua-duanya mempunyai keupayaan memproses yang hampir sama. Hasil kajian menunjukkan platform Macintosh memperlihatkan keupayaan yang lebih tinggi berbanding komputer peribadi dalam kesemua proses render.

ACKNOWLEDGEMENTS

Alhamdulillah, thanks to Allah s.w.t and deep thanks to my Supervisor Pn. Lili Nurliyana Abdullah to her support, guidance and encouragement throughout this project.

It is very generous of Associate Prof. Dr.Abdul Azim to his indeed helps through out this project. I acknowledge the support from lovely wife Norzelawati, my kids Nurul Azizah, Abdul Hakim and Abdul Hanan. Thanks to Faizan, Razalee, Azizol Zamri and Usuloudin, the KUITTHO computer laboratory assistant who helped me during the process of this project.

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CHAPTER 1

INTRODUCTION

1.0 Introduction

Science fiction, cartoon and action movies today cannot avoid from using computer graphic especially 3 Dimensional (3D) models and animation as part of their features. When talk about 3D models and animation, terms like modeling, animation, rendering, wire frame, texture, photorealistic and non-photorealistic and color resolution need to be understand.

Definition for 2D is like square drawn by tracing vertices of a line as it moves perpendicularly to itself. In other words, a 2D graphic is a graphic that has height and width but no depth. Definition for 3D is like cube drawn by tracing paths of vertices of a square as it moves perpendicularly to itself. In other words, is a 3D graphic is a graphic that has or appears to have height, width and depths. Figure 1.0 show the different between 2D and 3D.

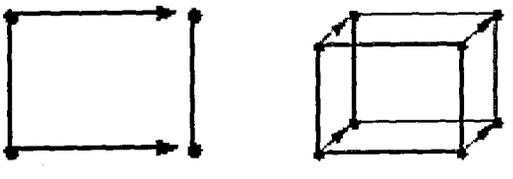

Figure 1.0 Illustrations of 2D square and 3D box

When take a look at 3D graphical image on our computer monitor, images made up of a variety of shapes, although most of them are made up of straight lines. There are squares, rectangles, parallelograms, circles and rhomboids, but most of all are triangles. However, in order to build images that look as though its have the smooth curves often found in nature, some of the shapes must be very small, and a complex image like a human body that might require thousands of these shapes to be put together into a structure called a wire frame. The wire frame has to be given a surface.

From the surface in the real world, there are information about it in two ways either look it in different angle or touch it whether it's soft or hard. Texture can explain the things whether it smooth, or does it have lines, bumps, craters or some other irregularity on their surface.

Rendering is the process of converting 3D geometric descriptions of graphical objects into 2D image plane representations that look real. Rendering can simulate the appearance of real-world textures, colors, surface shadows, highlights and reflections.

Non-photorealistic 3D models are objects being created by modeler using computer graphic. The models are not realistic such as cartoon, robot, human, and furniture, animal and so on. Photorealistic 3D models are also object being created by modeler using computer graphic

but it is more realistic in terms of colour, texture and reflectance when compare to the real object. Photorealistic 3D models used millions of different colors for the pixels making up an image to get the realistic color. Variety in texture comes both from mathematical models for surfaces to stored "texture maps" that are applied to surfaces. The qualities that we can't see also very important to make the model look realistic such as soft, hard, warm, and cold, with particular combinations of color, texture and reflectance. If one of them is wrong, the illusion of reality is shattered.

1.1 Problem Statement

Previously, three ways of rendering techniques had been used in computer graphic. The rendering techniques were empirical simulation, ray tracing and radiosity. The main problem for all these three techniques were took long period of rendering time. This was due mainly because of colour resolution, graphics hardware and quality in terms of application and content to be executed by the machine (PC-based or Macintosh-based). Therefore a study needs to be done in each of the main factor. However this project will concentrates only on the usage of colour resolution and comparison between two different platforms in the rendering process of 3D animations.

