CREATING BELIEVABILITY AND THE EFFECTS OF TECHNOLOGY ON COMPOSITING

A Thesis

by

BRANDI JANNINE DUNN

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

December 2006

Major Subject: Visualization Sciences

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Approved by:

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ABSTRACT

Creating Believability and

the Effects of Technology on Compositing. (December 2006)

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Chair of Advisory Committee: Prof. Carol LaFayette

This thesis focuses on the importance of technology to create believably composited effects. It was found that many factors culminate in generating believability in a film, including: suspension of disbelief, the story, and the quality of the special effects. Many technical aspects lend to the creation of successful special effects and are involved during every stage of production. There is a discussion of several of the important criteria analyzed during preproduction, production, and post production. A brief history of the technical effect industry is discussed.

Personal work for this project includes three case studies. In the form of short video projects, these studies are applications of the researched industry concepts. They deal with issues including incorporation of digital models into live action footage, using pre-existing footage, digital makeup, motion tracking, masking, color correction, and generation of artificial lights and shadows. The creation of these videos included video recording and editing and used Maya ™ and After Effects ™. The final shorts showed examples of the strengths and weaknesses of the applied compositing techniques. Implications for the future directions of this field are also discussed.

TABLE OF CONTENTS

Page

LIST OF FIGURES

INTRODUCTION

"I dwell in possibility."
– Emily Dickinson

Long ago in a galaxy far, far away I was introduced to the original *Star Wars* trilogy. I was raised on the films; however, when I was fifteen I was privileged enough to see *Star Wars: Episode IV* (Kurtz& Lucas,1997) on the big screen for the first time. Twentieth Century Fox had rereleased the 1977 film to theaters. In the new theatrical release, many adjustments had been made to the original film. Many technological advancements in special effects had developed within the 20 years that span the two films. These modern effects allowed for new creatures to be created inside the film and fresh interactions to be made between characters. I was astonished to see this film that I had memorized from childhood in a whole new way. I had never recognized any flaws, but with the new special effects the story was made more believable.

I discovered during my graduate education that the field that inspired me the most was that of compositing. While all aspects in the production of special effects are important, it is the compositing of a film that creates believability for the audience in my opinion. It does not matter how well the different parts of the special effects are produced, if they are not integrated well into the live-action footage the level of believability will suffer. Believability is essential to the audience's involvement in the film. Without it the audience will be jarred back into reality and recognize the fact that they are sitting in a theater watching a movie. The goal of most films is to

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This thesis follows the style of *Cinefex* and is supplemented with APA style.

bring the audience into the environment in which the film takes place. Creating believability has been a long-term goal of the movie-making industry and will continue to be an important aspect of moviemaking for many years to come.

Over the years the advancement of technology has constantly allowed the industry to push the viewers' definition of reality. However, as technology advances, so do the viewers' ability to perceive special effects. What was once cutting edge is now often perceived as old-fashioned. This evolving expectation is important in keeping filmmakers on their toes. The ambition of a good compositor is to escape the notice of the average viewer; to create an effect so believable that the viewer wonders how such a fantastical world was captured on film.

The goal of this study was to understand what elements combine during the compositing phase of the film process to create a believable effect. To accomplish this, I first defined believability and analyzed many of the aspects that are important to its development. A brief history of special effects, most notably compositing effects, was included to help understand the development of effects. Short analyses of films that exist within the same film universe, such as remakes, were added to help recognize how effects can be used to improve the believability of a new film that was constrained by the film universe in which the original was created. Technical issues that aid in creating believable special effects were also included as important aspects that must be maintained throughout each stage of filmmaking. A comparison of the current compositing techniques, such as 2D and 3D compositing, illustrates different aspects of each method. Digital makeup references show a potential direction special effects companies may begin to show more focus toward. The concept of using pre-existing

footage for new film applications is discussed. Three personal case studies illustrate my own application of the concepts previously researched, and implications for the future of compositing conclude the study.

BELIEVABILITY

Defining believability is difficult, because its levels are different for each person. Believability is defined by Webster's dictionary as "confidence in the truth, the existence, or the reliability of something, although without absolute proof that one is right in doing so" or "to suppose, assume or understand." Both of these definitions are applicable to creating believability in films. The audience must have confidence in the "truth" of the visuals being presented in the film. They also need to assume and understand that what is presented is completely acceptable in the context of the film. For the purpose of this study, believability is defined as my personal "confidence in the truth of what is presented in the context of itself."

Suspension of Disbelief

One important element of believability is suspension of disbelief. This is the semi conscious decision that allows the viewer to enjoy the work of fiction even though the viewer knows that the story is untrue. Understanding how the suspension of disbelief is achieved is crucial to understanding the creation of believability.

Definition

The term "suspension of disbelief" was first used by the romance writer Samuel Taylor Coleridge (Suspension of Disbelief, 2006, June) in the *Biographia Literaria* in 1817.

> (...) it was agreed, that my endeavors should be directed to persons and characters supernatural or at least romantic, yet so as to transfer from our inward nature and human interest in the semblance of truth sufficient to procure for the shadows of imagination that willing suspension of disbelief for the moment, which constitutes poetic faith.

According to *Webster's New Milliennium Dictionary of English* (Suspension of disbelief, Webster's, 2006), a more common, modern definition of suspension of disbelief is "a willingness to suspend one's critical faculties and believe the unbelievable; sacrifice of realism and logic for the sake of enjoyment."

Four Factors in Suspension of Disbelief

To understand the four factors in the suspension of disbelief we turn to the theories of Norman Holland, professor of English at the University of Florida. Holland attempted to explain suspension of disbelief using a neuro-psychoanalytic analysis in his presentation at the 19th International Literature and Psychology Conference in 2002 (Holland, 2002, June).

In his presentation, Holland explains that in a human there are three types or levels of brain development; the reptilian, the mammalian, and the neo-mammalian. The reptilian brain controls all necessary functions for survival, including fighting, fleeing, eating, and procreation.

The mammalian brain is believed to have developed as a consequence of live birth and the suckling of young unknown to reptile procreation. This factor creates an emotional relationship of parent and child and therefore more complex emotions such as fear, rage, lust, and sadness as well as allowing the ability for play. Playing is the first step towards imagination and creativity.

Holland explains that the third type of brain, the primate or neo-mammalian brain, relies more on sight than smell which allows primates to gain a more complex image of the surrounding world. The primate brain is also responsible for the inhibition of response and aids in planning for more complex actions. These lead not only to the use of tools but also to complex social groupings that support a functioning society.

These types of brains are control different responses that humans possess. Each of them aids in the performance of separate aspects of the human existence, from reproduction and survival to high order mathematics and the creation of artistic masterpieces. These brains can be fooled and subdued, and that is what allows for the ability to suspend disbelief. One must understand the factors that must be reached for proper suspension of disbelief. When suspension of disbelief is used in literature, the following factors apply:

1. We no longer perceive our bodies.
2. We no longer perceive our environment.
3. We no longer judge probability or reality-test.
4. We respond emotionally to the fiction as though it were real.

Body Perception. Holland claims, "Neurology offers an easy explanation for body neglect: habituation." He suggests psychologists define habituation as “the decline of a conditioned response following repeated exposure to the conditioned stimulus.” (Holland, 2002, June)

While body stimulus continues to be unchanged, habituation causes the neurons in the brain to slow their firing rate so that information is no longer sent to the brain

concerning that part of the body. The body becomes unaware until there is a new stimulus. In the case of watching movies in a theater, most of the stimulus will come from the screen and the speakers. Since the viewer is less aware of himself, there becomes more connection with the content that is presented.

Environment Perception. Habituation also applies to environment perception. Sitting in a theater produces an environment intended to remove stimuli and encourage willing suspension of disbelief. The audience sits in a dark room which removes much of their awareness of their surroundings. Comfortable chairs encourage less physical movement which will aid in lessening the body perception. Because of this, the viewer becomes less aware of his or her personal body and more aware of what is occurring on screen. The suspension of disbelief is broken when one is forced to move, eat, or drink. These moments cause the viewer to be removed from the story and forced back into reality. Habituation contributes to the viewer not perceiving his or her environment as well.

Reality Perception. Once the first two factors have been achieved, the viewer is more susceptible to the stimulus being presented. Because the viewer has less awareness of his body and environment, his brain will have fewer reference points to "reality." This will allow the audience member to watch a film without constantly questioning the reality of its content.

If the audience is constantly seeking reality in the film, a proper level of suspension of disbelief cannot be achieved. They will not be able to become immersed in the fictional world of the film.

