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# Impressionist Rendering of an Animated Painting

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# IMPRESSIONIST RENDERING OF AN ANIMATED PAINTING

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A Thesis  
Presented to  
the Graduate School of  
Clemson University

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In Partial Fulfillment  
of the Requirements for the Degree  
Master of Fine Arts  
Digital Production Arts

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by  
Michela Diane Rose  
May 2012

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Accepted by  
Dr. Timothy Davis, Committee Chair  
Professor Tony Penna  
Dr. Jerry Tessendorf

## ABSTRACT

The following thesis documents the development of a non-traditional rendering technique, that of classic Impressionist painting, and its use to create an animated three-dimensional painting. Impressionist style painting has an organic feel to it, with brush strokes that remain visible in the dried paint and a light, lively color palette that seeks to capture the light in an image. Reproducing this style in a computer-generated image is no small task. For this project a CG paint method was developed, utilizing Maya Paint Effects and particles. This method was implemented with a script, saving time by automating the process as much as possible.

This project was implemented by a group of graduate students. Before settling on the above described solution, many alternative methods were researched and tested. The use of Maya Paint Effects and particles was proven an effective choice for this project because it produced the visual effects desired in a manner that was fairly easily handled by the available equipment. The particle script has been used successfully through three iterations of this project, each time bringing it closer to the original vision.

## DEDICATION

I dedicate this thesis to Momma, Daddy, and Will, who have been there every step of the way. Thank you for all of your help, I love you! Also, I think a shout out is appropriate for my many extended family members and countless friends who have listened to me drone on and on about this project for the last five years. I finally did it!

I would also like to mention Dr. Tim Davis for having the patience of a saint. Thank you so very much for all of your help!

## ACKNOWLEDGMENTS

I would like to acknowledge the contributions of several friends to this project. Dr. Tim Davis not only directed the original project but has also guided me through this thesis based on it. My teammates Rupali Parekh and Jamie Kelley were fantastic to work with and crucial to the project's success. Lucas McDaniel, Serenthia Ross, Rachel Drews and Yu-Ting Chiu all assisted us at some point, stepping in to help model, develop the look, organize, animate, etc. Finally, Steve Bushman, Kent Chan, and Edgar Rodriguez contributed character models to the project, which were discussed in detail in this thesis. Thank you to all of you, your efforts have made this project and corresponding thesis possible!

## TABLE OF CONTENTS

	Page
TITLE .....	i
ABSTRACT .....	ii
DEDICATION .....	iii
ACKNOWLEDGEMENTS .....	iv
TABLE OF CONTENTS .....	v
LIST OF FIGURES.....	vii
CHAPTER	
1. INTRODUCTION .....	1
1.1 Origin and Motivation .....	1
1.2 Project Goals .....	2
2. IMPRESSIONIST PROJECT RESEARCH.....	5
2.1 History of the Impressionist Movement.....	5
2.2 Character Research.....	17
2.3 3D Paint Techniques .....	24
3. CHARACTER SET-UP .....	41
3.1 Modeling and Rigging .....	41
3.2 Applying Textures .....	48
4. CHARACTER PERFORMANCE .....	54
4.1 Animation Layout and Management.....	54
4.2 Animating Scenes.....	56
5. PAINTING.....	58
5.1 Painting Characters .....	58
5.2 Painting Set Pieces.....	63
5.3 Compositing.....	64

Table of Contents (Continued)

	Page
6. CONCLUSION.....	67
REFERENCES.....	68

## LIST OF FIGURES

Figure		Page
1.	Example of early Impressionist project research (Davis & Johnson, 2003). .....	4
2.	French soldiers resort to using dead horses for food during the war (Evans, 1870).....	7
3.	Formation of the Paris Commune (Franco-Prussian War, 2011). .....	9
4.	Manet's <i>Luncheon on the Grass</i> (Manet, 1863). .....	15
5.	Monet's <i>Impression, Sunrise</i> (Monet, 1872).....	17
6.	Crinoline examples ("Crinoline," 2011).....	18
7.	Bustle examples (Breneman, 2010). .....	19
8.	The left image is the popular sack suit; the right image is the slightly more formal frock coat paired with light colored pants (Wisconsin, 2011 and Gentleman's Emporium, 2011). .....	20
9.	Children's Clothing (fotoLibra, 2011). .....	22
10.	Women's half-up hairstyles and Renoir's depiction of the casual straw hat (The University of Vermont, 2011 and Renoir, 1899). .....	23
11.	Eton, bowler, straw and common work hats (The University of Vermont, 2011).....	24
12.	Hand-painted paper, left, scanned into a digital format; on the right, the same image applied to a simple sphere and rendered in Maya .....	26
13.	Initial attempts at a painterly fur groom. ....	29



List of Figures (Continued)

Figure	Page
14. (a) Particles and paint strokes at object creation; (b) object moves but particles and paint strokes are left behind. ....	31
15. Original adult female model (left); altered for Impressionist project (right), scaled for example purposes .....	42
16. Original adult male model (left); altered for Impressionist project (right), scaled for example purposes .....	44
17. Original child female model (left); altered for Impressionist project (right), scaled for example purposes .....	46
18. Original child male model (left); altered for Impressionist project (right), scaled for example purposes .....	47
19. Color palette examples, Monet paintings (Monet, 1887-1888). ....	49
20. The hero woman's dress is more detailed in texture than any other.....	50
21. Images of the hero woman's original textures (shirt above, skirt below) (left); the same textures with lighting baked in (right). ....	53
22. First few lines of spreadsheet used to track shot progress.....	56
23. Hand-painted gazebo, rendered in three separate pieces and composited.....	64

List of Figures (Continued)

Figure	Page
24. The black arrows point to noticeable examples of the double ground cover image; the red arrows point to pockets of grass rendered with each character.....	66

# CHAPTER ONE

## INTRODUCTION

A beautiful countryside painted in the style of the classic French Impressionists was the vision that inspired this thesis. The result was a study of the history of the Impressionist movement, non-traditional rendering techniques, and stylized animation. The guidelines defined for this project revealed both technical and artistic goals, which were largely achieved in the final product.

### 1.1 Origin and Motivation

Stylized rendering is a popular topic of research in the Computer Graphics industry. From toon shading to graphic novel sketch to painterly techniques, many have attempted to art direct projects. Not all who try for specific effects succeed, but as the industry and the idea grow, the resources and other tools for artists become more readily available. Several years ago the Impressionist project, eventually named "Femme Avec Une Fleur" and from here on referred to as Femme, was born at Clemson University. At the time very few resources were available for painterly rendering techniques; therefore, several theories were tested with varying degrees of success. Here we will discuss the evolution of Femme.

To capture the vision of passing from the real world to an Impressionist environment, the animation begins in a modern art gallery, crosses the exhibition floor and pauses in front of an Impressionist painting of a wooded area. The

camera then pushes forward, moving into the painting itself, and follows a path through the Impressionist world. It passes a group of children listening to an older gentleman telling a story, boys playing near the river in the distance, ladies lunching in the grass, and a fountain spraying water into the air. Ultimately the camera focuses on a man presenting a sitting lady with a flower. The lady takes the flower and pauses, at which point the camera pulls back out of the painting and into the art gallery.

## 1.2 Project Goals

In order to create a computer animation in a certain style, one must understand the unique artistry defining that style. While Impressionism appears to be a rather loose form of painting, several definitive characteristics present themselves:

- 1) Visualization of individual paint strokes
- 2) Liveliness and variety of color palette
- 3) Emphasis on the interaction between light and shadow
- 4) Common subject matter (Cogniat, Elgar, & Selz, 1979, p.6).

The project goals became not only the creation of this project, but also the successful inclusion of all of these characteristics.

When creating a period piece, every detail must be considered in the appropriate time frame. What kind of clothing was worn in the late 1800's? What kinds of hairstyles were in fashion? How did people act in public? How did children play? Was it common to go swimming in a public body of water, or even

wading? In what season is this piece set? What time of day? What kind of architecture was common and what would be visible in this setting? All of these questions required answers at some point in the course of this project, either in the form of research or through sample images and other references.

Early research work on techniques for achieving painterly effects was built on a particle application that was eventually used for this project as well. A sample image of this work is shown in Figure 1. Femme focuses mainly on the research of Impressionism and painterly rendering methods invented in its creation, the development of such methods used specifically for this project, and the project's execution, failures, and successes.



Figure 1. Example of early Impressionist project research (Davis & Johnson, 2003).

## CHAPTER TWO

### IMPRESSIONIST PROJECT RESEARCH

The background of the Impressionist movement and the history of France during that time period is crucial to understanding the Impressionist artists' mindsets, and ultimately recreating their artwork in an accurate fashion. Also important is research for character development. Observing fashion from the late 1800's allowed artists on the project to clothe characters in appropriate daytime outdoor wear. Finally, the in-depth study and testing of the 3D paint technique development was vital to the project.

#### 2.1 History of the Impressionist Movement

The rise of Impressionism as an art form may be better understood by reviewing the state of France in the late 1800's. The end of the Franco-Prussian War and the fall of the Paris Commune left the country bruised and beaten, attempting to close itself off from outsiders and, reliant on tradition, unwilling to accept change and new ideas. Despite the general French attitude at the time, new trends in painting methods and subject matter were starting to gain popularity with artists, though not with critics and general audiences. The growing popularity and availability of photography was also beginning to have an impact on the way artists functioned.

Relations between France and the Kingdom of Prussia (part of Germany) had been tentative at best for many years. The Napoleonic Wars in the early

1800's had seen the two countries on opposite sides, resulting in a spectacular loss for France and the banishment of Napoleon I. The balance of power remained unsteady through the 1860's. The situation finally came to a head when a Prussian nobleman was named to the Spanish throne, which had been vacant for two years after the deposition of Isabella II in 1868. Insults were traded between the King of Prussia and a French ambassador, and France, led by Napoleon III, declared war on July 19, 1870 ("Franco-Prussian War," 2011).

Though they initiated combat, the French were not well prepared for the Franco-Prussian War. While France had a greater overall population than all of the German states that participated, the Germans were able to mobilize more soldiers in an efficient fashion. Germany initiated a draft requiring all men of fighting age to report for duty immediately upon mobilization of German troops, while France had no such conscription program. Germany also had a much better railway system at the time, allowing them to more quickly and efficiently move troops, whereas France was not able to deliver large numbers of their troops on time, leaving crucial battles undermanned and undersupplied. Figure 2 shows a famous illustration by Mary Evans depicting French soldiers during the Franco-Prussian war forced to use dead horses for meat due to shortages in available food. This illustration specifically shows the aftermath of the failure at "La Grande Sortie," an attempt to end the siege of Paris and the turning point of the war (Clayson, 2002). Germany also seemed to have the upper hand in the area of armament, utilizing heavier impact and easier breech-loading artillery than the French ("Franco-Prussian War," 2011). The war concluded with the fall



of Paris on January 28, 1871. The German states united as the German Empire and the Treaty of Frankfurt was signed on May 10, 1871 (Milner, 2000).



Figure 2. French soldiers resort to using dead horses for food during the war (Evans, 1870).