1.2 Project objectives

Based on the problem statements, the objectives of this project are:

i. To identify the appropriate colour resolution for the 3D models and their animation for fast rendering time.

ii. To identify which platform are suitable to render the selected 3D models and their animation.

1.3 Scope of research

The scope of this project will focus on two major categories. The first category includes the optimization of colour resolution for the 3D non-photorealistic models to reduce the rendering process in terms of duration.

The second part of the project is the comparison of rendering process between two different platforms which is PC-based and Macintosh-based for the same 3D model and animation.

1.4 Significance of The Project

3D modeling and animation has a very tight relationship with colour resolution, computer platform and rendering time. The higher resolution for 3D model the higher image quality can be produce and the more time needed for the rendering process. Due to this, the project is to find an appropriate color resolution for 3D model and animation and to find out which platform is suitable for non-photorealistic rendering process.

1.5 Organization of the Thesis

In chapter two, the literature review will discuss about the previous work done in the rendering techniques, rendering techniques for non-photorealistic model and the current techniques which used by the Lightwave 3D as a standard 3D software in this project. In chapter three, the topic is the methodology that used in this project. It will discuss about the comparative study that was choose as the methodology in this project. It also explain briefly about the overview of the experiment; how the experiment done, how to collect the data and how to analysis the data and come out with the conclusion. In chapter four, the topic experiment, which is explain in detail about the experiment plan, design, and the procedures

to make sure of the data validity. In chapter five, the topic is the result and analysis. This chapter will explain about the data collection, data analysis, result and interpretation of the data. Finally in chapter six, is the conclusion. The conclusion from this project is the finding for the best colour resolution and the best platform which produce the fastest time for rendering 3D model and animation.

CHAPTER 2

LITERATURE REVIEW

2.0 Previous Works

Traditional animation applies 2D images by creating the movements according to the right timing and follows some fundamental principles like squash and stretch, anticipation and follow through (Thomas 1981).When animator started using computer for their works, they gained advantages in modeling, animation and rendering of animation. Rendering is the process of converting three-dimensional geometric descriptions of graphical objects into two-dimensional image plane representations that look real. Many researches have been done in rendering techniques to stimulate the styles of artist. There are many rendering techniques that are now firmly established: counter rendering, empirical simulation, ray tracing, radiosity,

Contour line or image is one of the techniques of rendering that used traditional way or by computer rendering and ray tracing (Christ 1999). Contour lines are an important part of the styles of comics and cartoons. The animator makes counter line drawings for the animated character, counter drawings of the frame in between and finally color is painted in the spaces between the counter lines. When animator starts

using the computer in modeling, animation and rendering animation, it is easily viewed the 3D model from all directions. For rendering, the painting of each frame is done automatically. In computer generated contour rendering, there are some practical issues. Some surface should not have contours between them but have been modeled between them. Therefore, it is necessary to specify pairs of surfaces that should not have contour between them. Contour also can be on top of each other in image space. Therefore contours need to be composite in the rendering process and need a good strategy to apply on it.

Empirical simulation of light-object interaction in conjunction with polygon mesh objects was the first and most common used by Gouraud (1971) and Phong (1975). In fact an object considered to exist in isolation with a light source. It is a common phenomenon when an object hit by the light source, the reflection and shadow exist. However this technique does not cater for the light interaction between the object and ignore originates of the light source. In other words, empirical simulation technique had limitation on the object light reflecting. To overcome the limitation of the empirical simulation; ray tracing and radiocity techniques have been introduce for the illumination model.

Ray tracing technique simulates global interaction by tracking thin beams or ray of light as they travel through a scene from object to object (Cook 1984). It deals with specular interaction and suitable for scenes

consisting of shiny and mutually reflective objects. However, ray tracing cannot simulate diffuse interaction and very expensive than polygon mesh rendering.