Emotional Response. Holland's theories state that when one is suspending disbelief, the primate inhibiting brain turns off but the reptilian and mammalian brains stay active. This allows for the fourth part of suspension of disbelief. The reptilian brain allows the viewer to be threatened, even though rationally he knows there is no danger. The mammalian brain allows the audience to feel an emotional connection to the characters on screen even though the characters are fictitious. The creation of an emotional response from a viewer is important and connecting the viewer to the character which allows for more believability in a fictional plot.

Creating Suspension of Disbelief

Believability must be actively maintained by the filmmaker. Creating a proper level of suspension of disbelief within a film is set by factors including genre, plot, acting, and special effects.

Film Genres. The genre, or group category, of the film affects believability limitations. Genres include groups such as drama, comedy, documentary, or horror, along with others. Some genres can have content similar to events that the audience sees every day. Other genres are very dissimilar from normal human life. The genres that are less similar to everyday life require more suspension of disbelief. Science fiction

and fantasy stories are by their very nature going to require more suspension of disbelief than a documentary. Action films require more suspension because often they included feats that excel beyond what would be expected from an average human, including heroic acts and surviving feats that would normally be fatal to the character. Some genres, such as the romantic comedy, have less of a requirement (on average) for suspension of disbelief. Therefore, it is more difficult for a film to get an audience to believe less realistic characters, actions, or plots. In movies such as the *Indiana Jones* trilogy, the suspension of disbelief was intentionally pushed to the limit. The result was that the audience found the improbable acts amusing and therefore not intended to be completely realistic. (Suspension of Disbelief, 2006, June)

Plot. The plot is the storyline of the film and maintaining its is crucial to proper suspension of disbelief. Even if the initial premise is quite radical, the story must maintain consistency within the plotline. If the plot line is maintained, bizarre occurrences will not hinder the suspension of disbelief. However, if the plot becomes a disjointed or contradicts itself the disbelief will be broken and the audience will become separated from the content of the film.

For example, it is generally accepted that in the *Star Wars* universe there are many different species and races that inhabit different worlds. However, it would seem unlikely that there would be an average human businessman on a desolate planet such as Tatooine.

Acting. The performances of the actors as well as the script they are performing are vital in making a film believable. Characters must act, react and interact in a believable manner or there will be no connection to the audience. Unbelievable character representation prohibits an emotional connection and therefore makes suspension of disbelief difficult.

Special Effects. The quality of special effects is the fourth factor that heavily affects the presentation and believability of the film. If the audience is able to "see" the special effects it often breaks the suspension of disbelief. Film critic Leonard Maltin recognizes the need for the special effects to blend seamlessly into the story. Maltin (Magid, 2006, March/April) states that:

> Everything in a film should serve the story. I'm less interested in how that's achieved then whether it's achieved and done well… so long as I'm not distracted…. I don't want to be taken out of the movie by being made overly aware of the technique being used. (p. 47)

However, sometimes digital effects seem to be more important than the story to the filmmaker. Makeup artist Rick Baker (Magid, 2006, March/April) understands that sometimes the increased desire for special effects can be overwhelming.

> What bugs me about digital effects is there's no reality to them anymore. They've got creatures doing spectacular things, but when you're bombarded by one spectacular shot after another, it gets to the point where you don't care anymore. It's funny - stuff that I find hokey or unrealistic, people like. (p. 44)

The compositing of special effects is the final stage to creating a believable film that will transport the viewer into another world.

Special Case of Believability

There are occasions when an effect needs to be unrealistic to be believable. Often films that have a supernatural aspect will employ effects that are unrealistic in reference to the original film, which is also called the live-action plate, but can still evoke an effective suspension of disbelief. For example, in *The Ring* (Weisler & Verbenski, 2002) Samara, the spirit of an evil child, kills people after they watch a certain tape. At the end of the film, she is on the screen of a TV, but presses out of it into the live action space. When she does this, she does not become a solid part of the space. She remains flickering and moves in and out of the normal time flow, speeding to supernatural motions. This quality should be jarring, but it seems to fit in this particular environment. The effects were successful enough to help this film win the 2003 Academy of Science Fiction, Fantasy and Horror Films award in the field of Best Horror Film.

As the mainstream audience on a whole has become more discerning, it understands that what is presented is not always meant to be taken as truth and in fact is rarely unaltered. Even when the viewer knows that what is being viewed is not real, it is believable within the context of the film.

PRIOR WORK

History of Technology in Film

Movies bring the audience into fantastic places and allow normal humans to revel with bizarre creatures. As filmmaking has evolved, certain films have brought special effects to more revered stature in the industry. These works used the available technology of their respective times to create environments, but due to limitations of technology relied on camera angles and editing techniques to create believability rather than contemporary special effects. As technology evolved, so did the way the camera was used to tell the story. In this paper, I have studied how the available technology affected filmmakers' methods of production and postproduction, have observed the current state of compositing, and have analyzed its capabilities and limitations.

Early Effects

The majority of the film industry has constantly updated the notion of "believability." When the Lumiere Company first showed *The Arrival of a Train at the Station* (Bitzer, 1901), a film in Paris at the Salon Indien in 1895, a riot broke out. (Gunning, 2002) Audience members believed the train was about to run them over, and fled in terror. As films became more widely viewed, people accepted film as a "representation" of the truth. Yet many filmmakers have always attempted to create stories that push out of the real world and allow humanity's insatiable imagination to be brought to life and shared. As technology has progressed, it has aided in the creation of fantastic films. *King Kong* (Selznick & Cooper, 1933) left its audience amazed at the interaction of the heroes and a great ape who was discovered during an expendition on a

remote island. He escapes after being brought back to New York and becomes enamored with the beautiful actress heroine. RKO's production team used special affects to place Ann Darrow, portrayed by Fay Wray, in to Kong's hand. She was dwarfed in the palm of the ape that visually towered fifty feet tall. The sight of this giant ape sweeping the young heroine up the Empire State Building left the majority of filmgoers amazed; however, the first stages of compositing did come with limitations.

Stop motion animation forced cinematography to be somewhat rigid because live actors had to be matched to the animation so they could be integrated. From its earliest beginnings around 1907, stop motion animation allowed filmmakers to take the concept of using a series of still frames shown in rapid succession and apply it to a three dimensional environment instead of the more common hand-drawn cartoon. Puppets or clay figures were positioned, a frame was captured, then the model was moved the slightest bit and the process repeated. The technique allowed for Kong to be viewed as moving while his full body was on screen. The tedious nature of this process required the camera to remain stationary. At the time, the audience was not as aware of the lack of camera motion, as many films still used rigid placement of cameras to ensure proper lighting and motion of actors. They were also unaware that the towering Kong was a small puppet on a metal armature that soared around two feet tall.

A combination of this miniature Kong and live actors working with mechanical Kong anatomy were layered in postproduction to create this epic of man and beast. Even today, King Kong remains impressive. It is still possible today to appreciate the special effects that were cutting edge in 1933. Roger Ebert of the *Chicago Sun-Times*

said:

> In recent years I have focused on the remarkable special effects, based by Willis O'Brien and others on his f/x (effects) work in 'The Lost World' (1925) but achieving a sophistication and beauty that eclipsed anything that went before. The movie plunders every trick in the book to create its illusions, using live action, back projection, stop-motion animation, miniatures, models, matte paintings and sleight-of-hand. And it is not stingy with the effects; after a half-hour of lumbering dialogue and hammy acting, the movie introduces Kong and rarely cuts away from sequences requiring one kind of trickery or another. (Ebert, 2002, February)

While both stop motion animation and animatronics are still used in film today, they are being replaced by digital models that allow more flexibility in cinematography.

Color Film

With the popularity of the *Wizard of Oz* (LeRoy & Fleming, 1939) and *Gone with the Wind* (Selznick & Fleming, 1939), color film revolutionized the mainstream film industry, especially in Hollywood. As most humans have the ability to see color and therefore are more discerning about how colors interact, the introduction of color film caused some dilemmas that black-and-white filmmakers had not dealt with before. When color matching is done incorrectly, it can cause the effect to appear otherworldly and inappropriate to the composition of the scene. When films were black and white, value – not hue – was the factor that had to be matched to ensure a believable composite. Suddenly color matching became a vital step of postproduction when effects were incorporated into films. Mainstream viewers wanted more from filmmakers, pushing for both a visually interesting film and the special effects to match. Sometimes the technology was not up to the challenge.