Paris fell to the Prussians in late January 1871 following a five-month siege that had severely debilitated the city. The current mood of the common Parisian people was leaning toward a democratic republic while the ruling moderate republican party, led by Adolphe Thiers, sought to stay in command. Many had long been unhappy with work conditions, such as the lack of separation between church and state and the abolition of night work, which only worsened with the Franco-Prussian war. The rich got richer and the poor got poorer, resulting in food shortages, military failures and the fall of the city after Prussian bombardment. Finally, the current Government of National Defense sought surrender to the German Empire, which many working class Parisians resented bitterly and viewed as the last straw (Milner 2000).

An already existing citizens' militia, known as the National Guard, organized a Central Committee to become the decision-making body for the city. The 92 elected members were comprised largely of skilled professionals and political activists. Their stated purpose was to defend Paris if Germany decided to enter the city again, but Thiers worried the formation of such a governmental body, separate from the official governing institution, would provoke the Germans once again.

While forming the committee, or rather the Communal Council as it became known, Parisian rebel citizens and National Guard members alike had secured about 400 cannons in an attempt to arm themselves and to prevent those weapons from falling into German hands ("Franco-Prussian War," 2011). In response, Thiers ordered government troops to seize the cannons once again; however, most of the government troops had begun fraternizing with the rebels and were sympathetic to their cause. Thiers evacuated the city with all of the loyal troops and policemen he could find, retreating to Versailles. The Paris Commune, illustrated in Figure 3, ruled for about two months from March 26 to May 24, 1871, during which time they passed legislation designed to improve the post-war life of the Parisian worker (Milner 2000).



Figure 3. Formation of the Paris Commune (Franco-Prussian War, 2011).

Almost immediately the regular Army of Versailles began attempts to re-take the city of Paris from its rebellious inhabitants. Throughout April and May, government forces, constantly increasing in number, besieged the city's powerful defenses and pushed back the National Guards. On May 21 a gate in the western part of the fortified city wall of Paris was opened, and Versaillaise troops began the re-conquest of the city. The strong local loyalties that had been a positive feature of the Commune now became a disadvantage. There was no plan for an overall defense, but rather each section of the city fought desperately for its own survival, and each was overcome in turn. During the assault, the government troops were responsible for slaughtering National Guard troops and civilians. Many prisoners arrested for possession of weapons, or who were suspected of having fought, were shot in summary executions. The toughest resistance was mounted in the working-class districts of the east, which came to

a head in the vicious street battle that became known as *La Semaine Sanglante* ("The Bloody Week"). By May 28, about 50,000 Parisian rebels lost their lives either during battle or in execution afterward (Clayson, 2002).

Given the bloody history leading up to the start of the Impressionist movement in Paris, the French public was resistant to change in its beloved institution of art, particularly such drastic changes as the adoption of Impressionist characteristics. France had recently experienced a disastrous war in which they were betrayed by their neighbors, the Prussians. The newly formed German Empire celebrated its victory by parading through the streets of the beloved French capital city, which Parisians resented greatly. Political tensions were so high that what followed amounted to a civil war, and while short-lived, it incurred extensive damage not just to the city of Paris, but also to the morale of the French people. The mood of the people was therefore fairly closed-minded. Outsiders generally were not welcome, at least not to the extent that they had been previously, and determination arose to cling to French ideals in all aspects of creativity, from painting to music to literature.

Up until the late 1800's, Neoclassicism, or Academic Art, had been widely accepted. Academic Art, characterized by its highly polished style, its use of mythological, historical or religious subject matter, and its moralistic tone, was largely taught in the art academies (hence the name), where many of the artists during this period received their formal training (Maylon, 2011). One such academy was the Academie des Beaux-Arts, which set and held to the traditional content and stylistic art standards of the day. Still life and landscapes were

looked down upon and almost all painting was set indoors regardless of subject ("Impressionism," 2011). This approach was partly due to limitations in the tools of the day, i.e. pigments that artists would have to grind and mix for themselves (Broude, 1990). Somber, heavy colors and crisp, cleanly finished images of the subject matter in an idyllic fashion were preferred. The goal was not to portray the artist's emotional interpretation of the subject, but rather to recreate it in its accepted, canonic form ("Neoclassicism," 2011). Academic Art was the style that the 19th century Salons of Paris admired most. Consequently, it was also the style to which the French public had grown accustomed in the 1800's.

Romanticism in this time period was also an acceptable style in painting and in other visual arts, though probably less appreciated by the Salons. Beginning as a reaction to the Industrial Revolution in the late 1700's and the rapid, dynamic social change that culminated in the French Revolution and the Napoleonic era, the movement validated strong emotion as an authentic source of aesthetic experience, placing new emphasis on feelings such as trepidation, horror, terror and awe ("Romanticism," 2011). Romanticism exalted individualism, subjectivism, irrationalism, imagination, emotions and nature - emotion over reason and senses over intellect ("Romanticism," 2011). A fascination with the majesty of nature, human nature, folk culture and the medieval era are prevalent in the subject matter of this movement (Tansley & Kleiner, 1996). The difference, however, between Neoclassicism and Romanticism is mainly subject matter, as both movements value the same methods of physical treatment: indoor work, clean representation of subject

matter, no visible paint strokes, etc., with the exception of vivid colors for emphasis of mood and passion, introduced in Romanticism.

Enter the Barbizon school of artists, circa 1830-1870. Named for the village where they met on the outskirts of Paris, the Barbizon painters studied and practiced a new style, which eventually was called Realism. Again a shift in subject matter, Realism focused on the depiction of everyday subjects in their actuality, without idealization, and without omitting their sordid aspects. For example, rather than paint a historical scene or the ideal female form lounging on a bed, the subject of a Realist work might be three women working in a field, as in Jean-Francois Millet's *The Gleaners* (Tansley and Kleiner, 1996). This piece marked the introduction of common figures to Barbizon works, which until this point had focused on landscapes ("Realism," 2011); however, Realists by no means discarded the Neoclassical and Romantic approaches to their treatment. Rather than venture outdoors to paint a landscape, they remained indoors, choosing to paint from memory. The idea in Realism was to truthfully represent all aspects of the subject matter, regardless of stature, without artistic interpretation.

Despite their classic methods of painting, the Barbizon Realists chose landscapes, figures, and other common, everyday subject matter, and led the way for their protégés, many of whom became the original Impressionists. While the Barbizon methods of treatment did not stray far from the accepted standards of the day, their shift in subject matter choices led some painters, namely Monet, Renoir, Sisley and Bazille, to begin painting landscapes and contemporary life in

a lighter, more interpretive way. They shared mentors, such as Gleyre, Manet and Degas, and would meet to paint together, and later even meet to discuss their collective issues with the Salon. Like-minded painters Pissarro, Cezanne, and Guillaumin soon joined them.

Photography was becoming more widely available during this time period, creating one more push toward Impressionist art. Why try to recreate the exact representation of a scene when a photograph could capture every detail perfectly? Impressionism had to do what photography could not: further develop the subject as an art form and express the artist's impressions of nature (Tansley & Kleiner, 1996). Together, the Impressionist artists created new standards for the pieces they were choosing to create. Combining the common subject matter of the Dutch and Barbizon artists with the odd snapshot-like composition that was becoming common in Japanese prints, the Impressionist paintings typically met most of the following criteria:

1. Contemporary subject matter of a more general nature, rather than historical, religious and portraiture
2. Short, quick, thick strokes of paint (*impasto*) used to quickly capture the essence of the subject, rather than its details, which remain visible in the finished work
3. Colors applied side-by-side with as little mixing as possible, creating a vibrant surface and allowing the optical mixing of colors to occur in the eye of the viewer

4. Grays and dark tones produced by mixing complementary colors, avoiding the use of black paint
5. Wet paint placed into wet paint without waiting for successive applications to dry, producing softer edges and an intermingling of color
6. Emphasis on the play of natural light, with close attention to the reflection of colors from object to object, including the blue of the sky
7. Paintings often created *en plein air*, or outdoors
8. Snapshot-type composition (Broude, 1990).

Once or twice a year, the Academie held the Salon de Paris, a juried art show that the general public could attend. In 1863 a painting by one of the Impressionist mentors, Manet's *The Luncheon on the Grass* (Figure 4), was refused by the Salon based on its placement of a nude woman in a contemporary setting surrounded by two men (Robb, 1951). That year many other works by Impressionist painters (though not yet referred to by that name) were rejected as well, which highly offended the young artists. Such uproar resulted from these refusals that Napoleon III, fresh from a major defeat in the Franco-Prussian War and wishing to demonstrate that the Salons were democratic, demanded the rejected paintings be displayed in a separate show, the Salon de Refuses. This new show was more highly attended than the original Salon of that year and served to open the public's eyes to a new movement in art, even if it had not yet reached critical acclaim.





Figure 4. Manet's *The Luncheon on the Grass* (Manet, 1863).

While the (still unnamed) group of Impressionists continued to grow, their works continued to be rejected by the Salon. They petitioned for a repeat of the Salon de Refuses in 1867 and 1872, but were denied each time. At that point the artists took matters into their own hands and organized to form the *Société Anonyme Coopérative des Artistes Peintres, Sculpteurs, Graveurs* ("Cooperative and Anonymous Association of Painters, Sculptors, and Engravers") to facilitate the creation of their own exhibition. Members were expected to stop applying to the Salon and to deny any invitations to show there. For this reason Boudin, Jongkind and Manet (several of the members' original inspirational artists)

declined to participate, stating that they still wished to earn acceptance in the Salon.

The first exhibition by the Association took place in 1874 and received mainly negative critical reviews. One critic, Louis Leroy, rather unkindly reviewed Monet's *Impression, Sunrise* (Figure 5), calling it little more than a sketch and comparing it to wallpaper. From the title, he gave the group the name that would come to be accepted first by the public, and later by the artists themselves: Impressionists. The Association went on to produce seven more Impressionist exhibitions in 1876, 1877, 1879, 1880, 1881, 1882, and 1886. Membership of the group shifted as arguments over whom would be invited to participate, and simultaneous application to the Salon, pitted certain members against each other. Overall, though, the Association was successful in gaining public, if not critical, acceptance of Impressionism.



Figure 5. Monet's *Impression, Sunrise* (Monet, 1872).

Upon completion of this historical research the creators of this project had a better understanding of the birth of Impressionism and the political mood of the time. This allowed for the proper representation of the Impressionist movement, as the challenges and successes were taken into account along with the development of the style itself. They also seemed to have developed a feeling of connectedness with the project that had not previously been there, which became crucial to the project's success.

## 2.2 Character Research

In addition to the history and motivations of the time period, research surrounding the people and environments of the era was also required to

accurately portray the characters in this animated Impressionist painting. This research involved styles of clothing, styles of hair, common leisure activities, and architecture of the late 1800's.

In the time leading up to the late 1800's, women were wearing long dresses that nearly reached the ground. These dresses were usually tapered at the waist and full in the skirt, resulting from the use of a crinoline. The word *crinoline* originally referred to a material commonly used in petticoats to push a lady's skirts outward for volume. Crinoline eventually came to mean a steel cage device that shaped skirts in a desired fashion, first in an outward balloon shape as in the left image of Figure 6, and by the late 1860's, a more refined shape that added volume to the rear area and tapered down to fan out behind as in the right image in Figure 6 ("Crinoline," 2011).

