CREATING EFFECTIVE COMPUTER GENERATED SCENE LIGHTING USING TRADITIONAL FILM LIGHTING TECHNIQUES

A Thesis

by

JULIE MARIE GARCIA

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 2005

Major Subject: Visualization Sciences

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Approved by:

Chair of Committee,   Frederic Parke
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ABSTRACT

Creating Effective Computer Generated Scene Lighting Using Traditional Film Lighting Techniques. (December 2005)

Julie Marie Garcia, B.A., The University of Texas at Austin

Chair of Advisory Committee: Dr. Frederic Parke

This thesis explores the process of translating traditional cinematic lighting into the digital realm by understanding distinctly different lighting styles of three Directors of Photography. These Directors of Photography are Conrad Hall, Gregg Toland, and Zhao Fei. Digital lighting studies representative of the work of each Director of Photography were created. In these studies, the lighting in scenes done by each Director of Photography was digitally mimicked. As a result, the lighting studies provided valuable insight into the approaches of these masters of light. An animation was created to display a scene lit in the three lighting styles of each Director of Photography. The process, learned from the lighting studies, of creating three different lighting styles representative of each Director of Photography was applied to the final animation. The analysis and lighting studies of each Directors' of Photography style expedited the process of lighting the final animation in each different style. As a result, a more complex environment was effectively lit in three different cinematic styles with animated light.

To Mom, Dad, Christine, Ben and Daniel

ACKNOWLEDGMENTS

I would like to sincerely thank Dr. Frederic Parke, my thesis committee chair, for his guidance and expertise. I would also like to thank Professor Karen Hillier, my thesis committee member, for her artistic insight and direction. Also I would like to thank Professor Daniel Koetting, my thesis committee member, for his research suggestions and guidance about scene lighting.

I would like to thank the Visualization Laboratory faculty and staff for helping me during my graduate studies. I would also like to thank my friends and fellow Viz Lab students for their support. Finally, I would like to thank my family for their unconditional love and support.

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CHAPTER I

INTRODUCTION

In traditional film lighting, the task of illuminating a scene is more complex than just making everything properly visible. Lighting functions to transform an environment. The resultant mood created with light will influence the audiences' emotions so a greater understanding of the story can be achieved. In computer animated films, lighting serves the same purpose as in traditional film.

An effective approach to digitally lighting an animation in distinctly different styles will be achieved by faithfully emulating how a select set of Directors of Photography, masters of traditional film lighting, have used principles of light and their working philosophies to control light and ultimately influence the audience.

The works of three chosen Directors of Photography were analyzed and emulated. After analyzing films from each it was clear that each had a distinct approach to lighting. The Directors' of Photography approaches could be understood by their consistent use of particular lighting elements. Their styles were defined by analyzing the lighting preferences from several of their films. Questions were answered such as why were certain approaches favored over others and what factors influenced the emergence and continued use of very unique lighting styles.

After understanding each Directors' of Photography lighting style, each lighting style was applied to simple three dimensional room scenes. Still images from the films of each Director of Photography were used as reference to light simple room scenes. Setting up similar compositions of the room for each reference image allowed understanding how to digitally recreate the lighting setup created by each Director of Photography.

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The journal model is *IEEE Transactions on Visualization and Computer Graphics.*

Alias/Wavefront MAYA^{TM}, a 3D software package, *jrOcclusion*, an ambient occlusion plug-in, *Adobe After Effects*^{TM}, a compositing program, and *Adobe Photoshop*^{TM} were used to digitally recreate the lighting.

Finally the lighting setups learned from the scene lighting exercises were each applied to a final animation. The final animation was composed from a stationary point and lit in different styles based on each Director of Photography. The goal of the final animation was to show how different lighting styles can effectively influence an audience. The scene for the final animation was more complex than the earlier simple room environments, with models that were textured and with animated lighting.

CHAPTER II

BACKGROUND

II.1. About Directors of Photography

Director of Photography, or DP, is the American term for Cinematographer [1]. The DP determines the lighting setup, selects the film stock, chooses any filters, sets the exposure, and works with film processors to ensure the final look is what was intended. The DP lights a scene based on the explanation of the story and intended mood that usually comes from the film and art directors. The DP will have a crew of people whose number is dependent on the size of the production, to aid in setting up the lights, as well as a cameraman [2]. Figure 1 shows a complex lighting setup for the film *Sleepy Hollow* [3].

Many DPs have a recognizable style. Some DPs have strict philosophies about working with light. Nestor Almendros, a DP, is known to work with the available light in a scene and may use extra lights where needed. Other DPs exhibit preferences for stylistic elements developed throughout the films they have shot but do not claim to have a defining approach or style [2]. Also, a DP may have shot a series of films with similar stylistic elements although his or her lighting style may have radically changed for later films. A DP with a series of similarly looking films is analogous to Picasso's series of paintings during his "blue period".

II.2. Three-point lighting

The three-point lighting setup was established in traditional film lighting. It can provide guidelines for digital lighters as well. This setup is composed of key, fill, and back lights. Each light in the setup is named for its function. For example, the digital key light is

Fig. 1. A physical lighting setup for the film *Sleepy Hollow* [3].

referred to as the key, as in film. Rules for this setup are basically the same for traditional cinematic and digital lighting [4]. Use of the three-point lighting set-up should be based on the needs of the situation, rather than being used as a formula for lighting a subject or scene [5].

