Performing Leonardo's skill on computer: an in-depth study of connections and differences between computer 3D modeling/rendering and representational drawing/painting

Xurui Guo
Iowa State University

Follow this and additional works at: https://lib.dr.iastate.edu/rtd

Recommended Citation
https://lib.dr.iastate.edu/rtd/21241

This Thesis is brought to you for free and open access by the Iowa State University Capstones, Theses and Dissertations at Iowa State University Digital Repository. It has been accepted for inclusion in Retrospective Theses and Dissertations by an authorized administrator of Iowa State University Digital Repository. For more information, please contact digirep@iastate.edu.
Performing Leonardo’s skill on computer
An in-depth study of connections and differences between computer
3D modeling/rendering and representational drawing/painting

by

Xurui Guo

A thesis submitted to the graduate faculty
in partial fulfillment of the requirements for the degree of

MASTER OF ARTS

Major: Art and Design (Intermedia)

Major Professor: Steve Herrnstadt

Iowa State University
Ames, Iowa
2001

Copyright © Xurui Guo, 2001. All rights reserved.
This is to certify that the Master's thesis of

Xurui Guo

has met the thesis requirements of Iowa State University

Signatures have been redacted for privacy
TABLE OF CONTENTS

ABSTRACT

CHAPTER 1 – INTRODUCTION

A. Thesis objective

B. Methodology

CHAPTER 2 – BRIEF INTRODUCTIONS OF REPRESENTATIONAL DRAWING/PAINTING AND COMPUTER 3D GRAPHICS

A. A traditional way of 3D illusion creation, drawing and painting

B. A brief introduction of 3D computer graphics

C. Related terms about 3D figurative modeling

CHAPTER 3 – CONNECTIONS AND DIFFERENCES BETWEEN THE PRINCIPLES OF 3D COMPUTER GRAPHICS AND TRADITIONAL REPRESENTATIONAL PAINTING

A. Proportion

B. The system of perspective

C. Anatomy

D. Value

CHAPTER 4 – A CREATIVE COMPUTER 3D FIGURATIVE MODELING. A DIGITAL REPRODUCTION OF AN ANGEL’S HEAD IN LEONARD’ MADONNA IN ROCKS

A. Step1. Studies of the original painting and reparations for 3D computer modeling

B. Step2. Modeling in the computer

C. Step3. Rendering

D. Analyses of the working process (3 steps)
Computer graphics appeared only thirty years ago. Today, three-dimensional (3D) computer graphics are widely employed by movies, computer games and many other industries. Thanks to this new technology, the computer generated images on the screen are realistic and believable. However, there are other ways to create 3D illusions. They are drawing and painting. The traditional 3D illusion masters like Leonardo Da Vinci used brush and paint to simulate the concept of 3D space. So, computer 3D graphic and traditional fine art must have some mutual principles in order to reproduce the 3D illusions. In this thesis, the author discusses the connections and similarities between these two techniques, as well as differences. The discussion is divided into proportion, value, anatomy, and perspective for aspects. A digital reproduction of an angel’s head of Leonardo’s “Madonna of the rock” was presented as an example to demonstrate these relationships. The author argues that the basic art training such as drawing is equally important to both computer 3D artists and painters. The main purpose of the thesis is to clarify these connections and relationships, and give 3D computer artists specific guidelines and clues to improve their ability to produce more realistic images, and even to meet the traditional realistic art standard.
CHAPTER 1 – INTRODUCTION

A. Thesis objective

Before the author began to study in 3D computer graphic field, he had been practicing representational drawing and painting for years. This artistic background is very helpful in the application of 3D computer graphic study and creativity. However, it is not enough for a serious 3D computer artist. In order to find out the exact relationships between traditional representational art and 3D computer graphics, many studies had been conducted. In 1999, a paper titled *The Tyranny and the Liberation of Three-Space: a Journey by Ray-Tracer* (Mike King, 1999) was presented during the CADE’99 Conference. In that paper, Mike King discusses the attractions and the limitations of using linear perspective, a basic theory of traditional drawing in 3D computer graphics. That paper also includes contents about ray-tracing feature simulating traditional shading technique. However, the paper does not cover other important aspects of the connections between traditional art and 3D computer graphic, such as proportion. It also has less practical value because the author of that paper described all theories on a 3D software developed by themselves, not the popular programs like 3DS Max or MAYA. Later in 2000, an author, Barbara Robertson published an article on the magazine *Computer Graphics World*. This article was titled *Reel people, Animators breathe new life into digital characters* (Barbara, 2000). In that article, Barbara discusses the most updated new technology of creating real human-like character in 3D computer graphics. However, it emphasizes the technical issues of software package rather than basic creative principles of 3D modeling. Therefore, it won’t aid the 3D artists to reinforce their fundamental ability of building convincing realistic figurative models.
The main goal of this thesis is to clarify the relationships between the traditional representational drawing/painting and 3D computer modeling/rendering, including similarities, differences and shared rules between these two art forms. These clarified relationships and principles could be used as more “tangible” guidelines for 3D computer modelers and animators to improve their creative ability, and lead the digital artists to create more realistic figurative models, and eventually improve the quality and value of the computerized 3D graphics.