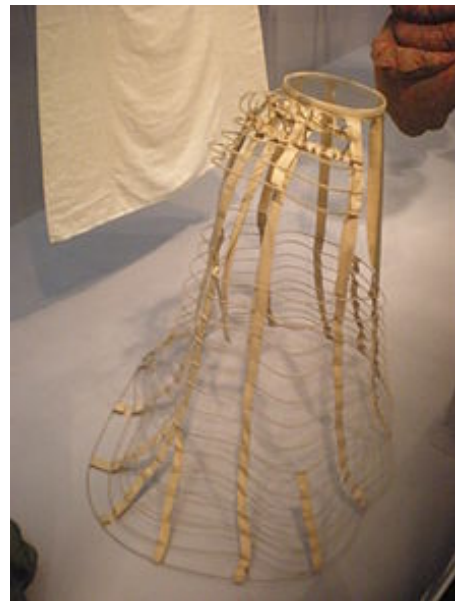


Figure 6. Crinoline examples ("Crinoline," 2011).

By the 1870's the crinoline had further evolved into the bustle, another typically steel cage contraption intended to enhance the womanly figure under dresses, as seen in Figure 7. The bustle attached to the back of a lady's lower waist and rested against her backside, rounding the shape of her posterior and pushing it outward in the back ("1870s," 2011). Her skirts lay over this device and again typically reached the ground, though more casual styles sometimes shortened to the ankle. These dresses were usually two pieces, a form fitting bodice with long or elbow-length sleeves and a separate skirt. Necklines were conservative during the day, but more lenient in eveningwear, where even sleeveless gowns sometimes accompanied plunging necklines. An alternate casual day style was a loose fitting blouse paired with a skirt in contrasting color.

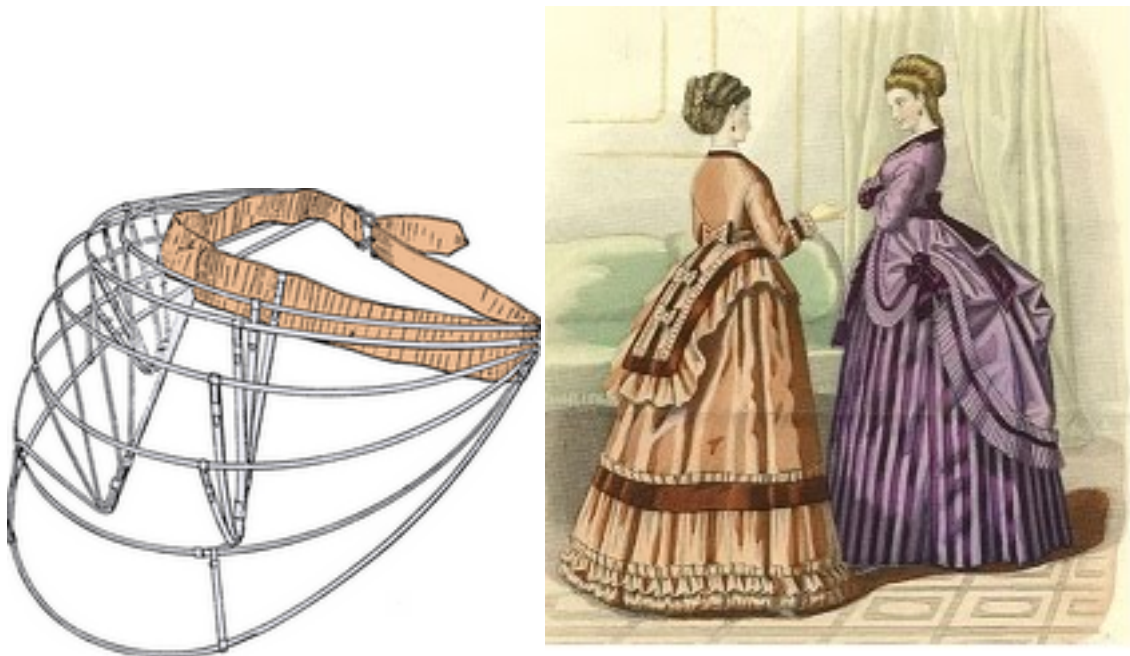


Figure 7. Bustle examples (Breneman, 2010).

Men of the era were transitioning from the formal frock coat and suit traditions to a more casual sack suit for daytime occasions including business, travel, and leisure. Sack suits were composed of varying qualities of wool and tended toward darker colors such as browns, blacks and grays. Younger men, however, often tended toward louder colors and patterns, opting for plaids or stripes (Wisconsin Historical Society, 2011). Sack suits were composed of three pieces: a coat, vest and pants, all from the same fabric. They were designed to appear fuller than frock coats, which were cut as form-fitting. Frock suits were common as well, but were often worn in mismatching combinations, such as light pants with a dark coat.



Figure 8. The left image is the popular sack suit; the right image is the slightly more formal frock coat paired with light colored pants (Wisconsin, 2011 and Gentleman's Emporium, 2011).

Children of both sexes wore gender-neutral gowns until the age of five. At that point both boys' and girls' garments began to mimic adult clothing, with length being the main difference. In general, the younger the child, the shorter the length of the outfit. Girls may have worn knee-length dresses from ages four to eight, mid-calf from ten to twelve, and floor-length dresses and skirts similar to their mothers thereafter ("1870s," 2011). Boys typically wore short pantsuits in their younger years, sometimes in sailor-suit style, and advanced to long trousers in their teens. Girls often wore aprons over their dresses to protect the fabric underneath and boys sometimes donned lace collars in *Little Lord Fauntleroy* fashion. A simple Christmas card illustration, depicted in Figure 9, accurately portrays several popular children's clothing styles of the time period.



Figure 9. Children's clothing (fotoLibra, 2011).

Typically in this period, women's hair was pulled back from the face and fashioned into some type of knot, chignon or arrangement of curls, often with a hat or bonnet on top. Hats sat forward on the head and sometimes tipped downward to allow room for styled hair in the back. Bonnets were also worn forward on the head, but included a ribbon tied under the chin. Bangs were common as well, eventually leading to more casual half-up, half-down hairstyles as in Figure 10.





Figure 10. Women's half-up hairstyles and Renoir's depiction of the casual straw hat (The University of Vermont, 2011 and Renoir, 1899).

Men's hair was worn short and oiled in a slicked-back fashion (Gentleman's, 2011). Long beards and moustaches were also worn oiled. The Eton, Bowler and more common wide-brimmed work hats were all seen in everyday use, as well as top hats for more formal occasions and straw hats for leisure time spent outside, as in Figure 11. Women also favored wide-brimmed boater-style straw hats for outdoor recreation. Children once again mimicked their adult counterparts in hat and hairstyles.



Figure 11. Eton, Bowler, straw and common work hats (The University of Vermont, 2011).

### 2.3 3D Paint Techniques

The final remaining topic of research was the 3D paint technique to be used for the desired Impressionistic rendering style. This task was part exploration, but also part hypothesizing and testing of solutions. Because of the few references to examine and the initial unknown aspects of this development task, it began in (and has been categorized here as part of) the early stages of the project. It did, however, continue to evolve throughout the implementation process.

The main objects that required painting in this project were the animated characters themselves. As these models possess many moving parts and somewhat significant levels of detail, they were the most difficult to paint digitally; therefore, they were ideal candidates for testing various methods. Many techniques were explored to create an Impressionist “look” in a 3D computer-generated world. One approach involved physically painting on paper and canvas surfaces, scanning the results into digital formats, and applying them as texture files on objects in 3D scenes. Another method applied Maya Paint Effects

to certain parts of the project (e.g. trees), which leveraged procedural results for rendering. Textures created in yet another approach used Corel Painter rather than painting directly in Maya. Also, the original particle research still held promise for producing the desired environment. A final idea used Maya Hair to represent Impressionist paint strokes. Each proposed method had advantages and disadvantages, as discussed below. The methods were each tested against a set of criteria deemed necessary for the digital paint technique:

1. Simulate the appearance of individual paint strokes, i.e., variant size, depth, shape, etc.
2. Create a method to keep these paint strokes in place on dynamic objects as they move through space
3. Inherit textures from underlying geometry
4. Create stable, efficient, and optimized renders.

Physically painted textures created an interesting look and was one of the best methods to retain the actual texture of the brush stroke, which was a primary goal in mimicking the Impressionist style. Several downsides to this method, however, prevented using this method in production. One problem was the difficulty in isolating the scanned paint strokes from their original physical lighting. While these strokes could be altered in Photoshop before application in Maya, such processing reduced the desirable effect of the brush strokes. Also, these images often looked good within their original setting, but once inside Maya, matching the desired lighting conditions for the textures within the scene

proved difficult. Even though the brush strokes were still visible in the scanned images, they lost any kind of 3D textured appearance they had originally, and appeared flat when applied to an object. The edges showed no overlap between objects, resulting in a forced and rigid final appearance. Lastly, little to no variation in the scale of the strokes appeared in the scanned paintings, though one would expect to see larger brush strokes close to the viewer and smaller strokes fading into the distance. Notice the flat, rigid strokes and smooth edges in the example image in Figure 12 below.

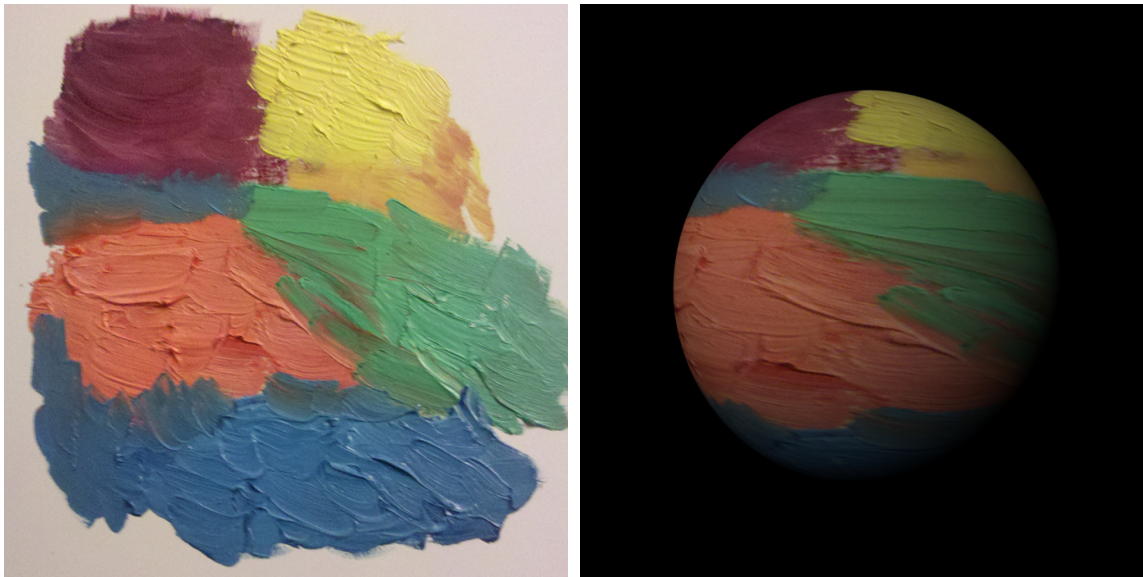


Figure 12. Hand-painted paper, left, scanned into a digital format; on the right, the same image applied to a simple sphere and rendered in Maya.