Developments in Film Stock

As film technology improved with the invention of faster speed film, such as Kodak's Tri-X in 1954, more motion was introduced into films, both through the movement of actors and cameras. (History of Kodak, 2006, March) These new film stocks captured images faster with less light and therefore could be used with lower lighting levels. Lower light levels allowed for much advancement in cinematography in the early 1950s, including the ability to shoot night-for-night instead of day-for-night as previously required. Before the creation of fast speed film, scenes in a film that took place at night were most commonly filmed during the day and then filtered with a blue filter, so that the scene appeared to have taken place at night. The faster speed film meant that night scenes could actually be filmed at night. This advancement reduced hard shadows during night scenes and created a more believable sense of time of day. Faster film speed also allowed for camera motion to become more common. With this camera motion the need for different technologies in special effects arose. The effects needed to be able to track with the faster camera movement, which proved time consuming as any interaction between live actors and effects was still composited completely by hand.

The Beginning of the Special Effects Industry

When *Star Wars* was filmed in 1977, George Lucas was unhappy with the special effects available at the time due to the closing of Twentieth Century Fox's special Effects department. (Industrial Light and Magic, 2006, October) To compensate

for this disadvantage Lucas created Industrial Light and Magic, which was one of the first companies that solely focused on special effects in film. With the company completely dedicated to this focus he could develop more technology to further the advancement of special effects. One of the effects that benefited the most from this new dedication was the field of keying, most notably color keying. Although the technology was still innovative, Lucas could now integrate this development into his film *Return of the Jedi* (Lucas & Marquand, 1983). Two of the main characters in the film, Luke and Leia are seen on speeder bikes navigating in and out of a dense forest on the moon of Endor, desperately trying to escape storm troopers. This visual effect was created against a blue screen, the actors on the speeder bike props navigated through an unseen terrain. During postproduction, the blue color was keyed out using new digital technology and replaced with the scene of a forest chase. This effect still remains impressive and its technology has become essential to the modern film repertoire. *Star Wars: Episode IV* (Kurtz & Lucas, 1977) won the Academy Award for Best Visual Effects, and both *Episode V* (Lucas & Kershner, 1980) and *Episode VI* (Lucas & Marquand, 1983) won the Academy's Special Achievement Award in the field of visual effects.

Analyzing Developments in Technology through the Same Film Universe

Remakes and altered re-releases are often great examples of a filmmaker trying to improve a film with the addition of new technologies. Examples of these films include *King Kong* which was remade in 2005 and the original *Star Wars* trilogy which was released in 1997. Sequels can also be used to show how new technologies are incorporated into the same story plot line. *American Werewolf in Paris* (Claus &Waller,

1997) is an example of how new effects technologies can change the tone of a movie that was meant to be in the same setting as its original, *American Werewolf in London* (Folsey & Landis, 1981).

Remakes

King Kong. Although he had to wait through much of his career before technology could produce the effects of his vision, re-creating *King Kong* had been Peter Jackson's dream since he was nine years old. When he was satisfied with the quality of the effects that could be produced, he directed *King Kong* (Blenkin & Jackson, 2005) a remake of the 1933 version. The film took the most modern technology and revisited the original script. (Fordham, 2006, January) This version allowed for much more dramatic scenes with cutting camera moves and epic interactions of computer-generated (CG) Kong and his live action environment, while staying true to the original intention of the 1933 version. The new technologies permitted the viewer to be swept along under the great strides of Kong, capturing more of the frantic nature and dramatic points in the film. The recent film allows the audience the illusion of moving with the characters of the film, unlike the 1933 version which often kept them in a stationary view, like that of watching a play. The new version of King Kong won the 2006 Academy Award in the field of Best Achievement in Visual Effects as well as winning Best Achievement in Visual Effects at the annual British Academy of Film and Television Arts **(**BAFTA) Awards. Roger Ebert said:

> *King Kong* is a magnificent entertainment. It is like the flowering of all the possibilities in the original classic film. Computers are used not merely to create special effects, but also to create style and beauty, to find a look for the film that fits its story. (Ebert, 2005, December)

Re-releases

Star Wars Trilogy – Episodes IV through VI. The plot of the *Star Wars* trilogy epic concerns events of a rebellion against an evil empire in a distant galaxy. In the original filming of the first installment, *Star Wars: Episode IV*, Jabba the Hutt had been cast in the film as a human character, and his scene had been cut from the first release of the film. Later in *Star Wars: Episode VI*, Jabba returned as a puppet. This change in character concept presented a potential problem for the re-release of *Star Wars: Episode IV* in which George Lucas wanted to add the Jabba scene into his new edit. The special effects in the 1997 version of *Star Wars: Episode IV* allowed Lucas to digitally re-create Jabba the Hutt. The special-effects team also dealt with the fact that Han Solo had walked completely around the original human character. The original footage of Hans Solo was repositioned digitally to allow the character to walk upon the CG Jabba the Hutt's tail.

Lucas also took advantage of other opportunities to create effects that were not available to him when he made the original films. Some of the changes were small, including cleanup to effects that the filmmakers had not been satisfied with originally, most noticeably the ground under a hovering transport vehicle. In the original 1977 film, the best technique available to accomplish the hovering was to scratch the film and repaint the empty space underneath the transport. This technique created a strange spot underneath the vehicle, but at the time the audience was willing to accept the believability of this technique. In the film's re-release, the spot was removed digitally, the special effects team being able to place background information, in this case a sandy terrain, under the vehicle instead.

Sequels

The American Werewolf films. Not all films are as successful at creating visual believability as the *Star Wars* trilogy. There were times in film production when the special effects advancements did not improve the quality of the films being produced. The horror classic *American Werewolf in London* (Folsey & Landis, 1981) and its sequel *American Werewolf in Paris* (Claus & Waller, 1997) both tell the tales of the complicated love lives of newly cursed American werewolves who meet their doom while vacationing in Europe. When *American Werewolf in London* was released in 1981, the primarily prosthetic special effects devices were praised as cutting edge. The prosthetic makeup achieved such excellence that it won the 1981 Academy Award in the field of Best Makeup. It also won Best Horror Film and Best Makeup at the Academy of Science Fiction, Fantasy and Horror Films. However, when its sequel *American Werewolf in Paris* was made, the filmmakers decided to progress from prosthetics to CG characters. The CG technology was still early in development and could not be fully integrated into the live action footage as effectively as the prosthetic effects. The CG elements seem to stand out and were distracting. The CG characters did not move naturally enough and their textures did not incorporate well enough into the environment. Many audience members did not accept the believability of these new characters and there was a failure to create the suspension of disbelief needed. James Berardinelli of ReelViews said, “On the technical side, it's all bad news. The computer-generated werewolves look painfully unreal. The creatures would probably have been more believable had they been men in wolf suits.” (Berardinelli, 1997)

By analyzing multiple films that were intended to exist in the same film universe, one can more thoroughly analyze the success of new technologies in special effects. It is easier to compare the believability of effects that were intended to exist in the same space. Elements such as genre and plot are similar, so one can look to the quality of the special effects in a more isolated manner.

TECHNICAL ISSUES IN CREATING BELIEVABILITY

To understand how new technology improves the quality of special-effects we must first examine how fundamental elements create a believably composited scenario, including creating a willing suspension of disbelief. There are many factors that make compositing possible. Preproduction and production factors include previsualization, lighting, camera information, space, and movement. Postproduction includes masking, rotoscoping, image adjustments, and final composition of the film. In this section I will discuss these important factors.

Pre-Production

Planning is a crucial phase for an effect-filled film, and it is encompassed in pre-production. For most films this stage includes writing, casting, and securing locations, but for a film with digital effects, pre-production also includes pre-visualization.

Pre-visualization

Even during the concept phases of film development, the layout must account for placement of lights, camera, characters, and motion. Companies specializing in pre-visualization are often hired to layout the planning of effects that will be added after the initial filming. This process allows the storyboard to be translated into three dimensions. This effect is often accomplished using a crude 3D model of the set and rough geometric representations of the characters that will be involved in the scene. Even in its rough form, this simple technique aids the filmmakers in the placement of actors and the props

in the live action scene. During production the same factors must be carefully recorded, as that information will directly influence the creation of effects layers, which are separate pieces of the effect which are layered in postproduction, applied to a 3D model or a new environment background. All the factors must be re-creatable to produce a high level of believability.

Production

After pre-visualization is complete, production of the film begins. Often a large section of the overall film project, production includes the work of live actors and non-digital sets and props. During production, many issues are monitored to ensure enough information to reproduce believability for the digital effects, including lighting, camera data, space, movement, scale, texture, and color.