On the other hand, radiosity technique particular on the light reflecting in all direction, from the surface of the object to another as a function of the geomatric relationship among surface. It deals with diffuse or dull surfaces and mostly used to simulate interiors of rooms (Alan 1996). However rediosity techniques cannot cope with specular interaction. Both techniques have their own limitation therefore effort for the research to incorporate specular interaction in the radiosity techniques.

2.1 Rendering Technique for Non-photorealistic Model and Animations

Non-photorealistic rendering (NPR) method has found a variety of techniques to simulate the styles of artist such as particle system, pen-and-ink illustration, cartoon shading, pencil sketching, stylistic rendering and silhouette edge detection.

New technique for non-photorealistic rendered have been proposed based on artistic effects using an interactively editable particle system by Matthew (1999). This technique maintained interframe coherence by

geomatric graftal objects to represent graftal textures and have shown it can generalize many other artistic effects. The system rendered at fast rates of frame on the low end workstation but it depends on the complexity of the scene.

New real-time algorithm for cartoon shading, pencil sketching and silhouette edge detection and new technique for generating motion lines to emphasize motion in 3D cartoon rendering had been introduced by Adam (2000). However this new technique only required per-vertex positions, material properties, texture coordinates and connectivity information. For cartoon shading, this new algorithm can make 3D model drawn like 2D cartoon and viewed interactively. This technique relies on texture mapping and the mathematics of diffuse lighting.

Stylistic rendering is the combination of multi-pass rendering and image processing technique used by Adam (2000) thresholding of surface color via the value of *n-l*. He present standard rendering equations to achieved cartoon shading that was presented by Gooch (1999) which creates a warm-to-cool transition for technical illustrations. NPR for rendering freeform design in modeling system had been applied by Zele (1996) and Igar (1999). Animated models rendered in a cartoon style by Meta (1999) but Adam (2000) used in multiple styles and is integrated with multi-resolution mesh system that improves scalability.

Silhouette edges detection (SED) technique has been used in NPR and illustration for many years. Hidden line algorithm has been used to provide a real-time rendering SED implement by Mark (1997). Silhouette with polygons similar as background colored suitable for rendered models which used by Adam (2000).

2.2 Rendering techniques in Lightwave 3D

Lightwave 3D used many of rendering technique to give more feature to the user. Illustration is one of the techniques which particularly in the technical diagrams, benefit from a simplification of visual detail which emphasizes the salient part of the image. Gooch (1999) provides with an algorithm for rendering objects with shading in cool to warm tones with about the same luminance. The algorithm blends between cool and warm colors using the overlap of the lighting direction with the surface normal, (the cosine of the angle of the light with the normal). This shading parameter is available in LightWave 3D through the Light Incidence type Input Parameter in the surface texture Gradient Editor.

In LightWave 3D, edge lines can rendered automatically be on an object-by-object basis. Typically they should be turned on for Silhouette Edges, Unshared Edges, Sharp Creases, and Surface Borders. For Silhouette Edges, apply the medium line and small lines for all others.

Applying the Shrink Edges with distance option enhances depth cues, and can also be used to generally attenuate the line thickness. Lines should be drawn in the default black.

When deal with the metal parts, appearance of fine milling groves on the surface are important. Such an 'anisotropic' or directional surface is often represented in illustrations by a series of light and dark bands running parallel to the long (minimum curvature) axis of the object. This effect can again be achieved in LightWave 3D version 6 and above by using gradients. For a cylindrical shape, the axis of maximum curvature goes around the cylinder. It happens to correspond to the U coordinate in a cylindrical UV mapping projection.

There are several ways to render this appearance. The simplest would be to replace the shading with a striped gradient based on the light incidence. Unfortunately, this surface is not working well on the faces away from the light. In addition, basing the stripe positions on the incidence angle is not faithful to the algorithm, because the stripes are not continuous along the surface, but shift based on the angle of the surface. If the vertical component of the lighting direction were ignored, this would be more correct.