B. Methodology

This thesis is divided into five chapters. Chapter 1: Introduction of the thesis; Chapter 2: Brief introductions of representational drawing/painting and computer 3D graphics; Chapter 3: Connections and differences between the principles of 3D computer graphics and traditional representational painting; Chapter 4: An Creative computer 3D figurative modeling. A digital reproduction of an angel’s head in Leonard’ Madonna in Rocks; Chapter 5: Conclusion. The main discussions about the relationships between traditional art and 3D computer graphics are included in chapter 3. These discussions are specified in four aspects: proportion, perspective, anatomy, and value. The theories from Chapter 3 are applied to a 3D figurative modeling work in Chapter 4 as a proof of these theories. The author made most of the sketches, sculpture and the computer graphics for this thesis.
CHAPTER 2 – BRIEF INTRODUCTIONS OF REPRESENTATIONAL DRAWING/PAINTING AND COMPUTER 3D GRAPHICS

A. A traditional way of 3D illusion creation, drawing and painting.

For thousands of years, people have constantly created images on two-dimensional (2D) surfaces to reveal the 3D physical world surrounding us, some as early as the paintings on the cave walls in Lascaux cave, France 16000 years ago. These prehistoric artists drew vivid animals in great simplicity (Figure 2-1).

Figure 2-1. Cave painting, Lascaux, France, 16000 years ago, (Ministère de la culture et de la communication, 2001)
As civilization continued to advance, the art of drawing and painting were widely spread around the world. The mural paintings in the Egyptian temples dating back to 5000 BC and the portraits from Pompeii of the first century are examples of people’s explorations and progresses of realistic drawing and painting. In the Egyptian’s work (Figure 2-2), the sense of basic proportion and structure of human figures are accurate. In the Pompeii case (Figure 2-3), people had already begun to pay attention to the shadow and light, and tend to build a more 3D-look figure on a 2D surface.

In the fifteenth and sixteenth century, the renaissance masters like Leonardo Da Vinci and Raphael (Figure 2-4), contributed their intelligence and spirit to drawing and

Figure 2-2. Mural Painting, Ancient Egypt, (Tulane University, Professor Lesters, Ancient world, Egypt, 2001)

Figure 2-3. A woman’s portrait, Pompeii, (humanities-interactive, Pompeii, 2001)
Many scientific discoveries, such as the theories of linear perspective, human anatomy were applied to realistic drawing and painting. People eventually grasped almost all of the secrets of how to create a believable 3D illusion, and the traditional representational art style became increasingly mature.

These artistic principles of representational drawing/painting include proportion, perspective, value, theories of light and color, geometry and anatomy.

For thousands of years the traditional art technique has remained the same. That is to say, natural or man-made paints are applied to a physical 2D surface. An artist’s eyes, brain
and hands are the primary efficient tools to pursue the illusionary effect. The scene of spaces and objects comes into artists’ eye, then, it is refreshed and edited in their brain. Finally, it comes out from artists’ hands and rendered on the paper and canvas. What has changed is that the knowledge and experience associated with how to create a believable 3D illusion had been passed down from generation to generation. Representational art technique reached its peak in the fifteenth and sixteenth centuries, during the Renaissance. People were satisfied with the 3D illusions the artists produced at that time. To build convincing 3D illusions on canvas became an even larger goal of drawing and painting of the time.

B. A brief introduction of 3D computer graphics

Drawing and painting dominated the reproduction of 3D illusions until this century. A new technology, photography emerged in the early 20th century. The lights reflected or illuminated by the physical world are collected by lenses. After a sequence of optical and chemical processes, images are transferred to a paper. This new technology can produce images much more convincing than traditional painting and drawing. However, it has less manual participation than painting or drawing. Therefore, it could be only regarded as reflections or recordings of the 3-dimensional world. People still need drawing and painting to fulfill their desire of creating and expressing what they can’t find in the real world or somehow altered the real world.