Lighting

Lighting is one of the most influential elements in creating believability. It sets the mood, or "the distinctive emotional quality or character" of the scene. The lighting information must be recorded, both to be able to re-create the same mood in a scene while constructing special-effects as well as to aid in the execution of those effects. Lighting is most critical in compositing effects that involve using a blue or green screen to create a chroma key mask. There must be adequate lighting behind the subject to contrast the silhouette from the screen. Lights must also illuminate the screen as evenly as possible, as variation in screen color makes masking much more difficult. Care must be taken that lights do not cast shadows onto the screen. Cast shadows on the screen

make removal of unwanted data more difficult and time-consuming, and often work against believability of the scene or effect. The concept of masking is addressed later in this section.

To create a believable lighting environment, additional lighting may be added in postproduction. While working on the special effects for the magical story of *Harry Potter and the Goblet of Fire* (Heyman & Newell, 2005), in which the main characters compete in a series of challenges to win the coveted Goblet of Fire. Framestore CFC generated digitally all underwater environments with 2D and 3D matte paintings. Live action underwater shots produce light artifacts called caustics due to the way light hits the surface of the water and is refracted through it. These caustics appear as small puddles of light that bounce brightly on the surface beneath a body of water, such as on the bottom of a swimming pool. "We had caustics, diffusion – all sorts of strange underwater lighting effects," said Tim Webber (Fordham, 2006, April) in reference to the production of these scenes.

> We studied all the quirks and imperfections of underwater cameras and tried to match those in our shots. We found that caustics have a strong feeling of being underwater, but they also made it feel like objects were close to the surface, so we used them fairly subtly because we wanted it to seem like Harry [played by Daniel Radcliffe] was quite deep. In fact, we had to remove caustics from some elements of actors in the tank, to make them look much deeper. (p. 104)

Other aspects that had been added included drifting particles, darting fish and underwater vegetation, which created a true sense of an underwater world.

Camera

The location, lens, angle, and movement of a camera must be carefully recorded, as the translation of this information allows for layers of picture elements to be properly coordinated. Without something as simple as proper lens data, the composited layer may "look funny" with a slight skew in perspective. The effect can be jarring to a viewer as it does not immediately stand out, but does not fully integrate the element into the space. Camera location recording makes motion-tracking possible. This data includes information such as the camera distance from the scene and how the camera moves during the action. Without this information, there is no simple method of animating the composited data to make the scene believable, because the information will have to be estimated in the digital space. With proper records, the trial and error of estimation can be avoided. Depending on the facilities available, this record may be as simple as handwritten notes and estimations by eye, or as complex as bar-coded ceilings that aid in tracking the location of the cameras.

Space for Digital Elements

The issue of space is mandatory for compositing. Without attention to space there may be a lack of balance to the frame, the composition may become too cramped or may be left with vast empty spaces. There must be a pre-visualization of the effects that will be added. Rough geometric models are used to block out the action and movement of the digital characters. In the case of composited characters or environments, a stand-in is often used during filming with live actors. This stand-in holds the place of the character that will be digitally added and gives the live actors a

reference for interaction. This practice allows for proper orientation of characters within the scene and contributes to believability. Actors can address the "character" on the set, make eye contact at the proper level, and leave the proper amount of space for the character that will be added later.

Movement

Similarly, movement affects the environment and the way the film is framed. Previsualization aids improper compositing of scenes that included a digital character or set. Understanding the placement and movement of digital elements in a scene is important to the placement of live actors. Otherwise, a character may walk into a digital character or reach through a composited glass. Changing lights must be recreated digitally as well. The movement of the lights helps the viewer understand that the same reality affects the digital character as do is to live actors. If it is not executed properly, composited elements will seem to exist in a different time or space and therefore not be believable.

Scale, Texture, and Color

Other characteristics of believability that must be noted include scale, texture, and color. These characteristics create a sense of coherency in a scene. If fantastical elements are brought into a scene, attention to human scale creates a sense of realism. Texture is crucial in creating form in a space: a perfectly polished chrome ball bearing will stand out against moss covered weathered rock. A color palette not only influences the mood and environment, but also how the elements are brought together. If a bright

red orb appeared in a pastel dawn scene, it would seem jarring and out of place. It would seem that the scene lighting was not affecting the orb and isolate it. Likewise on a more subtle level, a shadow that is too dark or light will look odd in a scene, as it would not match the others around it, and therefore not appear as believable as would a more appropriately created shadow.

Postproduction

Once all of the layers have been filmed and rendered postproduction can begin. The postproduction team brings the elements together to create a believable finished product. Aspects of postproduction include elements such as masking, rotoscoping, image adjustments, and visual effects. Below I discuss these elements.

Masking

Masking is a process that removes part of the original image, allowing elements from other layers to show through. Often it is used to crop an image, or part of an image, such as when a character is to be seen only in a rearview mirror. The any part of the new footage around the frame of the mirror would be removed to confine the new image within the mirror's reflection. Masking often uses keying, such as chroma keying used in blue and green screen techniques. Digitally selecting parts of a frame to be removed or altered is called keying. Chroma keying chooses the screen data by color so that an alpha channel, or section of transparency, may be created. This alpha channel is invisible when interacting with other layers. The "cutout" characters are then placed in a new background scene. Other types of keying include luminance keying which is based

on light levels and difference keying which uses a reference or background plate and preserves only elements that are different between the film and the reference plate. These different options for masking can be useful techniques, not only when planning the effects for a film, but also in cases were effects do not go as planned during filming.

The Legend of Zorro. Despite efforts to honor his promise to keep his swashbuckling to a minimum, in the film *The Legend of Zorro* (MacDonald & Campbell, 2005), Zorro rides again. Zorro and his horse jump onto a train in one scene. During the filming the filmmakers were promised a horse that could perform this jump, however during the actual performance the horse refused to perform properly, stopped and slid down on its belly instead. To solve this problem the horse and rider were digitally scanned and animated. The scene continues as Zorro and his horse burst through the top of one of the train cars. On screen, the jump appears to be approximately 8 feet, however, when it was actually filmed the horse and rider performed a 4 foot jump against a blue screen. The action was digitally enhanced to appear to be longer jump. (Duncan, 2006, January)

Rotoscoping

Another technique occasionally used to create masks is rotoscoping which is defined as painting, drawing or overlaying images onto individual frames in a movie. This technique can be implemented as a form of 2D animation or film effects, which was often used in early effects that were literally painted onto the film. This 2D painting style can produce a very interesting visual effect that can be seen in *A Scanner Darkly*

(Soderbergh & Linklater, 2006) and *Waking Life* (Kaplan & Linklater, 2001). Here it is not only as a method for special effects, but is also used to create a hand animated version of the film over the original footage. Rotoscoping also can be used when creating a mask shape by drawing. These masks are drawn and animated by hand, but when completed function in the same manner as other types of masks. Sometimes such masks are used to clean up a larger mask that was not completely keyed properly or which has fine detail that was not easily captured by the computer. Using rotoscoped masks is a very effective, yet time-consuming technique since everything is completed by hand and must be done at least every few frames. Minimizing the number of rotoscoped masks is a common goal as keying technology advances. The less rotoscoping that is required, the faster the composite will come together.

Image Adjustments

Image adjustments allow for the correction of imperfections in the initial creation of the image layers. A compositor is capable of creating continuity between the elements using such concepts as color balance, levels, and contrast. It is important that no individual element stand out. Since most humans can see color, differences in color space can be visually confusing and keep a composited element from fully integrating into a scene. Likewise, matching values of light and dark is a simple concept, yet difficult in execution. Sometimes simple alterations of hue and saturation can greatly affect continuity. Image adjusting can be a very time-consuming step of postproduction, but is mandatory for excellence when compositing.

Final Compositing Aspects

The last stages of postproduction include the addition of effects to further blend the lines between composite layers. The creation of extra shadows and false lights can aid in bringing an element into a space. The addition of motion blur allows the viewer to interpret the image as traditional film, without the abnormal crispness that is often achieved through digital renders. Audiences are accustomed to this blur due to the fact that film speed often is not quick enough to capture each frame of an action as a crisp image. To date, no motion picture film camera has been able to record every frame of a fast motion without a motion blur. However, when rendering out the final product of a digital effect, each frame can be produced as a sharp image. Adding motion blur helps to incorporate the digital effect into the film. Extra effects, such as lens flares, add final touches of what a viewer is accustomed to seeing, and therefore help to achieve greater believability in the final film.