The key is the first light to be positioned. No other lights should be added until the key's position is established [5]. The key is the brightest light and establishes the orientation of illumination. It creates the principal shadows, reveals form and texture, and also largely determines the amount of light in a digital scene. To avoid conflicting shadows, only one key should be used [6]. For most standard three-point lighting setups, the key is positioned 15 to 45 degrees above and to the side of the camera, as displayed in Figure 2 and Figure 3. As an alternative, an *upstage key* is a key positioned behind the subject [4], [7].

Fill light, usually diffused, is added to illuminate shadow areas and reduce overall tonal contrast. Fill light does not call attention to itself and should not cast any new shadows, or if any, faint and unobvious ones [6]. If more than one fill light is used, in a variation of the three-point lighting setup, the combined intensity of the fill lights affecting a given area should never exceed the intensity of the key light. The fill light is usually positioned opposite the key but closer to the camera so areas lit by the key and fill overlap, providing continuous shading for the subject [4]. For most standard three-point lighting setups, the fill is positioned 15 to 60 degrees to the side of the camera opposite the key and about 0 to 30 degrees above the camera, as displayed in Figure 2 and Figure 3 [4], [7].

The key-to-fill ratio is the proportional brightness of the key and fill lights. A 2:1 key-to-fill ratio would indicate that the key light is twice as bright as the fill [4]. A higher key-to-fill ratio would produce a less gradated lighting balance and drama between the light and shade. Scenes with a higher key-to-fill ratio evoke moods of vitality and dynamism. A lower key-to-fill ratio would produce a more gradated lighting balance. Scenes with a lower key-to-fill ratio evoke moods of beauty, restfulness, mystery and lack of vigor [6].
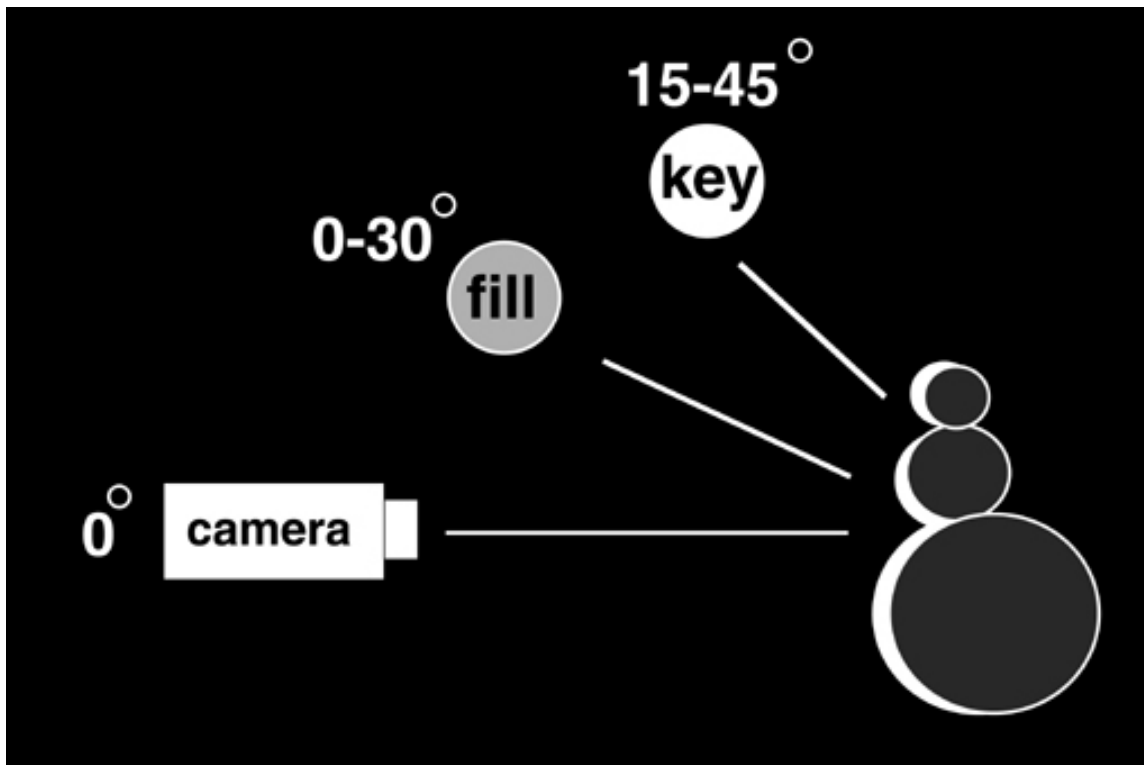
Fig. 2. Side view of the relative positions for the key, fill, and camera.
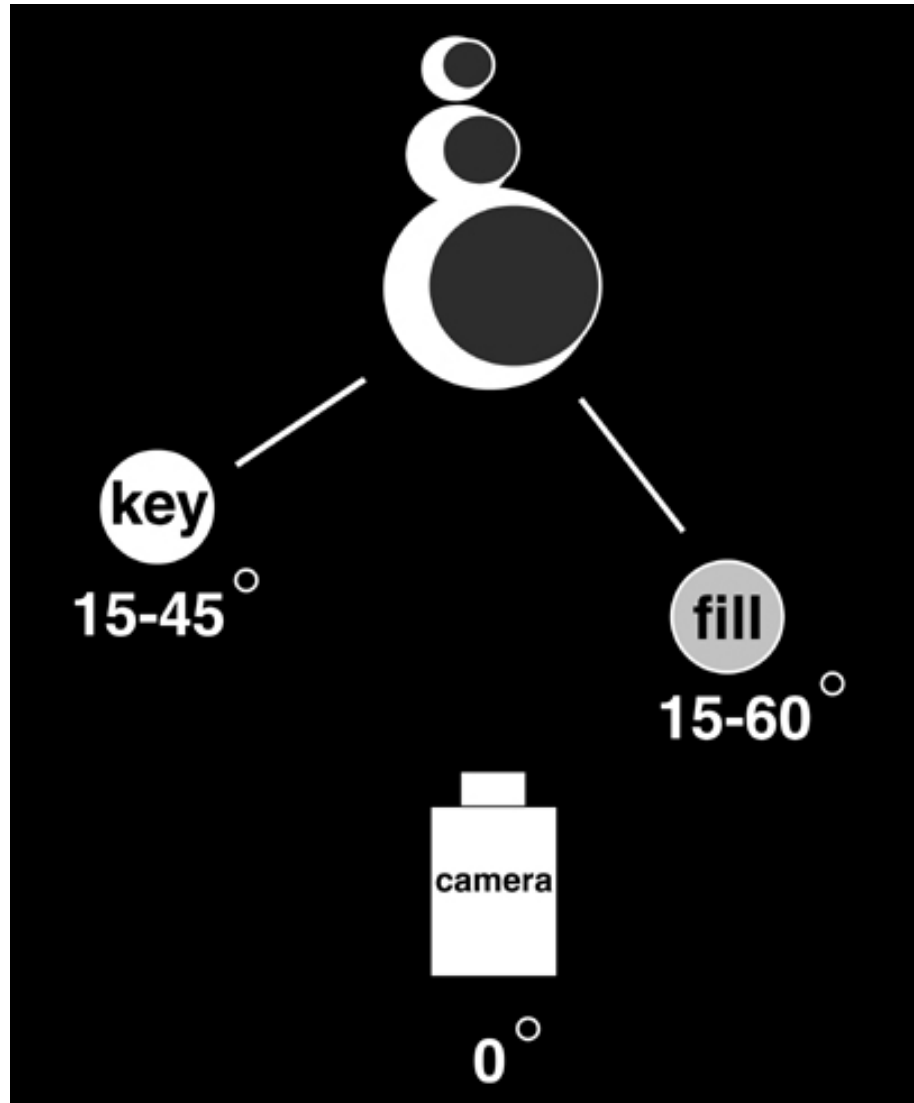
Fig. 3. Top view of the relative positions for the key, fill, and camera.
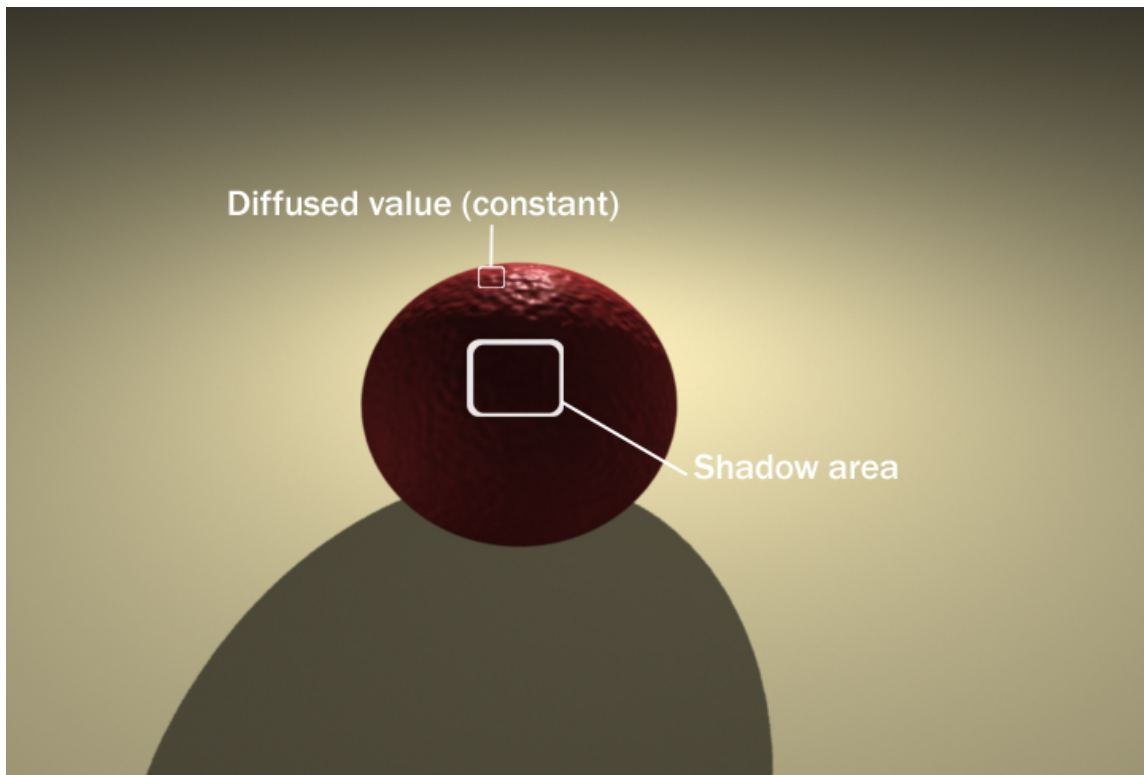
Fig. 4. An example of contrast with low fill levels.