An all-new technique, computer 3D graphics, appeared in the late of 20th century, following the new technological development of microprocessor and computer. It changed the media of visual art, especially in the realm of movie and animation.
“The evolution of computer graphics has taken three decades to bring onto the big screen. The illusion of a dinosaur acting live in *Jurassic Park*, was a milestone in the computer graphic film industry. If there were no visionary examples, contributions from people today might not have the interest to fulfill this imaginary fantasy” (The Team of imagesunlimited, 2001, p2).

In 1962, Ivan Sutherland created Sketchpad, a computer program in which people can draw directly on a CRT computer screen. This was a revolutionary step toward using the computer graphics imagery in the real business world.

In 1964, Ivan Sutherland and Dr. David Evan founded the world’s first academic computer graphic department at University of Utah.

In 1973, Dr. Alexander Schure and Edwin Catmull launched NYIT, a computer graphic lab developing computer graphic software. Meanwhile, other commercial computer graphic studios began to appear, and they did many experimental studies.

George Lucas, hired Catmull from NYIT to launch his Lucasfilm studio. They focused on applying computer rendered images to their film.

In 1982, a movie *Star Trek II: The Wrath of Khan* featured sixty-second of computer generated footage, by Lucasfilm’s Computer Graphic Division.

In 1982, *TRON* was released by Disney. The film contains over 15 minutes of fully computer-animated film.

In early 80’s, the computers became cheaper in price and stronger in power. This made it possible for computer graphics to be more widely used by the film industry.

“In 1989, in the film *The Abyss*, digital artists created a watery creature and animated it through the computer. It was a breakthrough for computer graphic technology. In this film,
the team at George Lucas’ Industrial Light & Magic (ILM) created the first completely computer-generated, entirely organic looking and thoroughly believable creature to be realistically mixed with live action” (The Team of imagesunlimited, 2001, p2).

Since then, digital imagery from computers has been widely adopted by most film producers. Those films include Total Recall, Toy story, Terminator 2, and Jurassic Park. Toy Story is another technological milestone. It was the first totally computer generated full length cartoon film. The team was Pixar Technology.

Today, we should call it a golden time of the computer aided or computer-generated films. The film industry is presently working on a totally computer generated real-actor like movie for the future.

As a crucial part of 3D computer generated imagery, the modeling technique has matured and become much easier than ever before. Software packages like 3D Studio Max and Maya, provide digital artists several approaches to build a life-like figurative model. Here is an example, Funky Graphics, (Barbara Robertson, 2000, p.31) demonstrates figurative modeling. For a Seattle ride film, the effects crew at Digital Domain created a virtual James Brown-30 years younger (Figure 2-5). “The digital model of young James Brown’s head at right was created in Maya using polygons and subdivision surfaces. The model at left was rendered with Pixar’s Render Man using texture painting, bump maps, displacement maps, and shaders to create the color and texture of his skin” (Barbara Robertson, 2000, p.31).
Figure 2-5. The 3D model of James Brown’s head (Barbara Robertson, 2000, p31)
C. Related terms about 3D figurative modeling

**Modeling** means building a character of an object on the computer. There are mainly three modeling methods, polygon, patch and NURBS.

**Rendering** refers to the generating of the images on the computer. It calculates the statistics of the model, the texture and the animation in the scene, and finally output to pixel-based images. Actually, it is a borrowed word from photo processing and drawing (Figure 2-6, 2-7, 2-8).
CHAPTER 3 – CONNECTIONS AND DIFFERENCES BETWEEN
THE PRINCIPLES OF 3D COMPUTER GRAPHICS AND TRADITIONAL
REPRESENTATIONAL PAINTING

So how could the computer 3D animation be able to produce such persuasive 3D images? It must be competent to do the same job as traditional drawing and painting. Thus, the computer 3D animation must somehow follow the same principles of traditional drawing and painting. In this thesis, the author discusses the connections and similarities between these two techniques, as well as differences.

At first, a strong foundation of realistic drawing skills can directly benefit the 3D computer modeling process. Drawings can be configured on the backgrounds in different viewports as references, helping the artists to trace the contours of the figure more accurately. Sculpture may also be used according to individual’s preference (Figure 3-1). A bonus of using sculpture is that it provides the artists a real 3D (not virtual) coordinate system for them to transfer into the computer. “A three-dimensional sculpture is much closer to the final character than two-dimensional drawing can be” (George Maestri, 1999, p18). Then sculptures can be photographed and used in the same way as drawings (Figure 3-2).

The author discusses the relationship of the two techniques, 3D computer Graphics and traditional representational painting, including the connections, similarities and differences in the following four aspects, proportion, perspective, value and anatomy, with the exception of theory of colors being not covered by this thesis.
A. Proportion

Proportion: “the correct relationship between the size, position, and shape of the different parts of a whole, especially as producing a beautiful effect” (Longman dictionary of contemporary English, 1987).