The author will use the Lightwave 3D version 7.0 as a standard 3D software for both platform; PB-based and Macintosh-based. The main reason why the author choose it as a standard software because only

Lightwave 3D can be run in multiple platform. Lightwave 3D also have tremendous advantages in rendering techniques for the non-photorealistic model and animation.

CHAPTER 3

METHODOLOGY

3.0 Comparative Study

The comparative studies had been chosen by conducting 2 groups of object which both groups receive treatment (without control group) to be experimented. The first group was PC Pentium 4 based and the other one was Macintosh G4 based. The experiment was conducted with the controlled same variables which were the same 3D models, same short 3D animation developed using the same 3D software; Lightwave 3D version 7.0.

The experimental design is to get the fastest rendering process time by manipulate the color resolution of 3D model and their animation. The experiment applied to two groups that mention earlier for comparison purposes.

3.1 Experiment Overview

The experiment conduced in the Multimedia Lab in the Faculty of Computer Science and Information Technology,

University Putra Malaysia. Two different platforms was selected which were PC-based with Windows XP Professional as their operating system and Macintosh-based with OS 9.0 as their operating system. One short 3D animation that developed using Lightwave 3D was selected to be rendered in both platform. Four types of colour resolution in three categories of screen resolution were tested in both platforms. This experiment was conducted to get the appropriate colour resolution and the best platform in the rendering process.

The experiment took three days to be completed. Each day separated in two session; morning and afternoon. Each session only tested for the one platform. Before conducted the experiment, several experiment procedures need to be alert to make sure the validity of data secured. During the experiment, rendering process time was recorded using stop watch and the data treated as primary data. After all the data was collected, analysis data process took the place to get the final result. From the data analysis, the best colour resolution and the best platform for the rendering process was choosen.

CHAPTER 4

THE EXPERIMENT

4.0 Experimental Plan

4.0.1 Limitation of research

While looking for 3D software, the author found only Lightwave 3D can be run in the multiplatform, PC and Macintosh. So the author's choose Lightwave 3D Version 7.0 as the 3D software in this project. Author also found that only non-photorealistic 3D models type that can be compromise with color resolution. For photorealistic 3D models, it needs the high colour resolution and of course need longer time for rendering process. It is not convenient for the author to choose the photorealistic 3D models as an object for testing. Therefore this project only focused on non-photorealistic 3D animation and not the photorealistic 3D animation.

4.0.2 Object Groups.

There were 2 groups of computer with different platforms. The first group was a computer with Windows XP Professionals as the

operating system, Processor Pentium 4 with 1.8GHz speed and 256MB SDRAM. The other group was a Macintosh with OS 10 as the operating system, Processor G4 with 1.0GHz speed and 256MB SDRAM. The experiment was done at the Multimedia labs at Faculty of Science Computer and Information Technology, Universiti Putra Malaysia.

4.1 Experimental Design.

Each group was installed with Lightwave 3D version 7.0; one of the popular 3D animation software. One short 3D animation with 130 frames was selected for the rendering experiment. Both groups were assigned to render the selected 3D animation and produced final output in QuickTime format. The output will be in three type of windows or screen resolution; VGA 640x480, SVGA 800x600 and XGA 1024x768. For each screen resolution, there are four types of colour resolutions; 256, 1000, million, and million plus colour to be tested. The experiment took three days to be completed. Each day separated with two sessions; morning and afternoon. On the first day, morning session; the PC-based was assigned to render the selected 3D animation and produce VGA output file with four types of resolution colour which mentioned earlier. For the afternoon session, Macintosh-based also was assigned with the same task as the PC-

based. The same process was done for the rest of the days but with different screen resolution output.

4.2 Experimental Procedures.

4.2.1 Conducting the Experiment.

Only one screen resolution out file with 4 types of resolution colour was produced for each day (morning and afternoon session) for each group from the rendering process.