Using Maya Paint Effects in the second approach resulted in some beautiful images, particularly for the trees. The process involved selecting an Impressionist color palette and a few particular brushes for drawing strokes, then manually applying paint effects strokes on the geometry skeletons of the trees. This method resulted in a nice rendering of the trees in the first appearance of

the painting in the gallery and in the distance throughout the rest of the painting interior. These trees experienced several iterations because they did not match the look of the rest of the project at first. One substantial problem in using Paint Effects was the increased render time. In order to easily duplicate and transport the paint effects tree foliage, the paint strokes on a single acceptable tree were converted to geometry. This added geometry was incredibly heavy, not only for use in the scene, but also for rendering. As a result, the grove of trees was split into many different scene files, each having only one or two trees, which were rendered separately and later composited together, as would become standard practice for most of the work in this project.

Another method for creating Impressionist brush strokes was the use of Maya Hair. The idea was that individual strands of hair might lend themselves nicely to mimic the look of strokes of paint. Since hair strands are grown from an object, they stay attached to that object by default and move with the object if it is animated. Further, Maya Hair can inherit the underlying texture of the object; therefore, the character geometry was textured in an Impressionistic fashion and hair color was derived from those textures. In practice, however, tests using Maya Hair quickly seemed to cause problems. As was expected, test renders consumed a large amount of time per frame and, when viewed as an animated sequence instead of single frames, appeared rather noisy. The noise problem might have been solved with further render testing and refinement, but Maya Hair is somewhat slow to render no matter how well it is optimized. Second, an experienced artist can accomplish a variety of effects with a hair groom. Base

and tip widths of hairs can be adjusted to represent variant stroke size, and many effects, such as bend, wave, scraggle, etc., can be added to differentiate between areas. An experienced hair groomer may have been able to produce a character object that appeared painted; however, such experience was not available for this project. Note in Figure 13 the lack of painterly features, while small, detailed areas such as ears and fingers, as well as creased areas such as the elbow and underarm, exhibit clear problems. The lack of grooming expertise, combined with the extensive time required to groom each character and dynamic object, as well as to render them all, ultimately produced a less-than-viable option for painting dynamic objects.



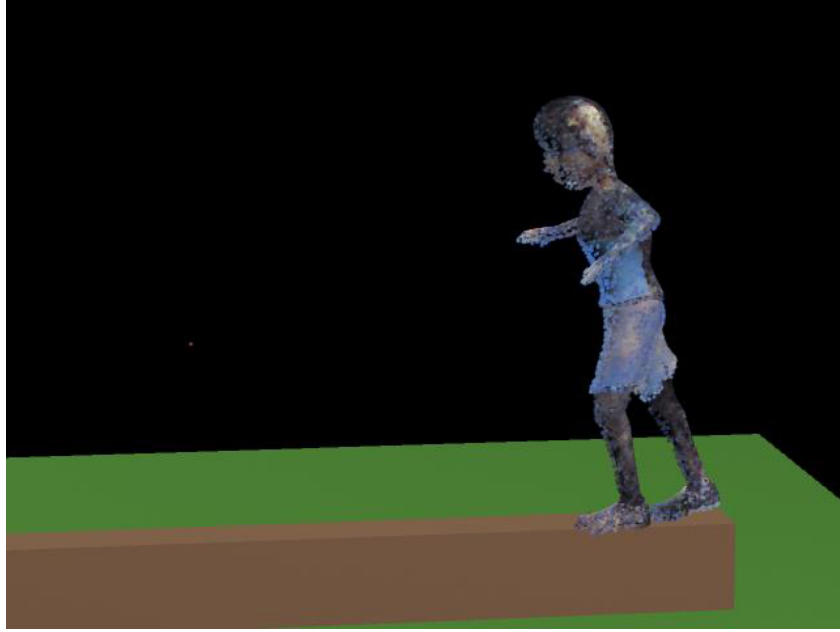
Figure 13. Initial attempts at a painterly fur groom.

The next approach combined particle systems and Paint Effects to apply paint strokes in an authentic fashion. This method presented two major problems: creating particles that would travel with their dynamic emitter object and attaching paint strokes to those particles.

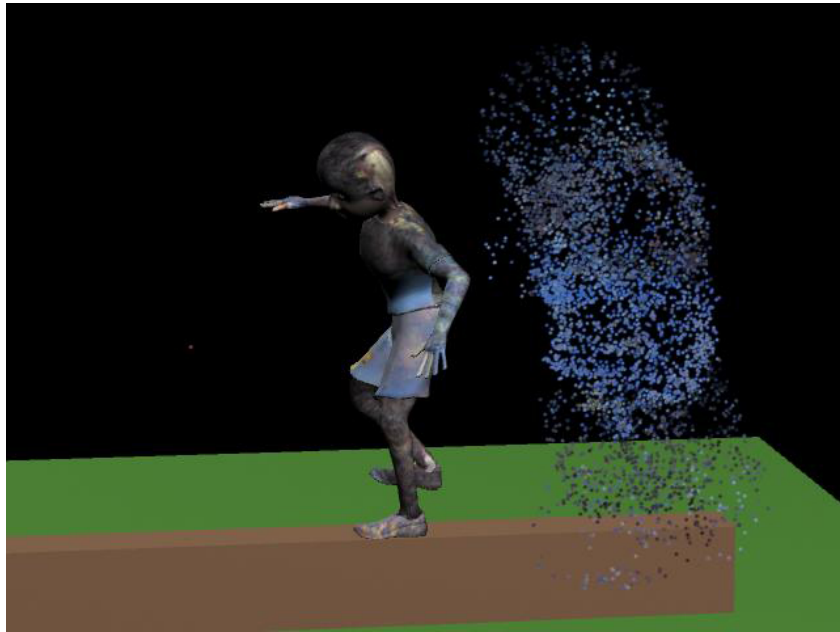
If particles are emitted from the surface of an animated object and are set to live forever, they remain at the same position as when they were created. The

result is that the animated character continues on its path, leaving its particles and paint strokes behind, as shown in Figure 14(b).





(a)



(b)

Figure 14. (a) Particles and paint strokes at object creation; (b) object moves but particles and paint strokes are left behind.

To force particles to stick to the geometry, the MEL goal command was employed, which allowed the surface object to be assigned as a goal for each particle. Applying this goal with a weight of 1.0 meant that each particle would try to follow or match its position to that of a certain vertex on the surface. The addition of goalU and goalV per particle attributes allowed the setting of the goal U and V for the particles to the matching U and V of the parent object. At this time a method for attaching paint strokes to particles was developed as well, and both functions were included in a MEL script.

The overall purpose of the script is to emit particles on the surface of an object through a certain part of the timeline. After particles are emitted evenly across the vertices of each selected object, a paint stroke is duplicated from a base Maya Paint Effects stroke and is attached to each particle emitted. Each paint stroke refers to the texture of the object itself to obtain its color information, thus covering the object in paint strokes throughout the entire timeframe. The following discussion includes excerpts of the pStr.mel script written for this project along with detailed explanation of the code.

This script first creates a series of string and float objects and arrays for storing various information needed throughout its execution. One array, \$objList, is assigned the objects selected (one or more) at the time the script is executed. The corresponding string variable, \$objName, receives the first object in that \$objList. A \$currentFrame float variable queries the current global time and is assigned the corresponding frame number. Another float, \$animStartFrame,

retrieves the animation start frame defined in the scene's playback options, which is then cast as an integer in \$startFrame.

In the code listed below, a *for* loop begins, which will eventually cycle through each object selected at function run time, i.e., all the objects in \$objList, starting with the first object selected by the user. The \$objShapeList array holds a list of all the parents and children of type shape of the current object. The \$objShape variable is then assigned the first object in that list. Next, the \$pEmList array is assigned a list of all the parents and children of type pointEmitter (which should be none) of \$objName (which at this point is the first object selected in the scene). The first entry in \$pEmList is checked and if it is not empty, an error message prints, letting the user know that an emitter already exists for that object. The main *for* loop for the script begins as follows:

```
1) for ($objName in $objList) {
2)   print ("applying strokes for " + $objName + "\n");
3)   select -cl;
4)   select -r $objName;
5)   $objShapeList = `listRelatives -type shape`;
6)   $objShape = $objShapeList [0];
7)   $pEmList = `listRelatives -type pointEmitter $objName`;
8)   if ($pEmList [0] != "") {
9)     error ("Emitter " + $pEmList [0] + " already
           present\n");
10)  }
11)  $pEmList = `emitter -type surface -name "impEm#" -r 0.1 -
           sro 0 -nuv 1 -cyi 1 -spd 1 -nsp 1 -cye none`;
12)  $pEmName = $pEmList [1];
```

If no error occurs, meaning no emitter is currently present, a new emitter is created and assigned to \$pEmList[0] with the following properties:

1. type = surface, name = impEm#
2. rate = 0.1 per square unit time

3. -sro (scaleRateByObjectSize) = 0, i.e. false, the number of particles is determined by rate alone, rather than object size multiplied by rate)
4. -nuv (need parentUV) = 1, i.e. the parent UV value is sent to target particle object
5. -cyi (cycleInterval) = 1, i.e. an interval of 1 frame is left between restarts of the random number stream, unless otherwise determined by cycleEmission, which is set to none
6. speed = 1
7. normal speed = 1
8. -cye (cycleEmission)= none, resets the random number stream for particle generation, set to none so has no effect.

The name of the newly created emitter (impEm#, where # is the value of the current iteration) is then stored in the variable \$pEmName for later use.

At this point, a new particle object is created and entered into \$pList, along with its corresponding shape and dependency information. Next, all emitters owned by the objects \$pEmName and \$pName are connected to the current selection list, and shading connection information is stored. The code continues as shown below:

```
13)    $pList = 'particle';
14)    $pName = $pList [0];
15)    $pShapeName = $pList [1];
16)    connectDynamic -em $pEmName $pName;
17)    $pShadeList = 'listConnections -type shadingEngine
                    $objShape';
```

The next part of the script enables the particles to move with the selected objects in the scene. The surface \$objName is assigned as a goal of particle \$pName with a weight of 1.0, which means that each particle will follow or match its position to that of a certain vertex of the surface. The following double array attributes are then added to \$pShapeName: goalU, goalU0, goalV, goalV0, and normalDir. This section of code follows:

```
18) // make surface goal for particles
19) goal -w 1 -utr 0 -g $objName $pName;
20) // add attributes so that particles can inherit parent's
    uv
21) addAttr -ln goalU -dt doubleArray $pShapeName;
22) addAttr -ln goalU0 -dt doubleArray $pShapeName;
23) addAttr -ln goalV -dt doubleArray $pShapeName;
24) addAttr -ln goalV0 -dt doubleArray $pShapeName;
25) addAttr -ln normalDir -dt doubleArray $pShapeName;
```

If the \$useNormal variable is true, the parent surface's normal is assigned to the particles in world coordinates. The addPerParticleGoalPointAttr command allows particles to reference surface attributes such as Normal or Tangent and inherit parent UV attributes on the surface where the particle was emitted. Particles can then use this information to stick to the surface by using goal weights (Chang, 2011), as in the following script statement:

```
26) if ($useNormal) {
27)   eval ("addPerParticleGoalPointAttr " + $pShapeName + " 0
        WorldNormal vectorArray;");
28) }
```

Two more double array attributes are added to \$pShapeName: parentU and parentV. The dynExpression command is then used on the per-particle attributes for \$pShapeName to set goalU to parentU and goalV to parentV upon

creation. This step ensures the particles' positions match that of the corresponding UVs on the object's surface, as seen in the code below.

```
29)      addAttr -ln parentU -dt doubleArray $pShapeName;
30)      addAttr -ln parentV -dt doubleArray $pShapeName;
31)      dynExpression -s "goalU = parentU; \n goalV = parentV" -c
          $pShapeName;
```