CURRENT COMPOSITING TECHNIQUES

2D vs. 3D Compositing Techniques

2D and 3D compositing techniques are often similar, but the concepts behind them are different enough to justify a separate classification. Below I make explicit the differences between these two techniques.

2D

For classification in my research 2D compositing includes effects that are added as if painted directly onto the film. They do not require the creation of a 3D digital model that will be added into the scene. Such a 2D technique is used when adding blaster fire from weapons in a film like *Star Wars* (Kurtz & Lucas, 1977). This particular effect was animated by hand. Similar effects are now commonly produced digitally, but are still created on a 2D plane. In addition to these animated effects, I also include layering video elements into a scene in 2D compositing. This technique may take the form of placing an actor shot in a green screen studio into footage shot elsewhere or some other footage such as a meteorologist standing in front of an animation of local Doppler radar information. Supernatural movies, especially those concerning ghosts, often use this technique. Since the actor is on a separate layer, individual elements such as opacity can be easily controlled. Although 2D space must still be taken into account, the third dimension is much less important because compositing is performed completely from the perspective of the frame, therefore

whatever “looks good” can be used without as much concern for the depth into the acting space.

3D

Use of 3D compositing, or incorporating a 3D model inside a scene with traditional actors, has become increasingly more popular as technology becomes cheaper, faster, and more convincing. Examples include Jar Jar Binks from *Star Wars: Episode 1 - The Phantom Menace* (Lucas, 1999) and the trolls in the epic battles of *Lord of the Rings: The Two Towers* (Lynne & Jackson, 2002). In these cases, a digital model was created to move within the space of the action. The third dimension becomes critical so that a digital character can both move in the space and also interact with traditional actors on the constructed set. As previously mentioned, stand-ins are often used when digital characters or props will be added in postproduction. When working on the digital aspect the environment is recreated to block out the actions of that character. The camera settings must be matched as well as conditions such as lighting. The character is animated on the digital set. If the digital character will be obfuscated by live action elements, the effects team may choose to “pre-mask” the character with digital stand ins that will not be visible when the shot is rendered out. When properly executed, the finished layer should line up correctly when placed over the live action plate. Another option is to place masks over the finished layer to remove the required sections as part of the postproduction. This method allows for more flexibility for re-filming the live action plate, but normally takes longer in postproduction.

Both types of compositing take advantage of many of the same techniques, including, but not limited to masking, blue/green screens, color adjustments, and motion tracking. It is often in the best interest of the filmmaker to use aspects of both methods to take full advantage of the technology while still keeping the viewer interested in the plot, otherwise the film may be perceived as "too CG" and distracting; in other words, not believable.

Other Options

An additional technique known as 2 ½D uses 2D elements in a 3D space. Two-dimensional videos or images are placed on planes, but the planes are layered in a three-dimensional space that a camera can "fly through." Camera effects can also be added, such as depth of field. This technique can be used to fake a 3D scenario, allowing a pre-existing piece of film to be broken down into a 3D space. Use of 2 ½D can be an option for altering preexisting footage, allowing a different camera motion or a still photograph to be transformed into a simple clip of fly through video. This technique is becoming more popular in television, as it allows for an effect that is more visually interesting than a simple photograph, but cheaper than a recreated scene using live actors or digital animation. If used subtly, this technique can produce a believable effect. It also can be employed to create a stylized affect when implemented in a more dramatic manner.

Another method often used in all types of compositing is to imply complexity of an effect through editing. In one of the Sci Fi Brand's shorts, *Nightclub* (Nightclub, 2004), a man transforms himself into a woman. Most of the transformation is filmed close up, where the viewer sees each sequence of individual shots in rapid succession.

The viewer reads each shot as a progression, and the effect is made believable through the viewer's ability to fill in gaps between edited sequences. The final shot of the completely transformed man was digitally modified so that he appeared to be a woman. The rest of the short was unchanged digitally, implementing only editing tricks. Because the audience was allowed to see the whole progression, they were able to translate the series of cuts into a process that would account for the final digitally produced product.

Digital Makeup and the Taboo of CG

As the quality of special effects has improved, the film industry has massively increased the usage of CG effects in the films it produces. However, some filmmakers have been hesitant to surrender to the digital revolution, such as director Jon Favreau. They are quick to point out less successful examples of CG effects and slow to incorporate them into their own films, choosing instead more traditional effect methods, such as models, animatronics, and traditional latex makeup prosthetics. In the early years of digital effects, it seemed that filmmakers wanted effects to be either fully digital or completely traditional. As believability becomes more common due to the advancement of technology and the integration of effects into live action film, some have come around, including Favreau, who remains a fan of classic effect techniques. For his film science fiction tale, *Zathura* (D'Esposito & Favreau, 2005), he had intended to shoot as much of the movie as possible, using digital effects only when absolutely necessary. According to Joe Bauer (Duncan, 2006, April), visual effects supervisor:

> Jon has a classic sensibility. It's not so much that he doesn't like CG - he doesn't like being able to *spot* CG. He doesn't like the aesthetic of CG when it's recognizable as such; whereas, he doesn't mind being able to spot a miniature, because he finds charm and warmth in its aesthetic. (p.23)

Even with his preference for the use of traditional effects techniques, Favreau did choose to add a CG shots into his film Zanthura and was pleased with the results.

However, in addition to filmmakers being more open to using both types of techniques, the beginning of the 21st century brought a new compromise between traditional methods and fully 3D models. This compromise is the new field of digital makeup.

Digital makeup allows the live actors to be costumed in digital elements. Although the exact scope of digital makeup has not been completely defined, this upcoming field allows traditional makeup techniques to be incorporated with 2D and 3D digital elements. Digital makeup also includes using digital effects in a manner similar to traditional makeup, often offering new solutions that may not be available from prosthetics. It is often more believable to use digital makeup on an actor than to use a completely digital model. It is also less intensive than the creation of a believable CG character model, and normally cheaper for that reason. Captive Audience™ is a company on the forefront of this development.

Following their early digital work in *The Passion of the Christ* (Sisti & Gibson, 2004), Captive Audience™ furthered their digital makeup effects in the horror suspense film *The Exorcism of Emily Rose* (Boardman & Derrickson, 2005). The true story-based movie tells the story of a priest on trial for the death of a young girl who he believed was possessed. The concepts behind the digital makeup effects that would be created for the film were relatively simple, and during filming the actors would perform simple motions such as opening their mouth to scream. However, "the gauntlet of terror" scene was digitally enhanced using 2D and 3D effects overlaid on the actors' performances, adding

creepy black goo that oozes from the eyes, pale and veiny skin, milky white eyes, and grotesque jaw dislocation. These powerful effects were attained using basic concepts of both digitally painting in a 2D manner on the film as well is generating some effects on basic 3D heads which were match-moved to the actors' performances and layered onto the film in postproduction. (Duncan, 2006, January)

During this film the character of Emily Rose undergoes disturbing deformations of her own body. The film team had originally designed the effects to be performed by a puppet with the actress's face digitally added to it in postproduction, but as the film progressed the actress became more limber and the team realized she would be able to perform most of what was needed. They proceeded to film what the girl was capable of performing with and without the use of supports and from there her motions were further contorted. Extra bends and twists were added to the actor's performance in a very convincing manner and she was also fitted with a pair of digitally created and match-moved eyes that effectively brought her possession to life. (Magid, 2006, March/April) "I've always wanted to combine the two because makeup effects has its limitations, as well as does visual effects, but what's interesting is the idea of bringing them together under one roof," (p.42) says Keith VanderLaan, special makeup effects creator for the film.