Proportion is crucial to both computerized art and traditional art. It is almost the second step right after the composition. In figure drawing or figure modeling, proportion will determine whether the final rendered image is successful in realistic and artistic aspects. The proportion of a figure must basically follow the statistical measurement of an “average” human figure. However, this might vary under certain limitations, according to gender, age, race, and genetic difference. Artists, on the other hand, can use this variation to achieve
special goals. The variation cannot exceed the limit; otherwise it will destroy the believability of the 3D figure created.

The ideal human proportion might be different due to times, geographic regions, and cultures. The “ideal man” differs from artist to artist too. The following examples show the differences. The one on the left represents the classical proportion in ancient Greece, which claims that the height of a man equals 8 times of his head’s height (Figure 3-3). The one on the right was drawn by Dürer. Obviously, it has exaggerated proportion. The female figure was stretched to about 10-12 heads height, but shows more grace (Figure 3-4).

Figure 3-3. Doryphoros (The Canon, or Spear Carrier), (Kantonsschule Zürcher Unterland, Klassische Sprachen Latein, Griechisch, 2001)

Figure 3-4. Proportion study, (Dürer, Russell, 1967, p161)
The next two examples show the different proportional requirements on computer figurative modeling. In order to create a realistic character or a cartoon character, the artists must choose different body and facial proportional rates (Figure 3-5). The one on the left is for realistic character modeling, "an average human is about 6-8 heads tall. If the character is taller, it may appear more lithe and graceful" (George Maestri, p.9). The one on the right is for a cartoon character. The figure’s height equals approximately two and a half of the height of its head. It looks so cute because this is the proportion of a baby, and it attracts love and care from the audience’s instinct.

Leonardo Da Vinci had many drawings of human proportion study. The ratio of measurements of different body parts represents the classical proportion originated from ancient Greece and Roma (Figure 3-6, Figure 3-7).

Figure 3-5. Realistic Proportion for 3D animation character (Maestri, 1999, p.9)
Figure 3-6. The ideal human Facial proportion, Leonardo
(Lyle Svendsen, 2001a)

Figure 3-7. The ideal human body proportion, Leonardo
(Lyle Svendsen, 2001c)
The next illustration is an average and more detailed European female figure proportion which is adopted by most of the artists. It could be used for realistic 3D modeling reference too (Figure 3-8).

It is easy to find most proportional measurements in books. However, artists should rely on their eyes rather than a sequence of numbers. One cannot always use a ruler when he or she is drawing on the canvas or modeling in the computer. An artist's sense is more valuable and sometimes more accurate than a statistic guide. Because if an artist rigidly follow the measurement of proportion, he or she may fail to catch the personality and spirit of the character they are building. Hence, those so-called "ideal proportion" only can provide basic

Figure 3-8. proportion of a female body (Hale, 1977, p308)
guidelines for computer 3D modelers to get the very basic shape of the figure model. As the artists try to develop the special features on the model, they need to adjust from the books to their eyes.

B. The system of perspective

Linear Perspective plays a key role in our vision of the outside world. On the other hand, perspective is a powerful tool for visual artists to construct a believable 3D illusion on a two-dimensional surface, whether on canvas or on monitor screen. However, the secret of linear perspective remained undiscovered until the 15th century. The theory was established and employed by Renaissance artists and scientists. The discovery of the Linear Perspective’s mathematical basis was one of the triumphs of the Renaissance. The result was a stunning visual effect. The spaces in the paintings allow the viewers to seemingly walk in. The theory of perspective is so important that it had become one of the basic accomplishment for all visual artists.

“One simple and fundamental concept relates all the complexities of perspective: objects appear to diminish in size as they recede into the distance” (Mendelowitz, 1976, p 90). “In the terms of traditional perspective, we generalize this phenomenon as: Sets of parallel lines converge to a vanish-point as the move in the distance” (Mendelowitz, 1976, p 90).