Contrast is determined by the ratio of the intensities of the key and fill lights. When decreasing the contrast of an object, the illumination of the true tone of an object or its *diffused* value is constant while increasing the intensity of the shadow value. Light reflected off an object can be described in terms of having diffused or true tone, shadow, and specular values. Keeping the diffused value constant allows contrast to be determined by manipulating only the shadow value [8]. Figure 4 displays a variation of the three-point lighting setup with a backlit sphere with low levels of fill light created using an upstage key and two fill sources placed on the right and left sides of the camera. Figure 5 displays the same sphere with less contrast. More intense fill was achieved by moving the two existing area lights closer to the sphere.

The function of the back light arose from the need to separate the subject from the
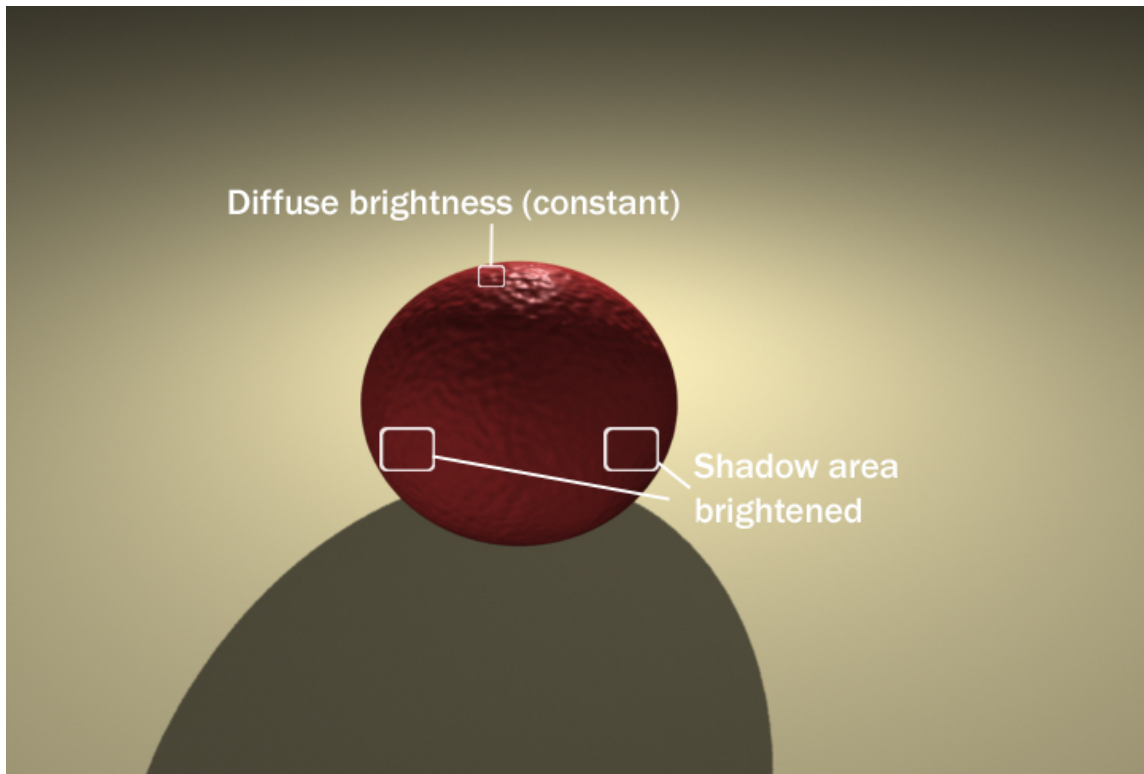
Fig. 5. An example of contrast with higher fill levels. Decreased contrast was achieved by moving two area light sources closer to the sphere.

background in traditional black and white photography. In color cinematography, a back light is not as necessary when sufficient color contrast exists between the subject and background [9]. The back light may have a higher intensity than the key. However, a back light may look inappropriate if it is too bright and out of context with the environment lighting. Consistently using a back light creates a styled look [5].

A "rim light" illuminates the subject's edges and generates an outline of the subject. A "kicker," also known as a "3/4-back" or "cross-back" light, is positioned further towards the camera, on the non-key edge of the subject. It is used to make the subject look more three-dimensional. A "liner" light is positioned more forward towards the camera and contributes to the subject's diffuse lighting [6], [9], [10], [11].

Recognizable variations of the three-point lighting setup can be created. The familiar "silhouette" style focuses on the subject's outline without illuminating the form. The silhouette style is achieved by placing an unlit subject in front of a light background. The "semi-silhouette" is achieved by back lighting a subject and also using low intensity frontal fill light to reduce contrast.

The "notan" style emphasizes pattern and color and reduces contrast of the form and texture. The notan style is achieved with intense soft frontal lighting to flatten the subject. Fashion show lighting utilizes the notan style.