To ensure the color from the shader on the selected surface is inherited by the particles, several attributes are added to \$pShapeName: vectorArrays for rgbPP, rgbPP0, opacityPP and opacity PP0. The inheritColor and inheritOpacity values for \$pEmName are then set to true such that those values will indeed be inherited. A list of the surface shader attributes for each shader for each selected object are then stored in \$pShaderList, the first of which is assigned to \$pShaderName. Similarly, the color attributes for each shader associated with an object are stored in \$pShaderColorList, with the first in \$pShaderColorName. The purpose of this block of code is to connect the shader of each object to the emitter for that object, as seen below.

```
32)      // set attribute so that particles inherit parent's color
33)      addAttr -ln rgbPP -dt vectorArray $pShapeName;
34)      addAttr -ln rgbPP0 -dt vectorArray $pShapeName;
35)      addAttr -ln opacityPP -dt vectorArray $pShapeName;
36)      addAttr -ln opacityPP0 -dt vectorArray $pShapeName;

37)      eval ("setAttr \"\" + $pEmName + ".inheritColor\" 1");
38)      eval ("setAttr \"\" + $pEmName + ".inheritOpacity\" 1");

39)      // get shader of each object and connect it to emitter
40)      $pShaderList = `listConnections -source true -destination
          false ($pShadeList [0] + ".surfaceShader")`;
41)      $pShaderName = $pShaderList [0];

42)      $pShaderColorList = `listConnections -source true -
          destination false ($pShaderName + ".color")`;
43)      $pShaderColorName = $pShaderColorList [0];
```

Finally, several attribute details are adjusted: max number of particles, emission start frame (to animation start frame), current time (to start frame), and particle rate (to maximum at start).

```
44) // set max number of particles
45) setAttr ($pName + ".maxCount") $npar;

46) // set emission start frame to animation start frame
47) eval ("setAttr \"" + $pShapeName + ".startFrame\"" +
        $startFrame);

48) // key particle emission
49) currentTime $startFrame;
50) eval ("setAttr \"" + $pEmName + ".rate\"" + $npar);
51) eval ("setKeyframe \"" + $pEmName + ".rate\"");
```

To generate the particles, the frame range must be played, including a runup of 30 frames that forces the particle emission. The initial state is saved with \$pName and the emission rate is set to 0 so that the emitter becomes inactive. The script then prints a statement telling the user the number of particles generated. At this point all of the particles needed for this process have been generated.

```
52) // emit particles
53) currentTime $startFrame;
54) playButtonStart;
55) runup -mx ($startFrame + 30);

56) select -cl;
57) select -r $pName;
58) saveInitialState $pName;

59) // reset emission to 0 so that the emitter becomes
    inactive
60) eval ("setAttr \"" + $pEmName + ".rate\" 0.0");
61) eval ("setKeyframe \"" + $pEmName + ".rate\"");

62) eval ("keyframe -index 0 -absolute -valueChange 0 \"" +
        $pEmName + "_rate\"");
```

```

63)     $pCount = `getAttr ($pShapeName + ".count")`;
64)     print ("particles generated: " + `getAttr ($pShapeName +
        ".count")` + "\n");

```

Several loop variables are created to control the main particle loop, which iterates through each particle created by number and attaches the corresponding paint stroke. The position and color information of the new paint stroke is stored based on the particle position and underlying texture. The base stroke is then duplicated, stored in temporary variables, and renamed to free temporary variables. The stored color and position information is applied, and if \$useNormal is selected, the normal information is applied to the paint stroke.

```

65) // main particle loop
66)   for ($i = 0; $i < $pCount; $i++) {

67)     // get uv for this particle
68)     $fl_array = `particle -at parentU -or $i -q $pShapeName`;
69)     $upos = $fl_array [0];
70)     $fl_array = `particle -at parentV -or $i -q $pShapeName`;
71)     $vpos = $fl_array [0];

72)     // set color of paint stroke from surface
73)     $col = `colorAtPoint -o RGB -u $upos -v $vpos
        $pShaderColorName`;

74)     // duplicate stroke
75)     select -r stroke1;
76)     $uname = $id + $i;
77)     $dup = `duplicate -name $uname`;

78)     $cName = $dup [1];
79)     $texid = $dup [2];
80)     $utex = $texid + ".color1";

81)     if (!objExists ($utex)) {

82)       $texid = $dup [1];
83)       $cName = $dup [2];
84)       $utex = $texid + ".color1";
85)     }

86)     rename $cName ($cid + $i);

87)     select -cl;
88)     select -r $uname;

```



```

89)      $exp0 = "float $pos[];\n $pos = `pointPosition " + $pName
          + ".pt[" + $i + "]"`;";
90)      $exp1 = $uname + ".translateX = $pos[0];";
91)      $exp2 = $uname + ".translateY = $pos[1];";
92)      $exp3 = $uname + ".translateZ = $pos[2];";
93)      $exp = $exp0 + "\n" + $exp1 + "\n" + $exp2 + "\n" + $exp3
          + "\n";

94)      expression -s $exp;

95)      // set color of stroke
96)      setAttr $utex -type double3 $col[0] $col[1] $col[2] ;

97)      // set strokes to lie oriented on surface, if desired
98)      if ($useNormal) {

99)          $strokeShapeList = `listRelatives -type shape $uname`;
100)         $strokeShape = $strokeShapeList [0];
101)         eval ("setAttr \"\" + $strokeShape + ".useNormal\" 1");

102)         $localNormal = getParticleAttr("-attribute",
          "goalWorldNormal0PP", $pName + ".pt[" + $i + "]");

103)         eval ("setAttr \"\" + $strokeShape + ".normalX\"\" +
          $localNormal [0]);
104)         eval ("setAttr \"\" + $strokeShape + ".normalY\"\" +
          $localNormal [1]);
105)         eval ("setAttr \"\" + $strokeShape + ".normalZ\"\" +
          $localNormal [2]);
106)     }

```

For each iteration of the main particle loop, a completed percentage message is printed, followed by a paint stroke generation complete message when all strokes have been created. All selected particles and paint strokes created for the object are grouped together in *obj/Name*strokes. Once the script has completed particle and paint stroke generation for all selected objects, it prints out another message stating completed stroke generation for all selected surfaces.

```

107)     // print out % progress
108)     if ((float) $i / $pCount > $pcent) {

109)         print ("paint stroke generation: " + $pcent * 100 + "%
          complete\n");

```

```

110)         $pcent += 0.1;
111)         }
112)         }
113)         print ("paint stroke generation: 100% complete\n");

114) global proc particleStroke ( )

115) {
116)     particleStroke1 (300, 0);

117) }

```

All of the above takes place in a procedure called `particleStroke1`, which receives parameters `nPar` (number of particles desired) and `useNormal` (true or false). `particleStroke` is the function the user actually types into the command line of Maya to run the script. The user first sources the `ps.mel` script that houses the user interface, which calls `particleStroke` and places default parameter values of 300 particles and 0, meaning do not use normal, in the input boxes.

The above script emitted particles that live forever and travel with their dynamic emit surfaces, as well as applied paint strokes to those particles. The paint strokes also derived their texture information from the underlying surface and rendered in a stable matter. This particle and paint stroke method resulted in a fairly decent representation of Impressionist-style painted and animated objects that fulfilled the desired characteristics of the project.

## CHAPTER THREE

### CHARACTER SET-UP

Once the Impressionist-style paint technique was developed, character and scene models became first priority. A rough animatic had already been created to plan camera movements and determine character and scenery requirements. At this point in the project, the characters required were a generic adult male, adult female, child male and child female.

#### 3.1 Modeling and Rigging

Rather than creating the generic character models from scratch, starter models were borrowed from other projects: an untextured generic female polygon model wearing a long formal (sleeveless) dress; a low-poly, untextured generic male model in a snowboarding suit and boots; the title character from “Mileena Malign” as the female child, a polygon model that came fully rigged and textured, but with no hair; and a “Pirate Boy” character for the male child, a fully rigged and textured polygon model. All of these borrowed assets provided a great starting point, but also required some updates before they would be ready to use. While the body model for the adult female had a reasonable level of detail, her costume necessitated considerable change. Rather than a sleek, sleeveless formal gown, this character needed to be wearing a full-length dress with two full sleeves and a bustle. The outfit also needed some interchangeable pieces so that many different generic variations of this character could be

created. An entirely new dress model was created to replace the original outfit (see Figure 15). This model was composed of two pieces, blouse and skirt, which could be matched or given contrasting textures to vary the clothing across different characters. A broad belt was added, almost more of a female cummerbund, allowing this outfit to appear more convincingly as either one or two pieces with added color variation. The skirt piece was floor-length, effectively eliminating the need for shoes. Rather than creating many hairstyles, a low bun style was designed, which was viable for the main character, but was camouflaged in other instances by a hat or umbrella. The setting for the animation is a sunny day by a riverbank; therefore, those in the scene would be wearing daytime, outdoor wear.

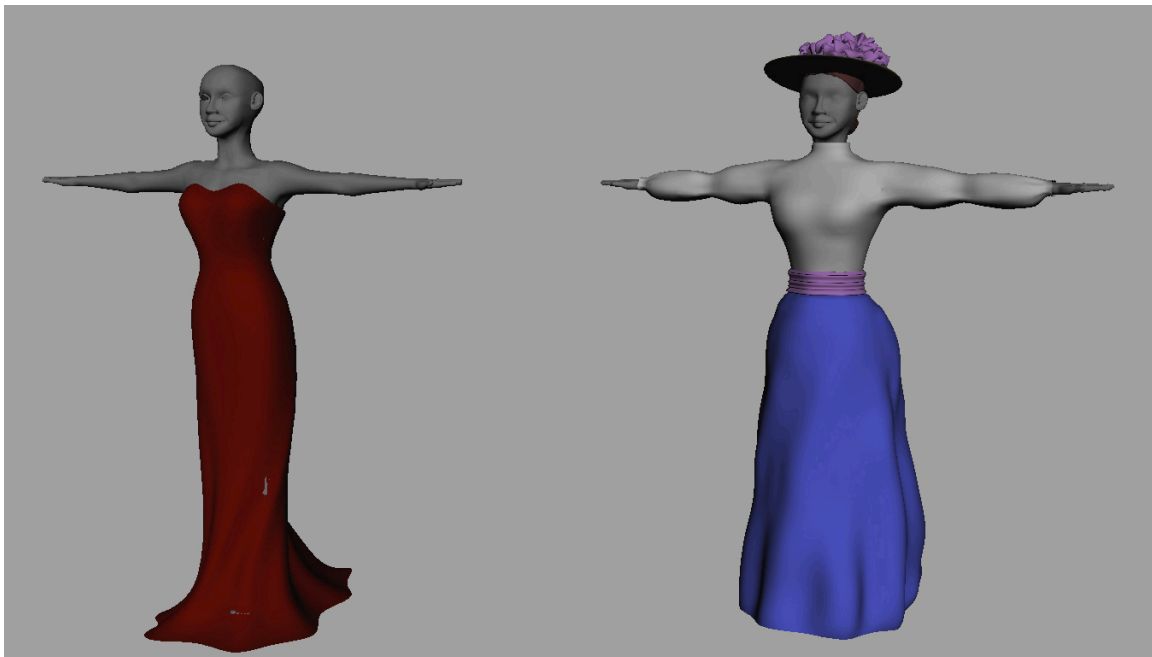


Figure 15. Original adult female model (left); altered for Impressionist project (right), scaled for example purposes.