There are several terms involved in the system of perspective, “eye level,” “vanishing point” and “horizontal line.” For visual artists, the most frequently used perspective types are “one-point,” “two-point” and “three-point” perspectives. There are three examples. (Figure 3-9, 3-10, 3-11)
Figure 3-9. One point perspective, Leonardo, study for *Adoration of the Magi*
(Mendelowitz, 1976, p91)

Figure 3-10. Two point perspective, Jan Vredeman, Perspective Study
(Mendelowitz, 1976, p95)
It seems that computer artists never need to worry about the perspective. Because the perspective effect which the virtual camera simulates is always accurate. Instead of finding the vanishing points on the painting, the job left for 3D computer artists is to adjust the viewpoint, view angle, lens, near range, far range and so forth to obtain the most desired effect. The maneuver of the perspective becomes more complex on the other hand. The perspective adjustments in 3D computer graphics can affect the final rendering effect dramatically. To obtain a desired perspective effect, the artist may need to adjust the values assigned to each of the options many times. For example, In Maya 3, a computer artist needs to deal with Focal Length, Angle of View, Film Gate and other over twenty values for the
camera. The following examples are different views of same model with different camera lenses. One is with 135mm lens and the other with 25mm. The results are quite different. In the 135mm lens image, the angle of the parallel lines on the character’s face changed gradually at small amounts. The 25mm lens image looks more dramatic and has a deeper space. The angels of parallel lines changed sharply and seemingly become converge not far from the edge of the picture, as well as close-deformation features being accelerates.

Moreover, In 3D computer graphics, artists can easily get exaggerated and distorted effects by choosing short lenses (Figure 3-12).

![Figure 3-12. Different visual effects of 135mm and 25mm lenses in 3DS Max](image-url)
C. Anatomy

“If you want to design a humanlike that animates well, you need to understand the human skeleton – how it put together and also how it moves” (George Maestri, p50).

For traditional artists to draw figures, they must know the structure and mechanism under the figure’s skin, bones and muscles. Many great artists such as Leonardo Da Vinci and Michelangelo had conducted anatomical studies on the bodies. “Leonardo considered science to be so all encompassing for him, it even subsumed painting” (Jack Wasserman, 1980, p25). Leonardo was an extraordinary anatomist. The studies and discoveries he made in anatomy made his figurative drawing and painting come alive with great accuracy and created a sense of freedom at the same time. Here is one of many sketches drawn by Leonardo Da Vinci for his anatomical study (Figure 3-13).

Figure 3-13. Anatomy study of a man’s shoulder,
Leonardo Da Vinci, (Lyle Svendsen, 2001b)
Anatomy is equally important to the computer artists. Practically, artists cannot build a accurate head or a body only from information the artists obtain directly from observation without knowing the anatomical structure (Figure 3-14 & 15).

It will also help if artists know how these structures, bones and muscles interactively work together to form the body movement, gesture and facial expression. This is extremely useful for 3D computer modelers and animators. Figure 3-16 shows a digital character’s facial expression pattern. And this pattern is a direct result of the muscles under the skin. When each of the major muscles moves, it distorts the surface of the 3D model accordingly.

Figure 3-14. A computer modeled skeleton (Maestri, 1999, p50)  
Figure 3-15. A computer modeled bone structure of a head (Maestri, 1999, p90)
A. Levator Labii Superioris
B. Zygomatic Major
C. Risorius
D. Triangularis
E. Depressor Labii Inferioris
F. Mentalis
G. Orbicularis Oris
H. Orbicularis Oculi
I. Levator palpebrae
J. Corrugator
K. Frotalis

Figure 3-16. Facial expressions of a digital character, (Maestri, 1999, p91)

D. Value

"In the visual arts the term value denotes relationships of light and dark. White under brilliant illumination is the lightest possible value, black in shadow the darkest – with the angle of shades constituting a host of intermediate grays" (Menelowitz, 1976, p.76).

Because of light, we can see. The reproducing of what we see is a process which simulates the light arrangement we see in the real world on a 2D plane. It is somewhat like the mechanism of the camera. The light comes into our eye and is transfer to the brain. After a sequence of analyses (in a very short time), we know what the objects are, how far they are, or the volume and the depth of a space. For artists, they continue to explain these perceptions to the viewers by painting them on 2D media, transferring the arrangement of the black and white value to the viewers again. The illustration below is the basic value pattern of a sphere, or, more accurately, we should call the shadings of the sphere Chiarocuro. The systematic changes of value can be divided into six gradually blended stages: highlight, light, shadow, core of shadow, reflected light and cast shadow (Figure 3-17).
Traditional artists apply media such as charcoal, pencil or paint on paper or canvas by following critically designed shading pattern and carefully controlled contrasts. Shadows and light can be employed to build a very convincing and dramatic atmosphere in drawing and painting. A drawing by Rubens is a fine example of this technique (Figure 3-18). In traditional art, the main purpose of using value is to create the feeling of volume and mass in the 3D space. Usually this approach is used accompanied by lines and marks, which can direct the viewer’s eyesight along the object’s surface. This is a useful technique that most 3D software does not presently offer.