The "chiaroscuro" lighting style would be the result of a perfect three-point lighting setup where three-dimensional form and texture are emphasized. Chiaroscuro lighting is achieved by carefully controlling tonal contrast with the placement and relative intensities of the key and fill lights. In Figure 6, Dalí used chiaroscuro lighting to emphasize the folds of clothing [6], [12].
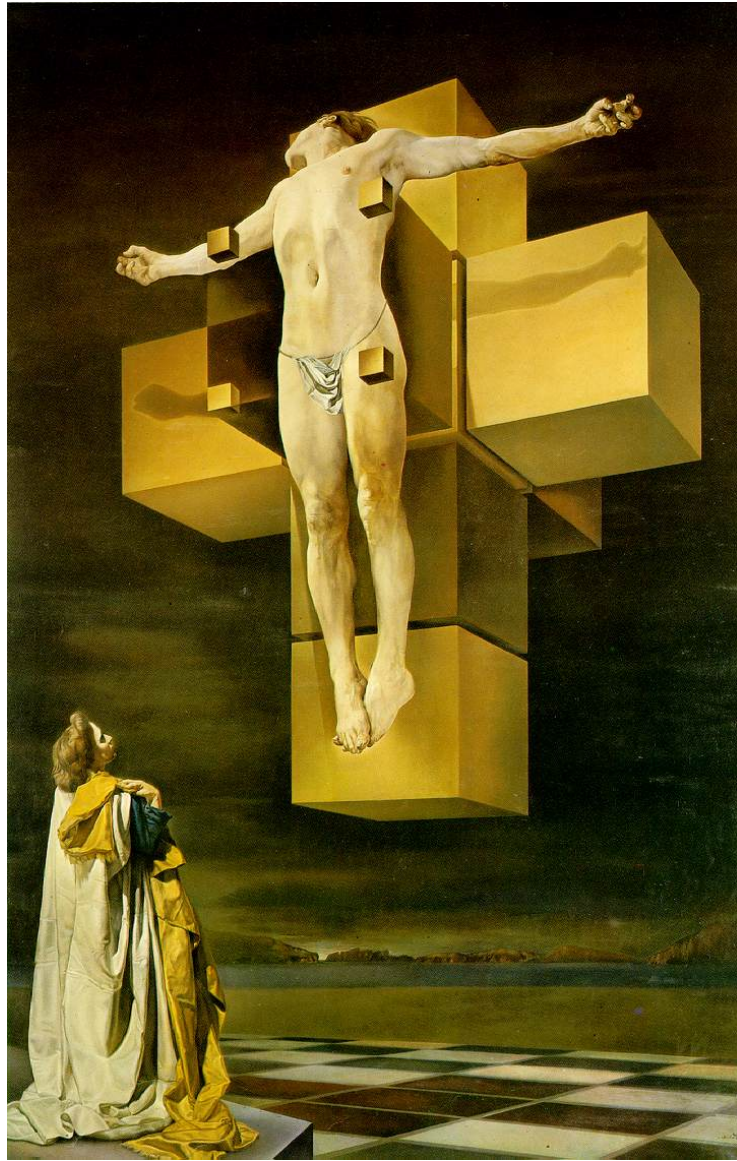
Fig. 6. A painting utilizing chiaroscuro lighting. Note the folds of clothing [12].

II.3.   Functions and qualities of light

Light functions in many ways to visually support the story in film, theatre, and paintings. Light can quickly and effectively direct the viewers' attention to an important visual cue. Also, light can have a dramatic effect on how the personality of a character or the characters' current situation is depicted by the way it illuminates the form of a character. For example, strong under lighting could be used to illustrate an evil character or to show a good character that is plotting a devious plan. Light is used to create moods and play upon the viewers' emotions. A dark scene subconsciously impresses upon the viewer a feeling of uneasiness or that something is lurking in the dark [10], [13].

An understanding of the qualities of light is necessary for controlling light. Intensity or brightness as well as color are qualities of light. In digital lighting, because there are no controls for the camera's exposure, controlling the intensity of the key light is important because it primarily determines the amount of light in the final image. The intensity of a key light should properly show the true tone of an object or its diffused value [8].

Another important quality of light is its hardness or softness. The smaller the source, the harder the source [6]. Hard light casts sharp edged shadows and produces a small area of transition between the illuminated and shadow values of an object [8]. Form and texture are emphasized with hard light [6]. Figure 7 displays an example of a sphere lit with a small point source producing hard light.