Once completed, all pieces of the adult female model, as well as her clothing and accessories, were UV-mapped for texturing purposes. The best approach was to project the models as flat and as close to their original shapes as possible, as if one were cutting the model in half from front to back vertically. Next, the UVs were laid out with the front and back sides separate, but within the same positive space on the UV grid. Alternatively, the models could be split symmetrically as if cutting in half down the center line of the face, so that only half of the work was done in the process of laying out UVs; however, this method was deemed to be overly complex.

The male model had a very low polygon count, which made it more useful for animation blocking than for rendering. Since the model had little detail for the hands and a distinctive face, the first two adjustments made were smoothing the model and re-working the face. The level of detail for rendered facial features in the painted versions was still unknown, so the more generic "Pirate Boy" model head was copied, scaled appropriately for size, and sewn onto the man model. Additionally, the mitten-style hands were slimmed down considerably to more accurately represent fingers. The rest of the snowboarding outfit was close to the right shape, but needed further detail. The jacket was split into a single-breasted suit, slimmed down to appear similar to the popular sack suits of the day, and lapels and a collar were added. A simple shirt was also placed under the jacket since the opening now revealed a bit of the model's collarbone area. The boots were scaled down and the heel made more distinguished from the rest of the shoe. The hair for the male characters was left to texturing, but a wide-brimmed

straw hat and a smaller, beret-type hat were useful to add variation across the different male characters (see Figure 16). The adult male model was then UV-mapped in the same manner as the adult female.

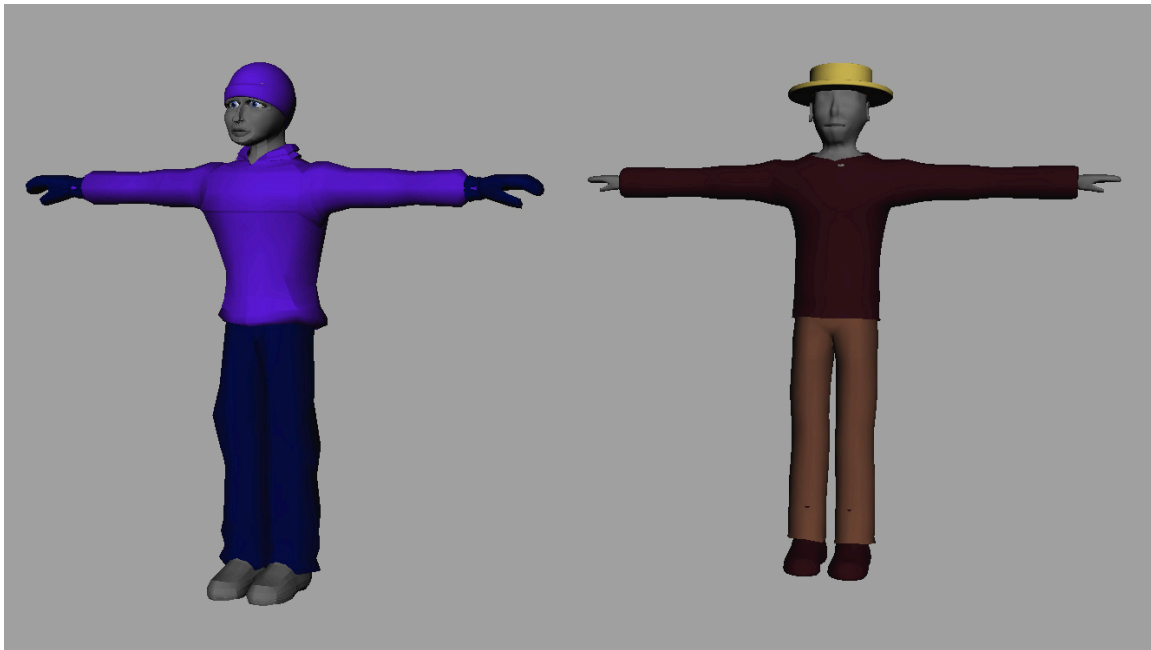


Figure 16. Original adult male model (left); altered for Impressionist project (right), scaled for example purposes.

The child female model was functionally ready to use when received in that she was rigged and UV-mapped for textures, but her body shape did not blend well with the rest of the characters. To address this issue, her large head was scaled down to better match her body proportions and her face was smoothed a bit to give her a kinder appearance. She had a simple dress that was easily updated to better match the style of the time period. A few accessories allowing the dress to vary in appearance across other girl characters included an apron over the front and a bow with trailing ribbons in the back. The original

model had elf-like feet, which were straightened and covered with simple flat shoes. The final additions for the child female model were a few different hairstyle options, including a half-up hairstyle with hair pulled away from her face and long in the back, as if fastened atop the head with a barrette; a low bun style like the adult female; and a short bob. Each of these hairstyles could be augmented with a bow on top, a flower tucked behind the ear, or a ring of flowers on the top of the head, as shown in the comparison image in Figure 17 below. The child female model needed no UV mapping, as she was already fully textured and rigged when received; however, she was UV-mapped in the layered fashion discussed previously, which was problematic in later stages of the project.

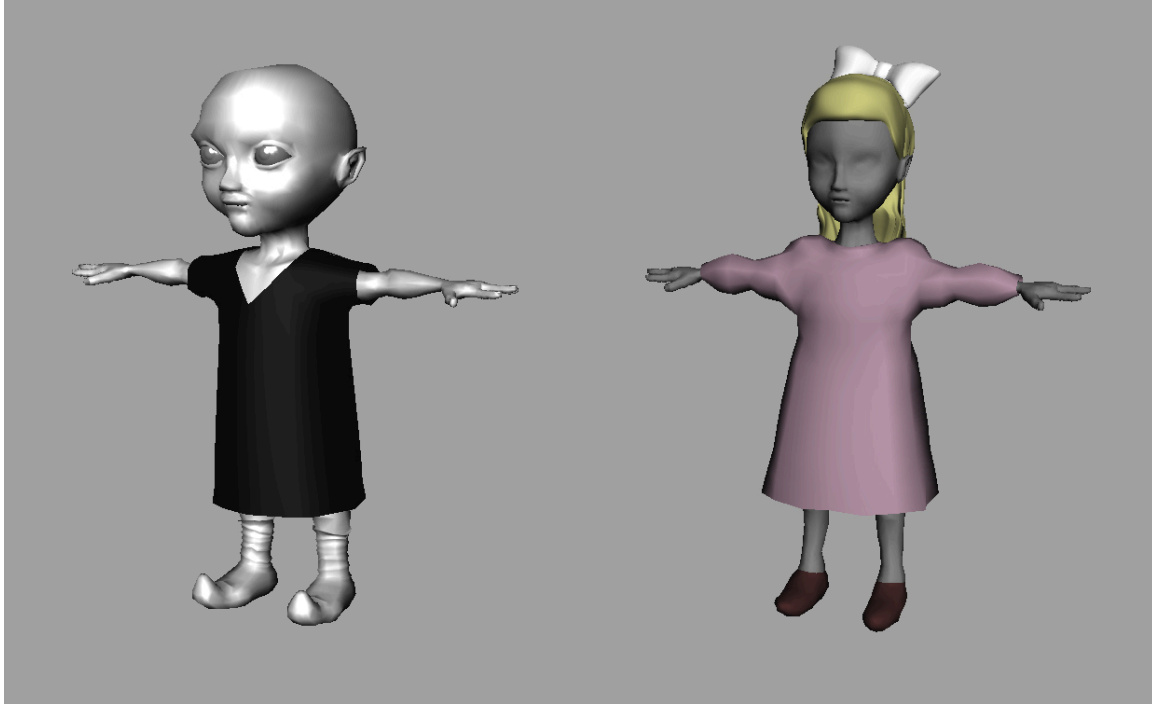


Figure 17. Original child female model (left); altered for Impressionist project (right), scaled for example purposes.

Finally, the "Pirate Boy" male child model contained an acceptable level of detail; however, his jumper was converted to a sailor suit, popular in the Impressionist time period and pictured below in Figure 18. This outfit included knee-length shorts, an undershirt, a jacket, a collar that spanned the shoulders, and flat shoes. By removing the collar and adding a wide-brimmed straw hat or a smaller beret-style hat, enough variations could be created to distinguish various boys throughout. Like the adult males, the hair for the boys was left to texturing, and all pieces of his model were UV-mapped for texturing.



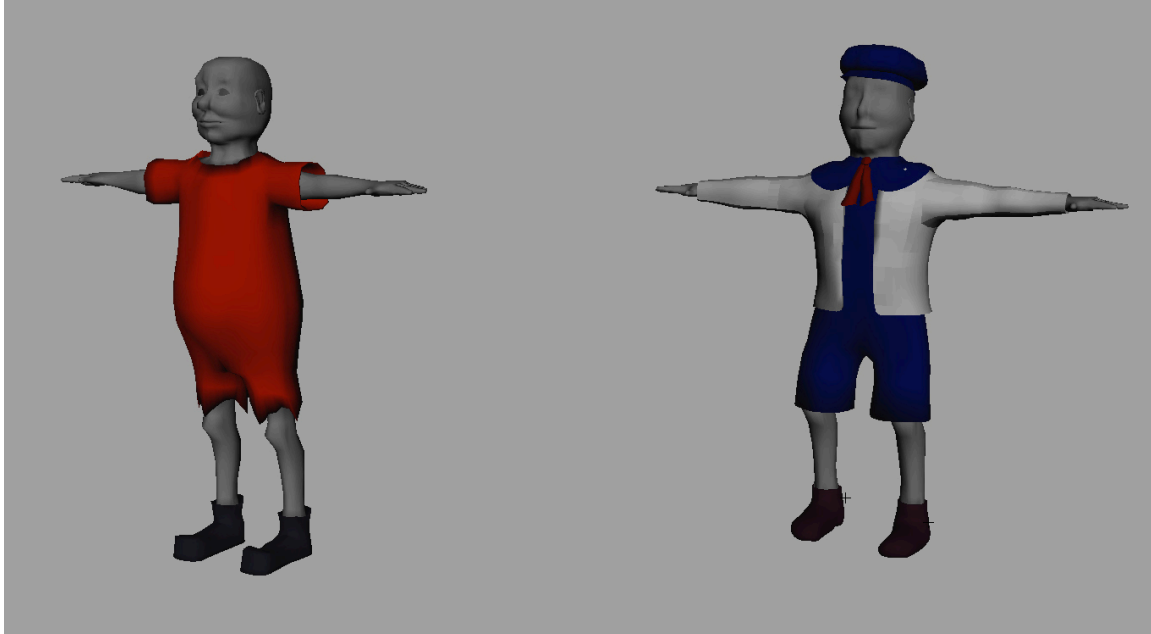


Figure 18. Original child male model (left); altered for Impressionist project (right), scaled for example purposes.

The range of motion planned for these characters was not large, thereby simplifying the design of rigs required for them. The female child model was already sufficiently rigged and her clothing additions were not significant; therefore, little rigging was required for the model. For all of the other characters, a basic joint skeleton was created. The spine, head, and hand movements were all controlled with forward kinematics by simply rotating the joints necessary to pose and move the character as desired. Inverse kinematic controls were later added for the arms and legs. A center-of-gravity control completed the character rigs for ease of placement in the scene. While these rigs were simple, they were adequate to move the characters as needed.