4.2.2 Threats to Validity

The lab experimental can suffer from the internal influences that may affect the experimental variables. In this case, they include:

- CPU's and RAM's tasks, which can be loaded with other task during the rendering process. Other than rendering process task can effect the CPU and RAM performance for the major task; rendering process.
- Computer temperature. During the rendering process, computer will produce heating. The CPU is

the main computer component and the main thing that produce heat during the rendering process. Over heating of the CPU can slow down the task processing and easily to crash.

Threats to internal validity can make the experiment more accurate. These included:

- The computer for this experiment; PC-based or the Macintosh-based must be reboot every time finished the rendering process. This was to make sure that the processor and memory free from other application or tasks. After reboot the computer, only Lighwave 3D application can be run on that computer and no other application can be open before or during the rendering process.
- The experiment was conducted in the computer lab with air-condition. The air- condition temperature was set to 20 degree Celsius. This level of temperature can make the processor not over heating during the rendering process so that the rendering process will not be slower and hard to crash.

CHAPTER 5

RESULT AND ANALYSIS

5.0 Data Analysis

The goals of the experiment feature both the appropriate colour resolution and computer platform for fast rendering time. Time comparison was used to test the overall result. The fastest rendering time was good for the time measurement but not in the output quality but the best output quality took longer time in rendering processed. For all rendering process, the author recorded the time for each of it into the experimental form. Table 5.0 show the overall of the experimental results for comparison rendering time between PC-based and Macintosh-based.

5.1 Result and Analysis

The results from the Chart 5.0 show that the bigger screen resolution size of the output file, the longer time in rendering process. Four types of colour resolution for each screen resolution size gave small impact for the rendering process time. Macintosh-based testing produced the same rendering time for VGA; 256 and 1000 colour, and SVGA; million and million plus colour output file. For PC-based testing, the result for VGA; 256 and 1000 colour, also produced same rendering time. Even

though 130 frames of animation could not give big impact to the rendering process time, the impact also can be increased if the frame increased.

In the commercial purposes, for example in the animation film industries, there are millions of the frames to be rendered. Small amount of the deference in the rendering time for the different colour resolution can gave them more time and higher cost to complete the animation film.

Screen Resolution	Colour Resolution	Rendering Time for PC-Based (second)	Rendering Time for Macintosh-Based (second)
VGA (640 x 480)	256 colour	725	614
	1000 colour	725	614
	Million colour	728	622
	Million colour plus	730	640
SVGA (800 x 600)	256 colour	1085	905
	1000 colour	1086	909
	Million colour	1088	910
	Million colour plus	1090	910
XGA (1024 x 768)	256 colour	1696	1380
	1000 colour	1699	1382
	Million colour	1702	1410
	Million colour plus	1729	1422