Soft light originates from larger sources. Soft light casts soft edged shadows and produces a larger area of transition between the diffused and shadow values of an object. Moving a large light source closer to an object will soften the light further [8]. Soft lighting is used to create subtle graded shading. Soft light can suppress texture and form if used excessively [6]. Figure 8 shows an example of a sphere lit with a large area source producing soft light.
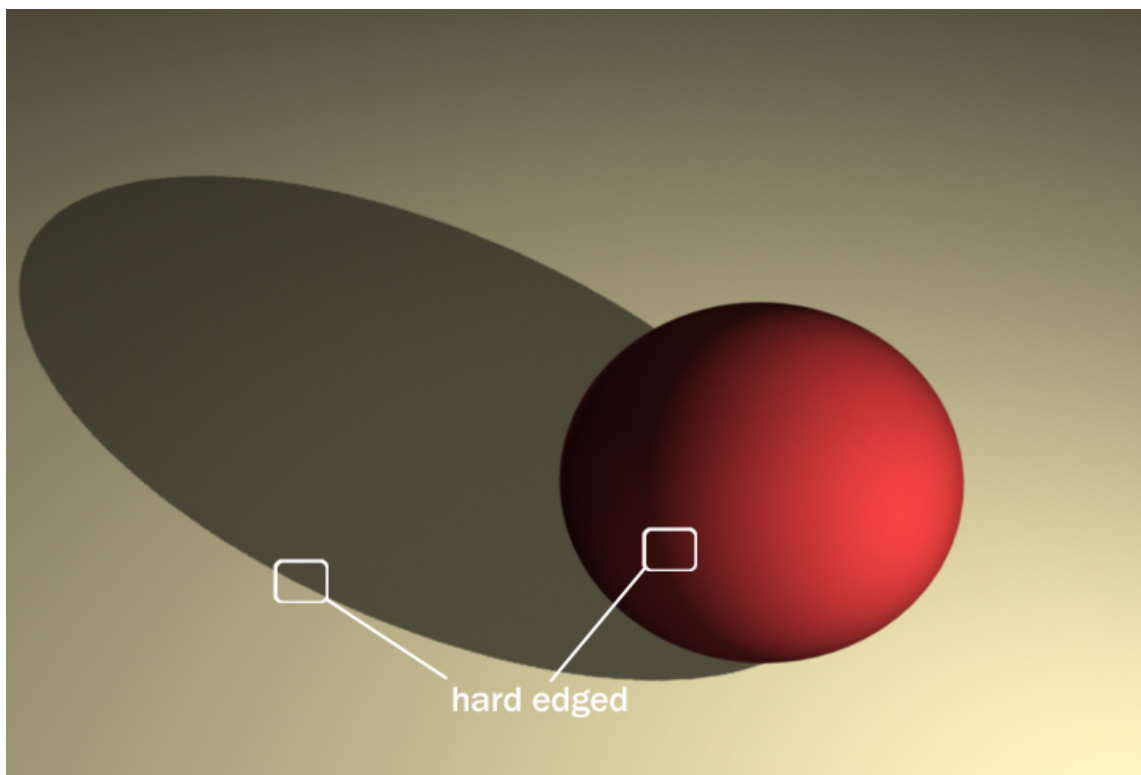
Fig. 7. An example of hard light. The sphere was lit with a point source.
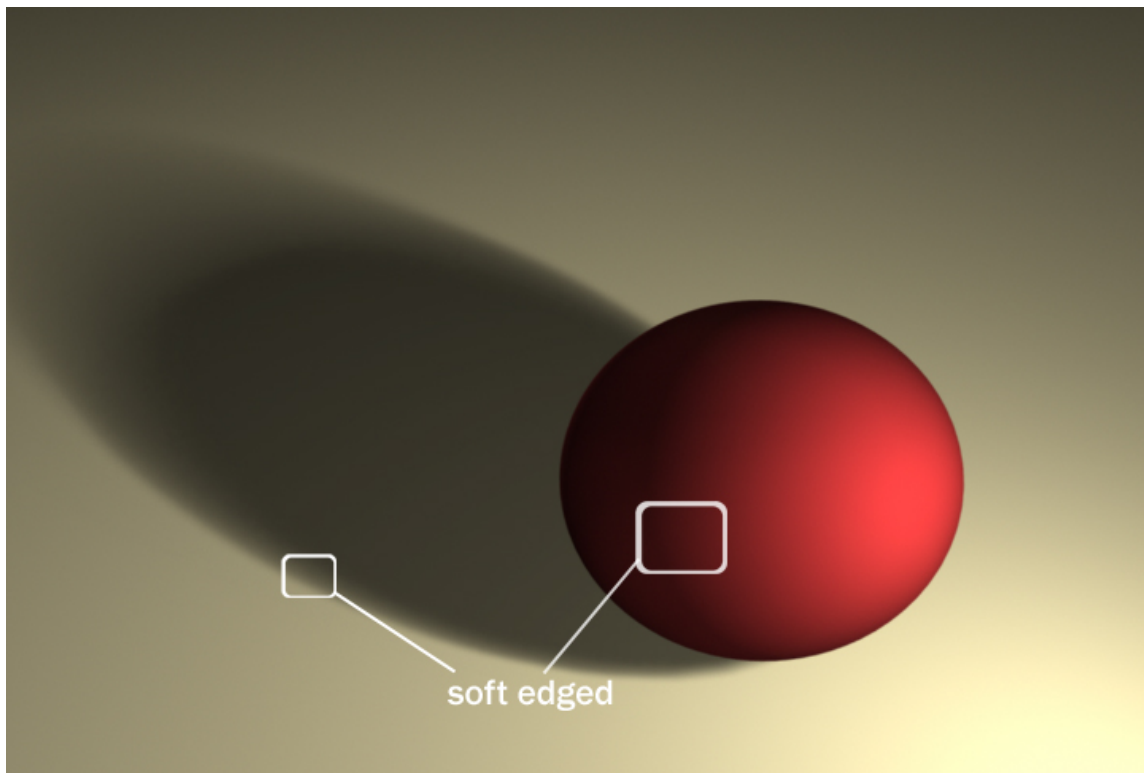
Fig. 8. An example of soft light. The point was changed to a larger area source.

Another quality is the throw pattern or shape of the light. The shape of the light can be used to emphasize parts of the subject [6]. In live-action lighting, window frames and tree branches are placed in front of lights and used break up the shapes of the lights [7]. Light can be broken up with cookies, irregularly patterned cutouts placed in front of the light. When the pattern has cloud like patches the effect is called dappling [14]. Defocused and soft dappling can create beautiful effects. The shadow patterns thrown either onto the background, subject, or both help suspend the viewers' disbelief that the scene has been contrived. The subject becomes integrated with its surroundings when both are lit with patterned light [6]. In Figure 9, Steve May's use of a throw pattern in *Butterflies in the Rain* enhanced the atmosphere of the inside of a piano [15].