> It just seems to make so much sense to have one group of people trying to bring that to fruition. Although I was very tentative at the beginning [about venturing into] uncharted waters, I think it absolutely works. You have to adapt. (p. 42)

In some cases, the actor is a major force in the development of a character's special effects; after all, he or she will be the one wearing the prosthetics or dealing with the motion tracking. In *Pirates of the Caribbean: Dead Man's Chest* (Bruckheiner &

Verbinski, 2006) the character of Bootstrap Bill, who has been cursed to serve Davy Jones, is played by Stellan Skarsgard. Over the course of the next two films the character will go through five periods of transformation. During the conceptual art phase, the makeup and digital effects teams decided that after stage two the character would become a fully digital character. Stellan (Magid, 2006, March/April) was not satisfied with the solution however saying, "I'll suffer through whatever you want to put on me, I just want it to be me." (p. 44) The makeup is quite tedious and will be digitally augmented in postproduction. Stellan is dealing with a huge, uncomfortable costume that is constantly wet, but is "doing it because it's real." (p. 45)

Some cases mandate the use of digital intervention. Traditional makeup and prosthetics are an additive process, but through the use of computers subtractive modifications may be used as well. Rick Baker, award-winning makeup artist, is hopeful for the future of digital makeup. "It offers opportunities to create more unique designs than makeup or animatronics will allow. The problem is makeup is an additive process," Baker (Magid, 2006, March/April) says. "I find it exciting that you can do things [with CG and makeup] you can't do with makeup [alone]." (p. 47)

At the end of *Harry Potter and the Goblet of Fire,* Voldemort emerges for the first time in several films and the character is seen with new physical features. The character is made all the more hideous by the fact that his nose is serpentine. This particular effect was achieved through both traditional makeup techniques and digital enhancement. Nick Dudman's makeup effect team placed gelatin prosthetics over Ralph Fiennes' eyebrows and used sheets of patterned transfer body art to create the veins over his face. (Magid, 2006, March/April) The actor also wore a set of false teeth that

increase the ratio of his gums to his teeth. Holes were placed in the prosthetics as well as dots across the actor's face so the motion could be tracked properly. In postproduction, a digitally created nose and cheek structure was motioned tracked to these dots that created the final effect of the flattened nose.

> Makeup artists are beginning to utilize the technology available to them to open up the visual opportunities that the medium affords them. There's the opportunity to do [digital] facial augmentation to break out of the confines of the human face, like in the latest *Harry Potter*, where Nick Dudman's beautiful prosthetic work on Voldemort also featured digital nose removal. (p. 43)

Digital makeup allows deterioration of an actor's body without threatening the actor's health. Richard Taylor, a special effects artist for *Lord of the Rings: Return of the Kings* (Weinstein & Jackson, 2003) enjoyed the liberation that the new makeup techniques offered in the metamorphosis of Smegel into Gollum. "So these days, CG enables makeup artist to subtract from an actor's face or body to create more believable characters -- the way and animatronics used to do. Gollum is a great example," Taylor (Magrid, 2006, March/April) says. "Andy Serkis's legs are healthy and muscular, not at all Gollum-like, so at Weta, we used digital augmentation to give him more Gollum-like legs." (p. 43)

The process of digital makeup is important in the evolution of compositing and film. As more films employ this technique compositors will be focusing more on adding effects on to live actors rather than adding digital actors into a scene. Their focus area may become smaller, being able to deal with only compositing a part of the character; however matching may become more difficult because the effect must blend seamlessly to the actor.

Forrest Gump

The multiple decade-spanning tale of the life of *Forrest Gump* (Finerman & Zemeckis, 1994) was a special effects masterpiece and included one of the first successful uses of digital makeup technology in the character of Lieutenant Dan played by Gary Sinise. During the course of the film, the lieutenant loses both of his legs below the knee in the Vietnam War. For most scenes the actor merely had his legs tied up to simulate the amputation. This is a time honored theatrical technique that can be very convincing, but comes with many limitations for movement. Audiences have become aware of this technique and expect it in cases where they know the actor is not an amputee. This expectation provides the potential to amaze the audience. In *Forrest Gump* a few scenes offer more "proof" to the believability of Lieutenant Dan's severed legs.

The first time the legs are removed is in the hospital scene in which Lieutenant Dan is lifted from his bed after his amputation surgery. This scene was brief, but did not allow for the actor's legs to be tied up or hidden in trapdoor furniture. During the opening of the scene, the actor is lying in a hospital bed, his shins and feet are placed through a hole in the bed that was digitally removed. His legs were covered in blue stockings that special effects supervisors were hoping would be able to be keyed out. Unfortunately that technique was not successful and the leg removal required rotoscoping on every frame as the actor is lifted from the bed.

In the second, he falls out of the wheel chair that he uses, and rolls onto the floor. This motion alone offers the viewer full view of the legs that they expect to be hidden, but have actually been digitally removed. To make the scene even more impressive, as

he climbs back into the chair, his body is swiveled next to a table. The audience recognizes that the actor's legs would have to pass through the table, which encourages believability that he has no legs beneath the knee.

Gary Sinise's legs first had to be digitally removed from the scene. This scene also used rotoscoping for the leg removal. But there was also the issue of the actor's legs passing through the table in the scene. This effect was accomplished by first shooting the scene without the actor but including all of the props. Once the empty plate was shot the placement of the table was marked, the table was removed, and the actor perform the scene. In postproduction the table was masked back into the scene over the removed legs.

The third case to remind the viewers of their belief in his amputation is while Dan is on the shrimping boat with Forrest. He climbs up on the side rail of the boat, swings around and into the water with a splash. This seems simple enough for an amputee, but the solid railing would block the non-amputated legs of the actor.

This effect was completed more simply than in the first scene, using a rail with a hole cut into it to allow the actor's legs to pass through. During postproduction, his blue-stocking legs were rotoscoped out and the rest of the wooden rail was added back in. In addition to this effect, the filming team was concerned that the numerous takes required would leave Gary Sinise too wet for quick filming. Therefore, when Dan jumps into the water, Gary jumps onto a dry pad that allows him to get back up and repeat the take as needed. A stuntman then came in to perform the water jumps until a satisfactory one was filmed. It did not matter that he was still wet, as his action can be seen for only a moment, under the plank that was digitally added, and then his splash.

Many in the film industry who are involved in traditional makeup techniques seem to be taking a positive outlook on the potential threat of the digital revolution. Ron Magid (Magid, 2006, March/April) of *Makeup Magazine* comments, "Indeed the ability of CG to enhance traditional prosthetic makeup and mechanical effects unleashed an explosion in the makeup industry that still is going strong – and has altered the craft forever." (p. 43) Hopefully the digital effects industry will work together with traditional makeup artist to blend the best of both techniques and create the most believable effects possible.

Pre-existing Footage

While many technical elements are crucial to creating a strong sense of believability, a compositor's artistic background and visual skills are fundamental to strong compositing. There are occasions when compositing becomes more artistic and less mathematic. Some projects do not allow for the common records to be taken that would permit more accurate recreation of the set digitally. Normally these records would be used to re-create the set digitally and aid in lighting believable effects. If these records are not available, the technical aspects of compositing must be implemented through a trial and error method in which only the compositor's artistic knowledge can judge when an effect is successful. Most often this problem arises with the use of pre-existing footage. There are different reasons that such footage would be used.

Historical Footage

On some occasions, such as in *Forrest Gump*, pre-existing footage was used to allow a level of believability that fictional characters participated in historical events and interacted with prominent figures. Many viewers, having seen the pre-existing footage before, were astonished to view this new character with these historical individuals, many of whom were deceased.

Using pre-existing footage often comes with many difficulties. Since the original film was recorded merely to document the events of the time, it is often lower quality, poorly lit, and hand-held, which can be the most difficult aspect to re-create digitally. Without the use of a tripod or dolly, these films often are recorded in a shaky manner that can be very frustrating to compositors when attempting to track motion to incorporate the new character into the scene. Although much of the tracking is still done by hand, some software has been developed to address the issue of motion tracking. Even when it is time-consuming, the perseverance often pays off, as the shaky quality adds "realness" to the composited scene. Some directors add camera motion in postproduction in an attempt to capture spontaneity. Robert Rodriguez used such a method in some of the scenes in *Sin City* (Weinstein & Miller, 2005). It is of course much easier to add camera motion after a scene has been composited then to attempt to track effects to an original film that is shaky.

An additional concern in compositing with historical footage is the age of the film. Many historical films have deteriorated over time or were shot with different film stocks. Both factors require careful attention and application of color adjustments. Re-creating the film grain or adding artifacts such as scratches that occur in the original film

will give more continuity to the scene. Software such as Adobe After Effects ™ and Vegas Video ™ provide tools to re-create these color palettes and textures. These color and texture changes may be accomplished through individual steps such as color correction and substitution or as complex as templates for particular film stocks. Even if a template can be used, it must be tweaked to match the original film footage.

Deceased Actor

Another case for using pre-existing footage is when the actor dies unexpectedly before the completion of the filming. While filming *The Crow* (Most & Proyas, 1994), actor Brandon Lee was fatally shot. This film is the story of a man brutally murdered who comes back to life as an undead avenger of his and his fiancée's murder, Lee's death was not only a tragedy, but also left the filmmakers with the difficult task of finishing the film without their lead actor. With the use of some clever editing and a few scenes with a composited digital stand in, most of the public was unaware of their dilemma when they viewed the final version of the film.