Table 5.0 Experimental Result

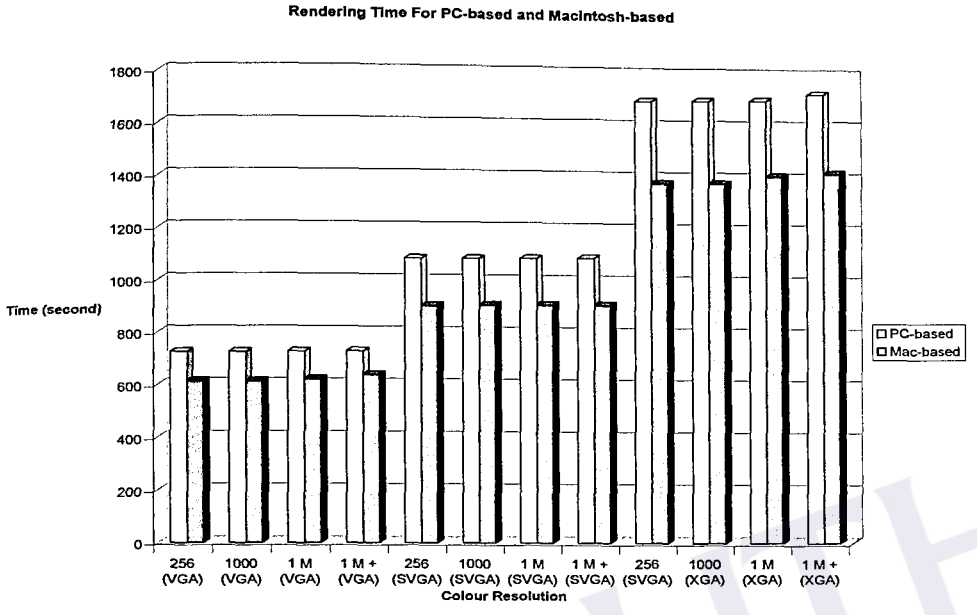

Chart 5.0 Comparison Rendering Time Between PC-based and Macintosh-based

Screen Resolution	Average Rendering Time for PC-Based (second)	Average Rendering Time for Macintosh-Based (second)
VGA (640 x 480)	727	622.5
SVGA (800 x 600)	1087.3	908.5
XGA (1024 x 768)	1706.5	1398.5

Table 5.1 Average rendering time between PC-based and Macintosh-based

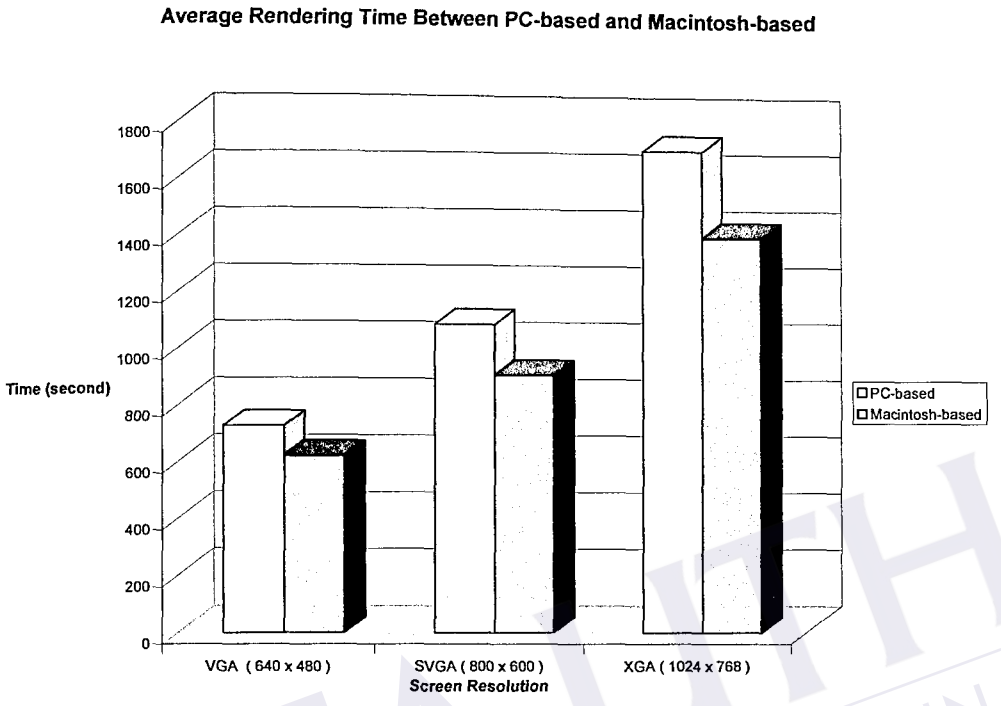

Chart 5.1 Average rendering time in the screen resolution for PC-based and Macintosh-based