Figure 3-17. Value gradations of traditional chiaroscuro (Mendelowitz, 1976, p79).
In 3D computer graphics, it is a different story. The 3D design software packages determine values according to formulas. That means that the computer automatically calculates and “draws” the value effect during the rendering process. In order to simulate the different shadings in the real world, such as leather, metal, mirror and plastic, software programmers develop various formulas for surface rendering. Below, figure 3-19 and figure 3-20 are standard value or shading options in Maya and 3D Studio Max.
1. Anisotropic
2. Blinn
3. Metal
4. Oren-Nayar-Blinn
5. Phong
6. Strauss

Figure 3-19. standard Shaders in 3DS MAX

1. Lambert
2. PhongE1
3. Blinn1
4. Phong
5. Anisotropic
6. Layered shader1
7. Layered shader2
8. Shadingmap1

Figure 3-20. standard Shaders in 3DS MAX
These features of the 3D software are complex for the 3D computer animators and modelers to relax. Though they don’t need “waste” time on hatching and rendering, they have to spend more time adjusting the lights, shadows and surface properties in the scene to obtain the desired visual results. Sometime, the computer automatically generated shadow and light effect looks chaotic. Traditional artists can choose what kind and how much shadow and light they need to build up a great 3D illusion. They can even alter or eliminate the shadows or highlights they don’t need. This versatility is still in need by many digital artists, while software providers are trying to develop such functions in their software packages. Nonetheless, serious art training is very important for computer 3D modelers and animators. Years of practice in realistic drawing and painting will give artist an enhanced ability to adjust and control the computer to achieve a believable 3D result by using lights and shadows. Further, getting familiar with value technique can help 3D computer artists go beyond merely following the rules of value. The 3D computer artists can maneuver the lights and matte, especially some negative light sources to intentionally construct a desired light and value environment, and therefore achieve a convincing digital 3D illusionary image.
CHAPTER 4 - A CREATIVE COMPUTER 3D FIGURATIVE MODELING.

A DIGITAL REPRODUCTION OF AN ANGEL’S HEAD IN LEONARD’S MADONNA IN ROCKS

Figure 4-1. Madonna of the rock, The head of the angel, Leonardo

(Wasserman, 1980, p176)

Based on the principles discussed in Chapter 3, the author built a digital model of an angel’s head in Leonardo’s *Madonna in Rocks* (Figure 4-1). The unique characteristics of each of the techniques and the relationships between these two techniques, the 3D Computer modeling and the traditional drawing, were clearly outlined by the working process.
A. Step 1. Studies of the original painting. Preparations for 3D computer modeling

At first, the author conducted a study drawing of the angel’s head. The purpose is to get a basic understanding of the painting. Such as proportion, perspective, value and the figure’s unique facial character (Figure 4-2).

Then, the author drew a sketch with the similar view angle in George Bridgman’s “Constructive Anatomy”. The goal is to understand the basic mess structure and major surface divisions (Figure 4-3).

Figure 4-2. A study drawing by the author
Figure 4-3. A sketch with the similar view angle by the author

Figure 4-4. Study drawings of the skull and muscles by the author
In order to study the skeleton and muscle structures of the figurative form, the author added two other drawings, one for skull and one for the muscles. The author intentionally altered the proportion of the skull to match the unique feature of the angel’s head, which has a larger forehead and a shorter face (Figure 4-4).

Next, the author created a clay sculpture copied from Leonardo Da Vinci’s oil painting. It was a process of transferring virtual 3D image (on the 2D surface) to real 3D space (Figure 4-5).

Figure 4-5. A sculpture of the angel’s head by the author
Next, the author drew several drawings from different angles of the sculpture. This helps solve the problems of understanding the 3D structure of the angel’s head, because the author could not see the opposite side of the angel’s head if he only uses the original painting as a reference for the 3D computer model. Also this technique helps on the understanding of the connection between 3D objects and 2D surfaces. The drawings with different angles can be used as references on the background in the viewports when modeling the head in the computer (Figure 4-6).

Figure 4-6. Drawings from different angles of the sculpture by the author
B. Step 2. Modeling in the computer

The software being used to build the model is Alias/Wavefront Maya 2.5. It is a very powerful package providing professional standard NURBS modeling tool and production standard photo realistic rendering. The hardware is a PIII766mhz computer with 512MB Ram.

The modeling began with a surface sphere. Additional isopams (divisions in MAYA) were given for adding details (Figure 4-7). This process critically followed the aforementioned studies of proportion and anatomy in step one. A clay sculpture was used as a guideline in true 3D form for the corrections and adjustments in the virtual 3D space on the computer. At first, a standard surface sphere was stretched and formed into a combination of a sphere and a cylinder. Here, the proportion of a simplest head must be accurate.