While not noted as one of the greatest movies of all time, *Plan 9 from Outer Space* (Reynolds & Wood, 1959) is an earlier example of using footage postmortem, and incorporating a double for the rest of the acting. *Plan 9* was Bela Lugosi's last film. The film is a story of aliens who resurrect dead humans as zombies and vampires to stop human kind from creating the a sun-driven bomb. Lugosi never knew the plot of the movie during his lifetime. Director Edward D. Wood, Jr. filmed Lugosi before the script was written. The script was completed and finished filming after the actor died, and Wood used a double, Tom Mason, to complete the role. The double was too tall to

resemble Lugosi and the entire portrayal involved the actor performing with his face covered with his cape. This is a fine example of how effects can be unbelievable, because even with his face covered Mason was not similar enough in build to replace Lugosi. However, it is also an example of another method of incorporating of pre-existing footage of a deceased actor.

New Application of Previously Unused Footage

A third case for use of pre-existing footage is the incorporation of footage from another film (many of which are unused takes) into a new film. A use of pre-existing footage is the previously cited example of Jabba's transformation from man to Hutt. This scene was able to make the cut into the release of *Star Wars IV: A New Hope* (Kurtz & Lucas, 1997) because of digital compositing. Even though the actors were still alive, they would have aged too much to reprise their roles with any continuity to the rest of the film. In the case of *Superman Returns* (Adler & Singer, 2006), which is a film that concerns the return of "the man of steel," and in which Marlon Brando posthumously reprises his role as Jor-el. This was the filmmaker's tribute to the original *Superman* films even though the compositing techniques were simple. Most of Brando's contributions were vocal, but in one scene he can be seen in the Fortress of Solitude emanating from the crystalline structure. Footage of Brando's face was simply layered in postproduction onto the set echoed throughout the great hall. Even though the process of the effect was relatively simple, it was well executed and successfully created a connection to the Christopher Reeve's films.

Whenever pre-existing footage is used and there is no documentation, much of the compositing must be accomplished using only the eye and instincts of the compositor. The only requirement is that it looks believable at completion, so different approaches may be used that would arrive at the correct solution. Time to complete the effect, technological resources available, and financial backing are common factors in the solutions chosen by an effects team. A compositor with a strong visual training will make the most of what is available.

CASE STUDIES

The methodology of my personal contributions to the study focused on the creation of three film shorts. Using some of the previously mentioned techniques, I attempted to create believable video effects.

Case Study #1 – 3D Model Composited into a Live Action Film

Problem

The first case study involved compositing a digital 3D model into a live action film. The goal was to create an effect similar to the replacement of the digital Jabba the Hutt that was added over a live actor in the re-release of *Star Wars: Episode IV*. The similarity between the Star Wars example and my case study lies in replacing an aspect of the actor with the digital model that was tracked to the live actor. The process included motion tracking a digital model to a live actor. The original concept for this short was to digitally enhance a live-action character, in this case a snake charmer at a carnival, with a subtractive costume element that is tracked to her motion. The factors that were to be observed included color keying, generation of masks, creation of the digital model, motion tracking the model to the film, and the compositing of the model into the film footage.

Implementation

This task required setting up a blue screen set and filming the live actress with her snake. [Fig. 1] After the film was digitized, it was edited and the masking process

began. My first hope was to use the Ultimatte ™ plug-in in Adobe After Effects ™ to chroma key the colors separately. In this case I used blue as the background color, and the corset was green and red. The difficulty arose during the red color selection, as it was too similar to the actress's skin tone. Overall the masks I produced were not precise enough, so I made the decision to try the Keylight ™ plug-in.

This keying method worked better, however there were some difficulties with it as well. As the tolerance of the mask was increased, flickering began to occur in the black color of her shirt as well as her hairline because the mask was removing too much information. Another complication was that the manner the red color was keyed in removed much of the red from her skin tone, even though it did not make it transparent. There was one section of film in which the actress's hand and snake would pass over the digital corset. The chroma keying refused to pick up the fine detail between her fingers and around the snake which made rotoscoping a mask mandatory. This proved a very time-consuming process, but important to create a detailed mask.

I created a simple geometric corset model in Maya ™. I re-created the studio lighting set up for the animation using both point lights and spotlights. The first attempt for motion tracking was to use Maya Live ™, a application in Maya ™ that is meant to track camera movement. It calculates well in 2D space, but not in 3D space, so it turned out not be the correct application for this project. I opted to use hand animation instead of using Maya Live ™. Using the original footage as a guide in Maya ™, hand animation proved a crude and tedious method, but offered me much more control. The corset frames were rendered and used as a separate layer in the final composite. [Fig. 2]

I opened the masked layer of original film footage in Adobe After Effects ™ and then overlaid the rendered frames of the digital corset. This however produced a very "cut and paste" look, so I re-masked the live action footage into two pieces, the section of the actress that was above the corset and her skirt below it. Cutting her body into two parts, allowed for a more believable layering of the corset into the live action, as I placed the corset between the two which created the illusion that the actress's body connected to the corset on both ends. I de-saturated the colors of the corset layer so that it would integrate better into the live footage.

To create a simple and non-distracting background layer, I purchased the rights to a stock image of a theater stage. I altered the colors from blue to red to create the color scheme that I wanted. I masked the curtains into their own layer. I added film grain to blend the still into a simulation of a video. I layered the final snake charmer over the background and added some shadows to her to enhance the believability. I also added 3D lights inside After Effects ™ to simulate the floor lights of a stage. I used a render of the woman to create a shadow that was cast on the background. Scratches and dust also lend to the suggestion of aged film. [Fig. 3]

Figure 1: Personal Filming of Snake Charmer.

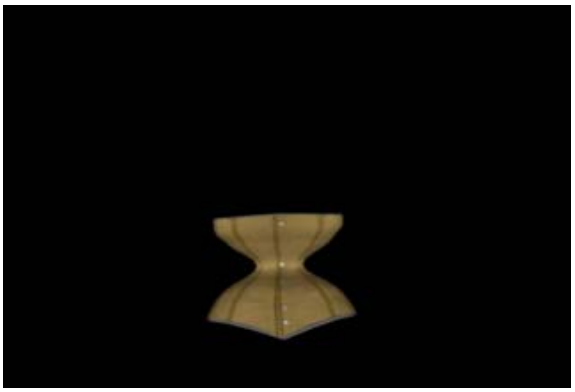

Figure 2: Digital Corset Render.

Figure 3: 3D Model into Live Action Film – Final Composite.

Results

The final product shows how 3D elements can be matched to a live action film. The film was also color corrected to suggest a stylized representation of an older film. Matching the animation to the actor proved to be the most difficult aspect of this project followed by the large amount rotoscoped mask generation. I believe the completion of this short film shows believability in many areas including color scheme and film grain texture, but there are still some difficulties in creating believability in the motion due to the hand animation of the digital element.

Case Study #2 – Pre-existing Footage

Problem

The goal of the second case study was to composite a live actor into a piece of pre-existing footage, similar to *Forrest Gump*. It included incorporating the new actor into the space as well as matching the quality of the original film. After I found some original footage, my concept was to add another scientist into the footage that included a chalkboard. I wanted to have a new actor come into the original scene and write on the original chalkboard. Accomplishing this included keying, generation of masks, compositing the actor into the space, color corrections and film quality duplication.

Implementation

The first step was to find a suitable piece of footage with enough space to add an extra actor. This was difficult because most films are framed on a central action or actor, which does not leave much room for another person. I found a copyright-free educational film, *Mystery of Time* (1957) released by the Moody Institute of Science (Internet Archive of the Moving Image, 2006, April). This film offered an option for adding in another actor as a scientist in the same lab. It also had an interesting color palette, with a strong red tint common in some 1950s films. [Fig. 4]

My first thought was to have the new actor approach and write on the original chalkboard. To accomplish this effect I hoped to use a difference mask to separate the actor and the writing onto a layer that could be placed into the new scene. First I had to find a chalkboard so that I would be able to create writing with the chalk texture required for believable compositing onto the older chalkboard. Most have been replaced with

whiteboards, which would not work for this concept. I eventually found one at a local church school, and did my first round of filming.

When I attempted to pull a difference key, I ran into my first big problem. A difference key uses a background plate (still frame) or video clip and then compares the new film footage. Any footage that matches will become transparent. The text and the actor not in the background plate should have remained. Unfortunately, since the computer does not compare shapes, only pixels, the tan chalkboard was too similar in color to the actor's face. This lack of contrast left huge spaces of his face transparent when the difference matte was applied. I began looking for another solution. I tried a few shots on a makeshift blue screen, pantomiming the motion of drawing with hopes of adding a digital smile. After checking the footage, I found the setup had unacceptable lighting conditions and made alternate arrangements to try again.