The next step in the character pipeline was binding character geometry to follow the motion of the rigs when animated, followed by weight painting the

geometry to the joints to ensure smooth transformations. During this stage the characters were imported into the animatic file to compare scale. While the adult male and female child were both acceptable in terms of scale with the animatic world, the generic adult female was excessively large and the male child was tiny. Since the character rigs were not scalable, no size changes could be easily made. The large and small characters were therefore unbound and scaled to appropriate size before their rigs could be reworked, bound and weight-painted. Two lessons that resulted from this process were to compare model sizes early in production and to create character rigs that are scalable. Since this latter addition could not be made without completely reworking all rigs, binding and weight-painting, all of the people in the painting are the same sizes, with no facility to create the appearance of children of different ages.

### 3.2. Applying Textures

The UV texture maps for each character model, piece of clothing, and prop, were used as guide layers for texture creation in Photoshop. These guide layers appear as partially transparent layers on top of the active layer to show the texture artist the current drawing location on the model. Some models, such as the flowers on the ladies' hats, the female cummerbunds, and the girls' bows, needed no specific mapping and were assigned square textures that were repeated as needed when applied to the model. Other models, such as the character bodies and most clothing items, needed very specific texturing, which was approached through the guide layers.

This texturing process formed the basis for the Impressionist look and feel of the piece. Although the paint strokes were actually created with particles and paint effects created by a script, the artistic direction began with the textures.

Through research of Impressionist paintings similar to the target appearance of this project, a basic color palette was chosen, comprised of mostly light greens, blues, purples and browns. Black, or any plain solid color, was not used within the painted part of the project. The basic process for texture creation began with a solid color covering the UV-mapped area, with a random pattern of brush strokes drawn on top in a complementing color. Sometimes these strokes would be a different color entirely, as in many of the clothing articles, while other times the color was simply a lighter or darker version of the same hue, as in the skin textures. This secondary layer was drawn with different brushes and varying opacity and jitter levels to randomize the patterns created. Figure 19 shows pieces by Claude Monet with the color palette chosen for this project.



Figure 19. Color palette examples, Monet paintings (Monet, 1887-88).

For a few special items, including the hero woman's dress seen in Figure 20, special patterns were painted in the textures. Once the base color and complementary secondary layer had been determined, they were merged together (hiding the guide layer) and blended where appropriate. Sometimes an additional filter would be applied to the result of the merge to further enhance the patterns. These textures were not the final visible textures, but merely the basis for particles and paint effects stroke generation. Randomizing and mixing colors in interesting ways in the underlying textures resulted in paint strokes with color variation similar to that in classic Impressionist paintings.



Figure 20. The hero woman's dress is more detailed in texture than any other.

One of the major changes that occurred later in this project was the addition of lighting baked into the textures. In the first pass of the project, no clear light source was present and the entire scene appeared to be uniformly lit. While this lighting scheme provided visibility of all objects in the scene, it was also necessary because every object in the scene was covered with Maya Paint Effects objects, which do not cast or receive shadows. One way to show lighting variations was to paint lighting effects into the textures from which the particles and paint strokes were being generated. First, the initial textures were applied to each object. Then, a clear light source was added, after much discussion as to the placement of that light.

The key light source, i.e. the sun, was placed in the corner of the scene behind the hero woman, and directed downward onto the field toward the left side of the screen. Still-frame render tests were then run in the animatic version of the file with no particles or paint strokes, in order to refine the lighting. Many fill lights were needed throughout the large scene to adequately light all of the characters and avoid harsh shadows. This lighting scheme, therefore, was important not only to the overall visibility of each character, but also to the Impressionist aspect of the project, since the relationship between light and shadow is a focus of Impressionist paintings.

With the lights appropriately placed in the render files, render textures were baked using the lighting/shading mental ray baking utilities. Larger items wrote 2048 resolution maps, with medium objects at 1024, and small objects at 512, with the following options selected: Bake Shadows, Use Bakeset Override,

Bake Out Light and Color. The textures wrote to individual texture maps that could then be opened in Photoshop and adjusted however needed. Despite best efforts, some maps rendered much too dark, requiring manual adjustment to fix those problem areas. The differences between the original textures and the baked textures were fairly dramatic, as seen in Figure 21. The updated textures were then loaded back into the object shaders within Maya, resulting in clear renders. The same method was used to bake out the ground plane textures using the animatic file with all character and environment models loaded to generate appropriate cast shadows.

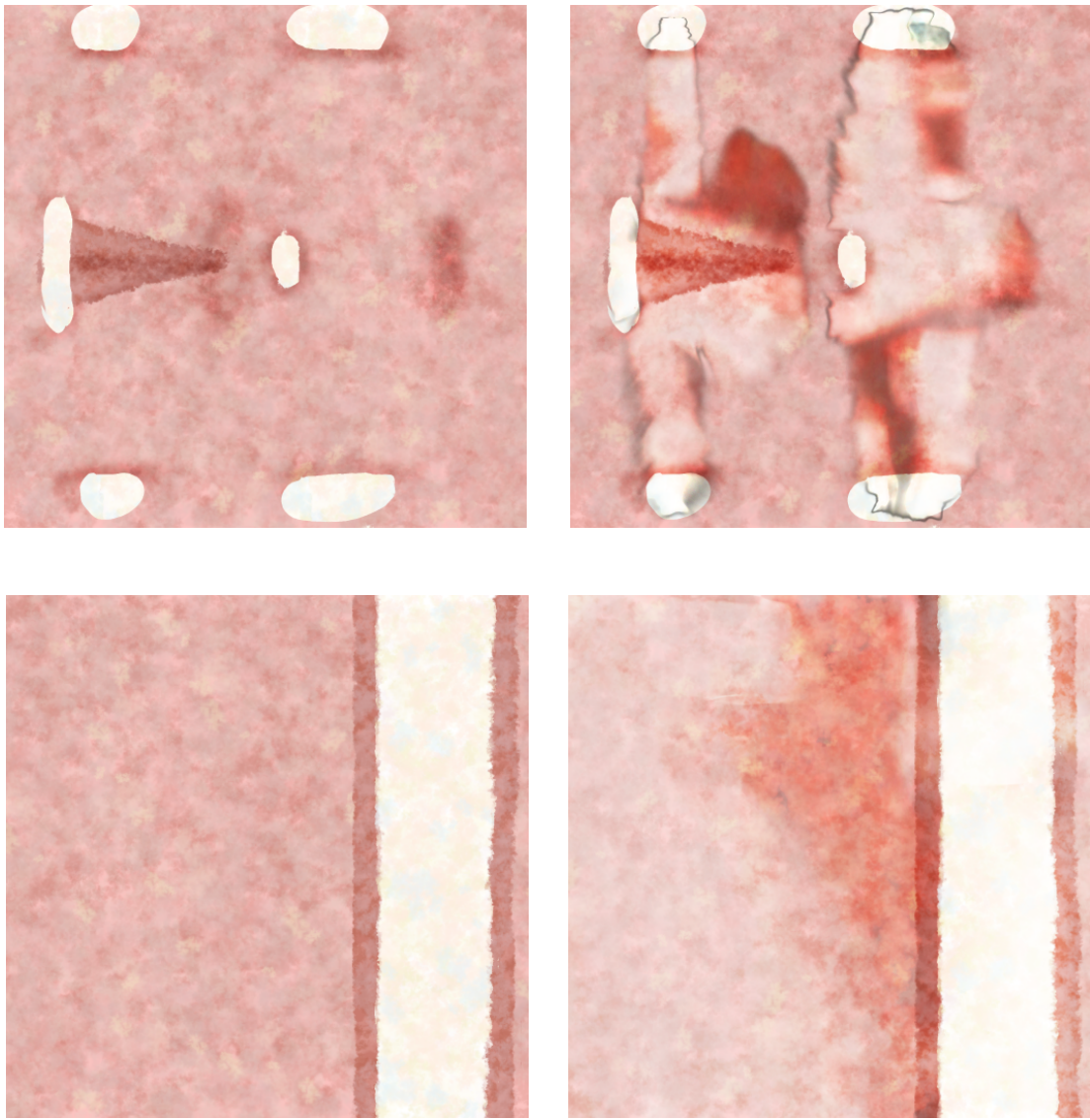


Figure 21. Images of the hero woman's original textures (shirt above, skirt below) (left); the same textures with lighting baked in (right).

## CHAPTER FOUR

### CHARACTER PERFORMANCE

In a typical production pipeline, a sequence is composed of many shots that are assigned to available animators fairly easily. Challenging shots go to more experienced and talented animators, while easier shots are reserved for newer animators, but in general each shot receives individual attention. Critiquing work is easier in this set-up, because a supervisor delivered a specific shot has only one person to address for that shot. Although individual shot animation should be viewed in sequence with its neighboring shots for continuity and performance matching, each shot can be handled individually. Also, once the animation for a scene is completed, it is made "live" to other production departments through an export and publish system.

#### 4.1 Animation Layout and Management

The fact that the animated sequence within the Impressionist painting is one continuous shot introduced interesting challenges for character animation.

Instead of the traditional process described above, this long shot was divided into shorter shots to facilitate the work of multiple animators. The complete shot originally required animation for almost 40 characters, which is no small feat even for experienced animators. As animation began, this number was pared down to 31 characters, which still represented a significant amount of work. For identification purposes, the characters were categorized by gender and age, and



assigned an identifier and number. For instance, the first group, an older man sitting on a stool and telling five children a fish story, consisted of man1, boy1, boy2, boy3, girl1, and girl2. Most of these characters appear in groups of at least two, such that each shot corresponded directly to the animation of groups of characters rather than the animation of all of the characters in one shot. The resulting nine groups ultimately dictated the number of “shots” that were assigned to individual animators.

Part of the set-up for these shots included the delineation of frame ranges for each shot from the animatic. The timing was fairly complicated since the original camera path at times revealed other parts of the scene as well as the characters in them, meaning that some characters appeared in their main shot and again in the background later in the animation. Fortunately this situation was remedied in later iterations of the project. A scene file was created for each group, including the characters needed for the scene, any props they might need, the ground plane and any necessary environment pieces and the camera to be used for the corresponding set of forms. Some of these scenes, mainly those with four or more characters in them, were geometrically and computationally heavy, due possibly to character rigs, and were therefore subdivided into individual character shots as needed.

Organization is clearly key on a project of this scale, necessitating a spreadsheet checklist for each individual character in an attempt to keep track of its status. Information included File Set-Up, Rough Animation Ready to Show, Final Animation Ready to Show, Final Animation Approved, Animatic Approved,

and Notes, as seen in Figure 22. This spreadsheet was also used in the painting stage.

	A	B	C	D	E	F	G	H	I	J	K
1	Shot/Character	File Set-Up	Rough Anim Ready to Show	Final Anim Ready to Show	Final Anim Approved	Animatic Approved	Paint File Set-Up	Render Ready	Rendered	Composited	Notes
2	Group 1										
3	Man 1	X	X	X	X	X	X	X	X	X	Final!
4	Girl 1	X	X								Head turn still not quite right, touch up (2/10/06)
5	Girl 2	X	X	X	X	X	X	X	X	X	Having trouble with face, try for more coverage
6	Boy 1	X	X	X	X	X	X	X	X	X	Final!
7	Boy 2	X	X	X	X	X	X	X	X	X	
8	Boy 3	X	X	X	X	X	X	X	X	X	
9	Group 2										
10	Man 2	X	X	X	X	X	X	X	X	X	
11	Girl 3	X	X	X	X	X	X	X	X	X	Has face problem
12	Woman 1	X	X	X	X	X	X	X	X	X	Still need to switch out NURBS hat
13	Group 3										
14	Girl 4	X	X	X	X	X	X	X	X	X	Final!
15	Girl 5	X	X	X	X	X	X	X	X	X	Final!