Figure 4-7. Modeling process in MATA 2.5, by the author
Then, the forehead, nose, eyes and mouth were divided and formed preliminarily form the sphere. Next, the Model was cut in half and mirrored. Since the mirrored half of the head was connected to the world space of the original half, the model kept in symmetrical when altered either half of the head. Here, the standard for proportion was switched from universal to individual. The previous studies of the angel’s anatomical feature began to help the author on the modeling. When the modeling process developed into forming the details of the figure, it became difficult to control the overall shape of the model. The combination of the proper control of proportion and anatomy can prevent mistakes while applying additional details. Gradually, strong foundation of art training clarified the image. Eventually, the final result of a realistic 3D figurative modeling mainly depends on the artists’ ability to control a complex yet highly united form. A visual artist should practice this ability throughout their life. During the modeling, the author constantly viewed and corrected the models in many different views. The virtual 3D maneuvering function provided by the program helped the author to improve the model toward the figurative oil painting by Leonardo.

C. Step 3. Rendering

Several lights had been positioned in the scene to simulate the light environment of the painting. Shadows were configured as "soft edge mapped format". Some of the lights with very low illumination value are used to simulate the reflections between objects. Maya “Paint-effect” function was used to build the curl hair. One important issue in this stage is to adjust the camera view to match the perspective view of the oil painting. Finally, the camera was configured as 135mm. In the “Global Rendering Option”, the author applied an atmosphere effect, which blurs the images according to the distance from the camera, and
this is an efficient way to emphasize the effect of perspective, and add more space into the image. Through color is not discussed in this thesis, the author used his knowledge of both traditional art and 3D computer art to adjust the properties of the skin, the eyes, the hair, the cloth, and then combined with the light and shadow, and eventually built the 3D atmosphere of the scene (Figure 4-8).

Figure 4-8. rendered image, by the author
D. Analyses of the working process

The relationships between these two techniques were revealed by the three-step working process. In the drawing and painting case, the artist only could work on one angle of an object, he can not really "turn" the object around adjusting the figure in a 3D space, except they can use their imaginations to get the other side of the figure. This is the limitation for traditional artist. However, this limitation can be an advantage at the same time, because the only angle is what the artist desired and pre-defined. Therefore, the artists can stay and focus on that angle, play with the marks and paints to create a virtual light and shadow environment, and finally build up a convincing "3D" model or space. The artist can even change some details of painting, like the light, shadow, or even perspective regulation to achieve a desired visual effect. Therefore, the traditional drawing and painting are more straightforward towards the final visual results, and provide the artists more flexibility of expression, as well as subtlety and rich material feeling.

For a computer artists, the situation reversed. The artists can "turn" the model all around to adjust every side of it. The 3D programs today allow artists feel they are using virtual clay in building the models. Nonetheless, the digital artists don't need to paint the tones and values. This can be easily accomplished by a wide variety of simulating functions stored in the software packages. What the artists need to do is sending commands through the keyboard and mouse. However, these benefits confine the artists' freedom of expression at the same time. Not only must they follow the rigid perspective though they can adjust it in some degree, but also have to frequently choose the options in between what they want and what the software can provide. Therefore, the final effects of the digital 3D modeling and rendering might not be the exact results the artists want. For example, in this case, the
beautiful curl hair of the angel drawn by Leonardo is impossible for automatic generation of the exact hair by MAYA. So the author chosed the nearest effect of what the MAYA’s “hair” function can produce. Another point is the shadows under the angel’s nose and chin. Leonardo altered the position, value and the softness of the shadows, to fulfill his intention to emphasize the figure’s grace and the elegance. That gives the computer modeler a difficult job to maneuver and rearrange all the lights and materials in the scene. The final result is not one hundred percent exact the same as Leonardo’s painting.