Artificially produced smoke and fog affect the quality of light. Fog desaturates color. Contrast is also reduced because dark tones are lightened. Fog can aid in the illusion of depth in a scene as the desaturation of color and reduction of contrast occurs for objects within fog and as depth increases like at the horizon line.

II.4.   Live-action vs. digital lighting

Setting up digital lights to mimic live-action lights often yields a digital lighting setup that is different from the live-action setup. On a live-action set, goboes and flags function to block light off. Goboes are large wooden screens that "go between" parts of a scene and a light source. Flags, miniature goboes mounted on stands, serve the same purpose but are useful when space is limited [7].

In the digital realm "lights and flags can exist anywhere in space without interfering with the camera or subject" [10]. In the digital realm you can specify lights and objects to not cast shadows, and control the color, density, sharpness of cast shadows. There are also negative intensity lights that darken instead of illuminate areas. Also, digital lights can

Fig. 9. An example of a throw pattern. The throw pattern creates interesting atmospheric effects as a butterfly travels through the inside of a piano [15].

illuminate certain objects and exclude other objects. Digital lights can also contribute to specular only, diffused only, or both values of an object.

When setting up digital lights to mimic the effect of a live-action lighting setup, typically more digital lights will be used to mimic the live-action lights. More digital lights are used because basic digital lights do not have the same coverage and ability to create the effect of reflected or indirect light as physical lights. As a result, many digital lights need to be used to recreate the look of one physical light's coverage and reflected light.

II.5.   Digital lighting workflow

The current workflow for digital lighters involves positioning lights in a 3D scene and subsequently rendering a lit version of the scene. This process starts out very roughly by positioning a few lights and then rendering a lit image. As the lighting setup becomes more refined, more lights are used and their positions and parameters are adjusted. As more lights are added, rendering time increases. For this time consuming process, several iterations are required to achieve a final image.

To make this process more efficient, interactive tools such as *Lpics* have been developed. Lpics, short for "lighting pictures," is a program developed by Pixar Animation Studios which allows high quality previews of lighting at interactive frame rates. Lpics is a relighting engine tailored to Pixar's existing system of applications. Lpics was based on the work of other earlier relighting engines [16]. Lpics enables a lighting artist to interactively position lights and adjust light parameters, like intensity and falloff, while viewing the results of these changes. Scenes with hundreds of lights can be rendered interactively, although the manipulation of multiple lights concurrently slows the interactive process. The preview quality is high but a lower rate of sampling is used with filtering of shadows and textures. Figure 10 displays images from the interactive renderer and the software renderer.

The effectiveness of the program has been demonstrated with its use in lighting almost all shots for Pixar's productions since it was introduced [17].

Digital lighters often use compositing for greater control over shadow, highlight, reflection, refraction, and other passes. Layers of a scene are separately generated, manipulated, and composited together with a 2D software package. Composited layers should look "naturally motivated by the [light] source in the scene" [10].

II.6.   Low and high key styles

The chosen lighting style for a scene, in the range of very low key to very high key, will set and reinforce the mood. A low key lighting style has tonal values that range from mid-gray to black. With low key lighting, there are a few properly lit areas to draw the attention of the viewer, and the rest of the image is generally underilluminated and dark [10]. Properly illuminating some areas avoids a murky image and maintains contrast and visual impact [9]. Low key lighting evokes somber moods.

Very low key lighting is composed of black areas that are broken up with smaller lighter areas. Very low key lighting evokes moods of mystery and drama or the impression of night. The absence of light leaves much to the viewers' imagination [6]. Figure 11, shows an example of very low key lighting from the film *Fat City* [18].

Mid-gray to white tones pervade scenes with a high key lighting style. The overall image is bright with a lot of soft fill, few dark areas, low contrast, and soft shadows. Also, high key lighting is usually used with sets light in color and subjects with light colored clothing [9]. High key lighting evokes a light-hearted and cheerful mood.