Figure 22. First few lines of spreadsheet used to track shot progress.

## 4.2 Animating Scenes

Because of the Impressionist painting style, the slow classical musical accompaniment, and the lazy afternoon setting of the piece, the characters were animated to move more slowly than normal to better portray the feeling of the piece and to showcase the 3D paint strokes. While animating to convey emotion through heartfelt performance is difficult in a normal time frame, animating in slow motion further increases the complexity of a shot.

Several methods for animating the characters in slow motion were considered. First, the shots could be animated in standard timing and then altered once the performance was locked. This method could possibly be accomplished simply by selecting and scaling all animation curves to lengthen their timing. Alternatively, animation tracks could be created for each character

and scaled using Maya's Trax Editor. Although the end results for these two methods should be the same, the animation tracks option was more reliable to execute since with the other method, one could easily forget to select one of the many animation controls for scaling. Another post-performance option involved adjusting the frames per second (fps). Here, the scene would be animated in 60 fps, then changed to 30 fps once the desired performance was achieved. Yet another method involving frame rate would have been to change the "By Frame" setting in the Render Globals to a fraction, say half, thereby making the timing change in the render step. Since the effect of either of these frame rate changes on particle application was unclear, the method of directly animating the characters in a slower than normal fashion was chosen.

## CHAPTER FIVE

### PAINTING

The paint application portion of the project required a similar set-up and tracking system as was implemented in the animation phase. Paint files were set up for each individual character, particles and strokes were added to all characters, props and environment pieces. These scenes were then rendered using an automated process, and finally all rendered images were composited in Shake by a composition artist. Clear notes were kept for each shot, which aided in the troubleshooting endeavors resulting from the inevitable problems encountered along the way so that each problem was handled in as efficient a manner as possible.

#### 5.1 Painting Characters

At this point, painting began through the application of paint strokes using the script created in the research and development phase (and most of the implementation phase). To prepare for particle and paint stroke application, each animated character was placed in its own individual scene file to accommodate the tens of thousands of particles generated and paint strokes applied. The script required a base particle stroke in each file to determine the shape of the strokes that would be generated; therefore, the default stroke used in testing (a medium-sized, flattened spiral shape) was imported into each file upon set-up as well, along with the render camera with appropriate Render Globals defined. The

general workflow planned for this part of the project was to open the set-up file, select each object in need of paint individually, apply an appropriate number of particles and paint strokes using the pStr.mel script, save the file with an added "\_rr" suffix (indicating render-ready), and initiate a batch render. Since each render would typically require up to a day to process, a Perl script was created to launch renders on the department's render farm. Even though this step seemed as if it would be simple and quick, several additional challenges presented themselves.

Columns for Paint File Set-Up, Render Ready, Rendered, and Composited were added to the organizational spreadsheet discussed in the Animation section (see Figure 22 above), which was extremely helpful in keeping the project on target for the final deadline. The Notes column was particularly helpful in tracking problems that the team encountered in the process of paint application. The first difficulty was that the particle application script worked only with polygon models, which was not known in the modeling phase of the project where models had been created in whatever way seemed most appropriate. Fortunately all of the characters had been created as polygonal models, but several prop, costume and set pieces had been made using NURBS. Also fortunately, NURBS objects can easily be converted to polygons using Maya's conversion utilities. This process required adjustments to UVs since none had been created for the NURBS objects; however most of these converted models used simple textures and thus required only slight changes. Since work files had already been established for each character, the offending NURBS models were

replaced in the base character rig files, then deleted from and re-imported into the render set-up files.

The next problem in the paint process was that the painted files grew too large to manage effectively. Often times applying paint to one of the last objects in the file would result in a Maya crash. Saving the files each time another object was successfully painted did not always solve the problem. In cases where painting all of the necessary objects in a file proved impossible, the amount of geometry painted was reduced.

On a related note, initial render passes revealed that significant model detail was lost in the paint process. The flowers on the ladies' hats, for example, had been intricately modeled but appeared only as colorful blobs when rendered. Fortunately, such models could easily be simplified without compromising the shot. Another slight problem related to these issues was that skin beneath clothing would occasionally extrude from rendered clothing inexplicably. Also, inadequate paint coverage on a piece of clothing would expose the underlying skin. With no skin surface present, the camera would simply see through the model to the back of the piece of clothing, which would often times camouflage the problem area. The solution to all of these problems was the simplification of models. All skin geometry covered by clothing was deleted from the models, both in the live paint files and in the base character files so that if any new files were created the corrected character would be used. This process reduced a great deal of unneeded geometry, but efforts were also made to reduce polygon count in other models as well. For instance, the aforementioned hat flowers were

changed to simple discs, the hero flower handed to the woman in the end was changed to a simple cylinder stem with flattened discs for the leaves and petals, and the girls' ribbons were all reduced significantly in detail.

The next issue was probably the most serious in this stage of the project. On the first-pass renders, all of the female children had spotty faces, usually on the character's left side. Originally renders included the geometry under the paint strokes, i.e., both the face surface and the paint strokes applied to it were rendered, which yielded an obvious patchiness in the paint. In subsequent passes the paint surfaces were not rendered, such that only the paint strokes were visible. The resulting facial renders now contained holes, which was unacceptable. To combat this problem, new render passes were run with double and triple the numbers of particles and paint strokes to cover the model. These tests proved unsuccessful, with the same spotty face problem appearing each time, and produced render files that were unusable due to their sheer size. The real problem turned out to be that the UVs for the girl model had been laid out in the mirrored layer method described previously, in which the model is split in half vertically with one side on top of the other in UV space. This shortcut in the UV maps for the girls caused unforeseen problems in the particle application since the particles were emitted evenly across the model UVs.

In an attempt to resolve this issue, a quick remap of the girl model's UVs was performed and saved in a separate character file. The model needed to be unbound from the rig for remapping UVs; therefore, weight maps for the rig skeleton were exported to ease the rebuild process. The UVs were reworked

quickly, the model re-bound to the skeleton, and the weight maps imported for the new model. The rebuild process worked perfectly and resolved the spotty face issue. The entire rebuild process for the female child was performed again, but with a much more carefully laid out UV map, and the change was applied to all the render files. This modification entailed unbinding the model from the skeleton, importing the updated girl model, transferring UVs from the new girl model to the old one in the file, re-binding the model, importing the weight maps and deleting the second instance of the girl character from each render file.

Coverage problems began to appear on the hero female's face as well, but this time most likely due to low coverage of paint strokes, exaggerated by the close proximity of the camera. The hero female also had the most detail in her face model and textures since she needed to be highly expressive. The model required a new base stroke that was much smaller and was represented by a more compact spiral shape than the default stroke used for all of the other characters. While this stroke produced results in high-concentration render tests, the model required a much higher number of particles and paint strokes on the face alone than any of the other characters, and also a much higher number than what was practical in a single file. The character was therefore split into two pieces for rendering. While using this paint stroke as the base for all paint files would be advantageous, many more render pieces would be generated, requiring more compositing later.



## 5.2 Painting Set Pieces

Beyond the characters themselves, several other objects throughout the project require painting to match the overall look. One of the more problematic pieces was the ground plane itself. This object did not move; therefore, it did not require the “sticky” paint strokes that the animated objects did. The ground plane, however, covered more area than anything else painted in this project, which presented other issues. First, no individual file could hold all of the paint strokes for the ground plane; consequently it was divided into 16 render sections, each with its own corresponding file. Each of these files contained the faces necessary for that section and used a variation of the paint stroke generation process to emit particles from only those specific faces and to subsequently attach paint strokes to them. For the ground plane, the base stroke was shaped as a wavy tube standing on its end to mimic the shape of grass, as seen in Figure 23.

The gazebo is another example of a prop that required specialized attention. This model was highly detailed and considered a showcase piece of the environment. The gazebo is large enough to be noticeable throughout most of the timeline and serves as the backdrop for the hero woman’s main performance. Painting the gazebo proved to be problematic since the model was too large to achieve adequate paint stroke coverage using the original pStr.mel script without losing details of the model. To prevent the gazebo from appearing as a large white blob, another paint script variation was utilized. This script was initially intended for filling holes left by the main script through hand-drawn paint strokes. While most of the object was painted with the original part of the script, a

few manually placed paint strokes would finish the job. The gazebo, however, was painted completely by hand. The resulting model was still so heavy that it needed to be rendered in three pieces (top, middle and base), and while it did appear slightly different than most of the other set pieces, the following image shows that many details were preserved, such as the weaving on the side pieces.



Figure 23. Hand-painted gazebo, rendered in three separate pieces and composited.

### 5.3 Compositing

Compositing began soon after painting had started. Because of large amounts of data, which led to rendering in pieces, a large Shake tree was created to composite all of the renderings. Many of the problems which arose in

compositing were related to the grass plane. Despite best efforts to adequately cover the ground plane with grass, it remained sparse when rendered. To alleviate this problem, the ground plane was rendered by itself and with an increased number of paint strokes, but neither of these options achieved the desired goal. A second pass of the particle script was performed, but did not generate different random particles for the paint strokes and thus produced the same result. The final solution involved doubling the ground plane pieces in Shake and slightly offsetting the replicated pieces from the originals. This approach effectively covered the holes in the ground, but resulted in a noticeable doubling effect which can be seen in the grass, as Figure 24 illustrates.

Another problem occurred when character renders were first added to the composite. They appeared to be placed on top of the grass rather than within it, because no grass was occluding their feet, or other parts of their bodies in contact with the ground. To solve this problem, characters were re-rendered with a small patch of grass around them. This approach minimized extra paint strokes and ensured that contact points were integrated properly with the grass plane. A minor drawback to this method was that a halo was visible around the characters' ground contact points, as seen in Figure 24.



Figure 24. The black arrows point to noticeable examples of the double ground cover image; the red arrows point to pockets of grass rendered with each character.

The composite file for the painting portion of the project was extremely large and difficult to manage. The render from that file alone required over a day to complete. The resulting sequence was converted to a high-resolution movie and composited with the museum frames for the initial and concluding paintings. The gallery file was then rendered to produce the final version of the project.

## CHAPTER SIX

### CONCLUSION

"Femme avec Une Fleur" was screened at Eurographics 2007 and the 2008 ACM Southeast Conference. It was awarded Honorable Mention at both Eurographics and the regional ACM conference. The project underwent a second iteration in which several improvements were made, mainly in the re-rendering of the paint strokes for the hero woman, baked textures to add lighting effects, and compositing corrections. Parts of the project have since been reworked a third time for the purposes of this study. The goals of bringing to life an Impressionist style painting while keeping the individual paint strokes visible, utilizing an Impressionist color palette, maintaining focus on light and shadow, and commonplace subject matter intact were all achieved. The current version of "Femme avec Une Fleur" may be viewed at the author's personal website (Kid Mikki, 2007).

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