Comparing the four images involved in the working process, subtle differences can be easily find among them (Figure 4-9). Some of the differences were caused by the features of different media, while others were caused by the artists. The discussion here focuses on the different media. Though the author followed the same artistic principles and judgments to build these images, the third image, the clay sculpture shows more differences from the first two 2D images, the original oil painting and the drawing. Why? When artists working on 2D media, they usually work on seeking the final visual result rather than exact correctness of the 3D objective. It is a common phenomenon that representational painters intend or not intend to break the rules of perspective, value, proportion, even anatomy for their goals, creating a convincing realistic, yet artistically refined 3D illusionary imagery on a 2D surface. And these “inaccurate” works are acceptable for the audience, because they fulfill the desire of the audience’s eyes. In this case, after the author built the clay sculpture, he found it was impossible to get the beautiful smile looking from the same viewpoint as the oil painting. That means Leonardo “bended” the angle’s face revealing the smile. However, the viewers don’t fell any problems with the perspective. This is a great advantage of artist using traditional art media. 3D computer artists should also get inspiration here. When it is
necessary to change the 3D space of the model or the shading feature in order to achieve a certain visual effect, they should choose not to rigidly follow the artistic principles such as perspective. This image generated by the computer shows an obvious difference from the original oil painting. The main reason is that when the 3D computer artist has too many distractions from the controls and options of the 3D software, they usually lose the accuracy and unity in the final result. Therefore, practicing in traditional art training, getting familiar and fluent with the 3D software can help the 3D computer artists improve and overcome this problem. The coming new 3D software packages also show promises for 3D computer graphics to reach a higher level.
CHAPTER 5 – CONCLUSION

We regard the drawing and computer 3D graphic as two techniques of 3D illusion creation. Both of them, traditional painting and computer 3D graphics have advantages and disadvantages. These are differences between them as well. However, the artistic motivation, the basic working process and the basic knowledge of visual arts remain the most important elements for both representational painters and computer artists. For 3D computer figurative design and modeling, knowing of the theories and principles of perspective, anatomy, value and proportion will directly benefit their creativities. Although computers provide many new possibilities to create images out of people’s imagination, it creates many challenges at the same time, both artistically and technically. The computer artists should combine these two techniques to utilize the advantages on both sides. Further, to integrate traditional art principles into the new technology without losing the humanity, accuracy, emotion and freedom of fine art is a task for every digital artist. For computer 3D modelers, basic art trainings, like drawing and painting improve their creative skill significantly, rather than playing solely with the computer and software. Furthermore, the traditional drawing and painting skills can be used as great sources of help during the character design and modeling process.

Color is another important issue of creating realistic visual art besides the four aspects discussed in this thesis, proportion, perspective, anatomy and value. Limited by the time and condition, it is not covered by this thesis. It will be the next step for the author to study. Nevertheless, some of the new topics emerged, such as how to apply material and media value to the digital art, besides the realistic visual effects, and how to apply fine art aesthetic
value to the digital arts like 3D computer animation. These topics give the author and all 3D computer artists more challenges and spaces to explore and experiment their artistic activities. These studies and discoveries will give both 3D computer art and fine art new directions and lead them to a new level to fulfill people’s artistic desires and imaginations.
APPENDIX


The Maya files for readers who want to know more about the 3D models the author made for the thesis. Maya 2.5 is required to open all Maya files in 3DforThesis. MS Word is required to open all Word documents in Xurui’s Thesis folder. MS Powerpoint is required to open files in slideshow folder. All images in this CD should be opened in Adobe Photoshop.
BIBLIOGRAPHY

Christusrex Rex, Raphael, 2001
http://www.christusrex.org/www2/art/Raphael.htm


humanities-interactive, Pompeii, 2001
http://www.humanities-interactive.org/ancient/pompeii/pompeii.htm

Kantonsschule Zürcher Unterland, Klassische Sprachen Latein, Griechisch, 2001
http://www.kzu.ch/fach/as/material/kg_gr/plastik/pl14.htm

King, Mike, The Tyranny and the Liberation of Three-Space: a Journey by Ray-Tracer presented to the CADE'99 Conference, 1999
http://web.ukonline.co.uk/mr.king/writings/earts/cade99.html


Lyle Svendsen, 2001a
http://www.webgod.net/leonardo/Anatomy/Leo68.jpg

Lyle Svendsen, 2001b
http://www.webgod.net/leonardo/Anatomy/Leo176.jpg

Lyle Svendsen, 2001c
http://www.webgod.net/leonardo/Anatomy/Man2.jpg

Maestri, George, Character Animation II, Indianapolis, New Riders Publishing, 1999


Ministère de la culture et de la communication, 2001
http://www.culture.gouv.fr/culture/arcnat/chauvet/en/ (Then click “Visit the cave”, then click “Hillaire Chamber - Panorama of the north wall” and zoom in)


Tulane University, Professor Lesters, Ancient world, Egypt, 2001
http://www.tulane.edu/lester/images/Ancient_World/Egypt/A71.jpg

ACKNOWLEDGEMENT

Special thanks to professor Steve Herrnstadt, professor Sunghyun Ryoo Kang and professor Bruce Smith. As Committee members of the author, they contributed their time and knowledge helping the author on the developing of the idea of the thesis. They also provided many resources for the author to enrich the content of the thesis. The credit is for their outstanding directions on this thesis.