This time I filmed in the motion capture lab at the University of Texas in Dallas. They have a larger wall than I had previously filmed against that is painted blue, which allowed me to tape pieces of green posterboard to the wall that the actor drew a smile on in white paint pen, so that I might be able to pull the drawing in a key. [Fig. 5]

Once the footage was digitized, I still had issues with the smile flickering and the grain not matching the original footage, so I decided to use a still of the finished smile. I applied the same motion tracking to the still and used rotoscoped masking to remove the drawing from the parts of the frames in which it is being drawn. Still not satisfied with the quality of the line and its low resolution, I used Photoshop ™ and drew a higher resolution image with a chalk texture brush in the frame. The frame was then returned

into After Effects ™. Shadows were also added onto the chalkboard to reaffirm the contact of the actor to the scene.

Matching the color palette was difficult, as the highlights of the lab coat had to be darkened to match the shirt of the original actor. I matched the red tones of the 1957 film and used masks to fix some problem areas. Some scratches were added and additional film grain was matched to the original footage as well. The color bar artifacts on the sides of the original screen were also duplicated to rest over the new footage and finalize the integration into the scene.

Figure 4: Original Footage – Mystery of Time (1957).

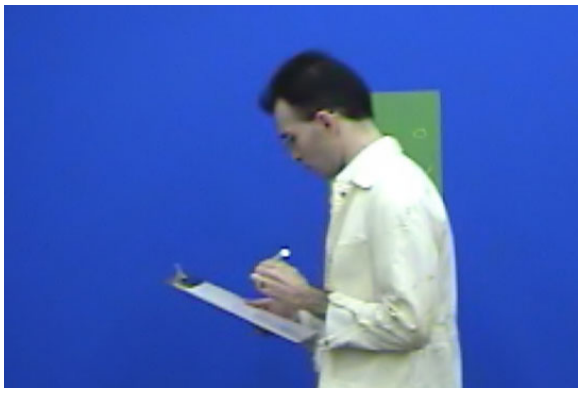

Figure 5: Personal Filming of Extra Scientist.

Figure 6: Pre-existing Footage – Final Composite.

Results

This case study brings the different 2D elements together into a cohesive film. Enough space was given to the new character to move through the scene. The hardest

parts of this short project were finding a historical film clip with enough space for a new actor and matching the original film color and grain. I think that this was the most successful of the case studies at creating believability because the proper color palette was matched and the movement was added correctly. There are still a few issues in the frames of the film. Due to the original film being 24 frames per second and the new footage being filmed on video at 30 frames per second, there is a slight visual flicker.

Case Study #3 – Digital Makeup

Problem

The third case study focuses on digital makeup, such as the effects in *The Exorcism of Emily Rose*. The work included generating a 3D effect to cover a live actor. The concept behind the piece is that a woman, after coming in contact a statue, becomes part of the same statue. To create this effect included generation of a 3D model with a bronze texture, creating an animated effect for the transformation, and final compositing into the live action scene with proper color correction.

Implementation

I filmed the live action plate in the afternoon with a strong backlight. Due to the small space and inability to use studio lights to fill in the front of the scene, there were some difficulties generating the desired depth of field. The film plate was manually masked and blurred using After Effects ™.

A digital model double was created using Maya ™. This stand-in received the bronzing effect that would be later applied to the human character. Generating the

bronze skin included procedural bump maps to simulate a three dimensional texture. The scene where the original footage was shot was recreated in Maya ™ with use of an environment cube that projected photographs of the original setting into the reflections of the digital metal. The digital scene was filled with lights to simulate the sun and reflected light. The character's eyes were also animated.

Once the model was rendered it was moved into After Effects ™ and color correction helped make the color of the digital bronze more similar to the live action statue. Contrast was also added to the model to make the lighting more believable. Shadows were added that would have been cast onto the digital model by the original one. An ambient occlusion render was blended over the digital statue's base color to simulate shadows that the object would cast on itself. The transition effect was generated using layers of noise animated in After Effects ™. The rendered noise was layered into the scene and then used as a luma matte (matte based on value) for the edge of the growing bronze. The rest of the metamorphosis was rotoscoped by hand, as I animated the transition's edge using the Pen Tool to create the mask.

Figure 7: Personal Filming of Statue.

Figure 8: Digital Makeup – Final Composite.

Results

The final case study shows how a 3D model can be matched to a live action film for the purpose of digital makeup to create a believable effect. The film was matched with digital animation and a transition blended the growing effect. The most difficult issues of this project were matching the bronze color and texture of the original statue and recreating the outdoor scene's lights and reflections. Overall I think believability was created in the digital bronze statue. The real world reflections cast properly onto the digital bronze help to set the digital statue in the live action space. The only outstanding issue is the movement of the plate and the bumps that were caused by it in the motion tracking of the digital model.

IMPLICATIONS AND CONCLUSIONS

The potential directions for the future of compositing seem as endless, as its growing importance of the relevance of the field. Compositing has branched out from the film industry and into others, such as architecture, commercials and music videos that will continue to increase their use of such effects. It continues to spread and will become more important in other fields such as medicine. As it becomes more popular in the film industry and technology continues to advance, compositing will infiltrate more aspects of filmmaking. Products that are only available to large production houses, such as bar code readers that allow for real-time compositing while filming, may trickle down into the smaller budget film productions. Technology is often a hand-me-down process in which the rich can afford the cutting edge. With demand, more companies will develop and refine the idea therefore driving down the cost and making it available to more people. It is probable that more films will follow in the pioneering footsteps of films like *Sin City*, in that the actors will perform on mostly empty sets and may never meet their screen partners, and scenes will be merged together in postproduction.

Believability is likely to remain a common goal of filmmakers and effects artists, as the public audience seems to enjoy the potential for more realist effects as technology advances. Such effects should become easier and cheaper with this evolution. Technical developments will continue to aid both hardware and software. There may come a point where believable effects come too easily and filmmakers may want to attempt to create a different style of effect. This wish may be similar to modern art movements like cubism, where the artists choose to abandon traditional realism to create something that was a new way of looking at traditional subjects. However, as in art, I would expect the

eventual return of the mainstream filmmakers' desire for believable effects. The other new styles may remain as an option, as there are still artist that create in Cubism style, even though it is not as popular as it was once.

The concept of digital film allows for the expansion of not only the subject, but also the actual framing and shape of films. There may be a push away from the traditional media format and aspect ratio, which was based on its predecessor, the still camera. Digital media may be cropped into any infinite number of shapes. It may be warped or layered with other images to create all kinds of perception effects. Technical capability may not coincide with the general public's acceptance of such radical camera use, which would keep traditional film standards for general audience films. But the options will continue to broaden.

Believability may become a burden as well as a blessing when used for compositing. At this time, most companies that use compositing do so for entertainment or to help people understand things visually. However, as the effects become more believable and cheaper to create, less moral applications may become more prevalent.

Films such as *Death of a President* (Gutch & Range, 2006) have started to show how CG effects can manipulate factual footage. In this film, President George W. Bush is assassinated. It is an important step forward for filmmakers, because it shows that pre-existing footage can be manipulated to change viewer perceptions concerning an actual living person, not a fictional character. Due to this malleability, it is probable that in the future video evidence will no longer be accepted as absolute proof, especially in court proceedings. Ethical usage of compositing will become more important, but harder to control. There may be a point at which people will never be confident in the

reality of what they see on video or film. Humanity's natural predilection to accept visual stimuli will remain relevant in all applications of compositing. As Darrel Anderson (Anderson, 2003) said in “Art Imitates Life (Yes, it’s News),”

> Computer-generated artificial realities so rich as to fool us into utter acceptance may seem a far stretch. However, our minds may be all too willing to bridge the gap. If you are wearing stereo goggles, that’s one thing. If virtual reality is riding in on your neurons, that’s another. Given the right state of mind we can be quite receptive. My most convincing dreams, in retrospect, are full of gaping holes. Many fictional scenarios employ drugs as a lubricant for (usually involuntary) artificial-reality immersion. Why not? Even more effective consciousness-altering devices, bio-tech, genetically engineered – are, or will soon be, available. It doesn’t matter how you get there, just that you’re convinced you’ve arrived. In the end, it’s all in the mind’s-eye of the beholder. (p.68)

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