5.2 Interpretation

Primary result of the experiment is evidence of the significant between colour resolution and the different platform. For PC-based, differentiation between the average time in VGA and SVGA screen resolution was 360.3 second. And the differentiation between average time in SVGA and XGA screen resolution was 619.2 second. The average result for the time rendering shows in the Figure 5.1. Although the VGA output file was the fastest time in rendering process, quality of the output is the worse compare to SVGA and XGA output file. Therefore the VGA output file cannot be the best rendering although it gave the fastest time in the rendering process. Another reason why VGA output cannot be the best because SVGA and XGA output format are commonly used in the graphic industry. As a result SVGA is the best output file for rendering process compared to XGA because SVGA output file took a moderate time to be produced. Chart 5.1 shows the average rendering time for screen resolution for PC-based and Macintosh-based.

Comparison between PC-based and Macintosh-based for computer platform in rendering process, shows that Macintosh-based produced the faster time compared to PC-based. Although it's quite difficult to get the perfect condition in terms of hardware performance for both platforms, the main criteria for the experiment had been taken. The main hardware such

as RAM is equal for both platforms. The main different between two platform were the complexity operating system functions and the architecture of the CPU. The architecture of Macintosh-based was design purposely for the graphics application environment. On the other hand, PC's-based architecture was not design for the graphic application only but it also for the multipurpose application.

In Malaysia, PC-based have been used in many 3D animation company. It is commonly used in the computer industries. Computer's hardware and software for PC-based maintenance are the most available in the market. Most of the major company used PC-based as workstation compared to Macintosh-based. It's due to differentiation in architecture, software and the file format. Small numbers of Macintosh users in Malaysia face the same problem when they try to communicate with large number of PC-based user.

The result from the experiment shows that Macintosh-based is the best platform for 3D animation rendering process. Therefore, computer user especially in the graphic and animation industries need to change their PC-based to Macintosh-based to get better performance in the rendering process.

CHAPTER 6

CONCLUSIONS

6.0 Conclusions

An experiment was design to investigate which colour resolution is appropriate for fast rendering process time. There are three different screen resolutions and each of it has four different colour resolutions. An experiment also to compare which platform is the best for 3D animation rendering process.

Comparison between screen resolution; the result shows that average rendering time for VGA and SVGA was 34% for PC-based and 32% for Macintosh-based. For SVGA and XGA, the result shows 36% for PC-based and 35% for Macintosh-based. Finally for VGA and XGA, the result shows that 57% for PC-based and 55% for Macintosh-based. VGA output file is the fastest in rendering process time but the quality of the output was the worst compare to SVGA and XGA. The best quality of the output file was XGA but it took the longest time in rendering process. SVGA is the best for rendering and output quality because it took slightly higher in the rendering time compare to VGA but produces better output quality. Another reason is the SVGA rendering

process faster than the XGA but produced almost the same output quality with XGA.

As a result, SVGA output with million colour resolution file format was the best for 3D animation rendering process compared to VGA and XGA output file. On the other hand, Macintosh-based is the best platform for 3D animation rendering process compared to PC-based because it produced the fastest in rendering process. However, more studied need to be done in terms of number of computer for each groups and number of different 3D software to be tested. This is because more number of computers in the groups can produced more accurate result compare to one member in the group.

Many of the 3D software should be tested to give more variety of data and accurate result can be identified. This is because different 3D software used different rendering technique and can produce different time in the rendering process.

6.1 Justification

The first objective for this project is to identify the appropriate colour resolution for 3D model and animation for fast

rendering time. The first objective was met by comparison between four types of colour resolution in three categories of screen resolutions. The final result shows that one million colour for SVGA was the appropriate colour resolution and faster for 3D model and animation rendering process time.

The second objective for this project is to identify which platforms are suitable to render the selected 3D model and animation. The second objective was met by comparison in rendering selected 3D model and animation between PC-based and Macintosh-based. The final result shows that Macintosh-based was the suitable platform for rendering 3D model and animation because it produced output file faster than PC-based. The main reason why Macintosh-based

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