Very high key lighting is opposite from very low key lighting. Light-gray to white tones fill scenes with a very high key lighting style. Very high key lighting creates illusions of openness and spaciousness and a mood of simplicity [6].
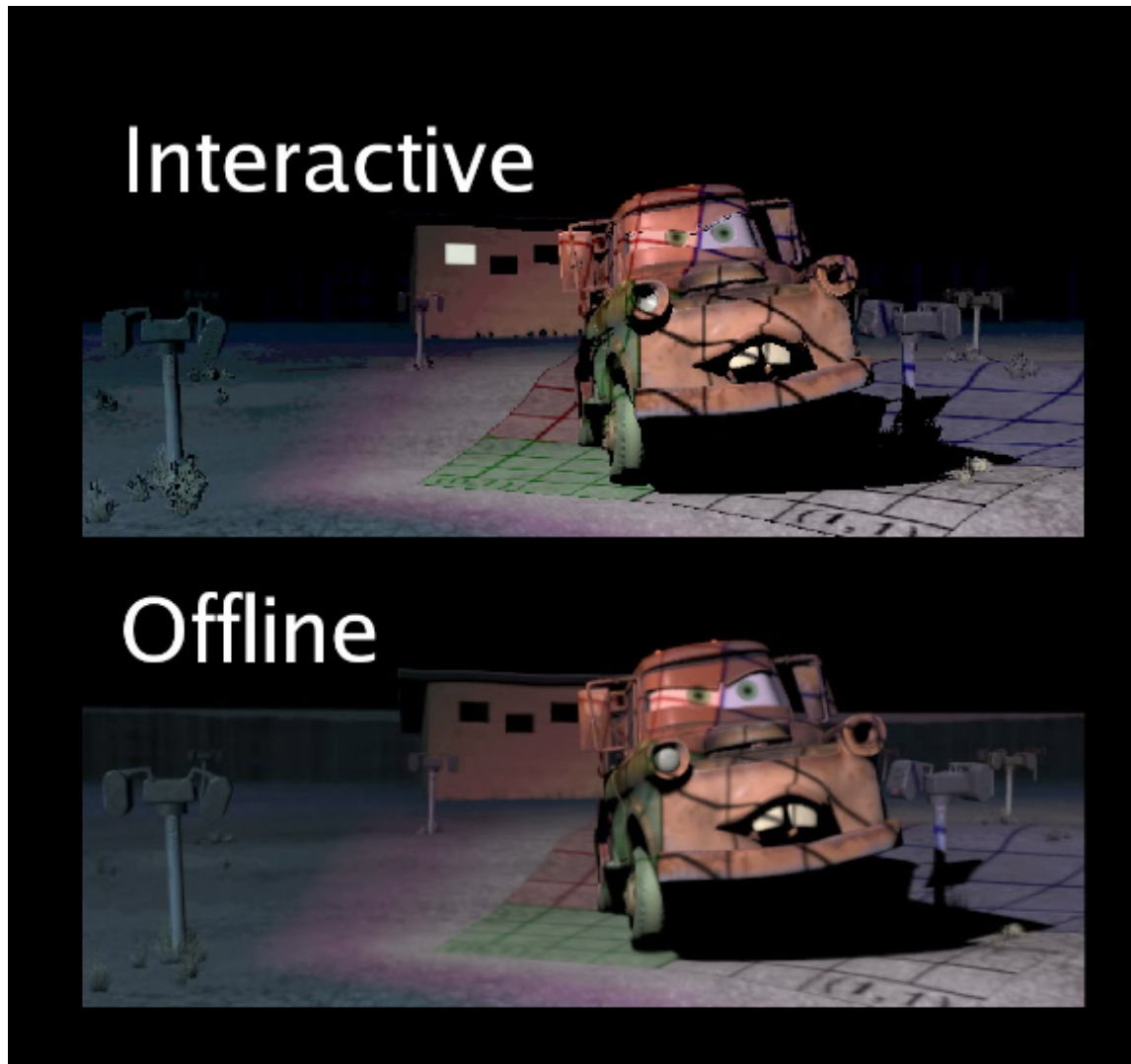
Fig. 10. A display of the image quality from Pixar's Lpics. The top image was created interactively using Lpics versus the same image created with their software renderer [17].

Fig. 11. A very low key lighting style used in the film *Fat City* [18].

Fig. 12. A stylized approach to atmospheric treatment from the film *Minority Report* [19].

II.7. Realistic and atmospheric treatments

Realistic and atmospheric treatments are two scene lighting approaches. Logical sources of light or practical lights, sources that the viewer can see like a window or lamp, provide illumination orientation with realistic approaches [10]. DPs approach a realistic lighting setup by mimicking a real world lighting situation and then cheating, or adjusting, the position and coverage of the light sources as needed. Additional light is sometimes used to augment the cheated artificial source. Realism can be simulated by convincingly faking the presence of off camera scene elements with cast shadows or lighting effects. Faking the flicker of light emitted from a camp fire is one example of simulated realism [6].

Atmospheric lighting treatments need not be logically justified like realistic treatments. Naturalistic treatment, one atmospheric approach, looks realistic without justification from practical lights. However, the resultant mood created would not be possible with a lighting setup based on the practical light sources. An even more exaggerated or stylized approach to atmospheric treatment is "preoccupied with special effects," attention grabbing, and mannered or artificial in character as displayed in Figure 12 [6], [14], [19].

II.8.   Recreating ambient light

Live-action and digital lighters work with the challenge of recreating ambient light. Ambient light, also known as reflected or indirect light, is "the light that reflects off of objects lit by direct light". In live-action, the existing natural ambient may be removed, redirected or augmented by using large black or white foam boards or framed cloth contraptions to either kill or reflect illumination back into the scene. The natural ambient light is usually not sufficient, and additional fill lights are necessary to soften the harshness of shadow areas. Live-action lighters spend a lot of time and effort to achieve the right balance of ambient and direct light in tradition film even though most moviegoers probably assume the lighting occurred naturally [5].

Digital lighters may recreate ambient light using bounce lights, ambient light, or global illumination techniques. Bounce lights are described as "localized, non-specular, low-intensity and colored to mimic to the surface they are reflecting" [10]. Ambient light effects for a scene can be approximated using point or parallel light sources [5]. Adding ambient decreases the contrast between the diffuse and shadow areas of a surface in a uniform way.

Global illumination techniques such as radiosity, calculate indirect light interactions between objects. Global illumination is not often used in animated productions for several reasons. It provides less control in adjusting the amount of reflected light onto a subject or scene [11]. Directing this reflected light for mood is difficult, even though the reflected light that it produces is photorealistic. Controlling the ambient effect produced by global illumination echoes the challenge Directors of Photography face when working with natural ambient light. Global illumination also requires time and processor consuming calculations. Scenes with high resolution geometry or very detailed modeling will take a long time to compute [20]. As a result, animation productions use bounce lights to achieve the
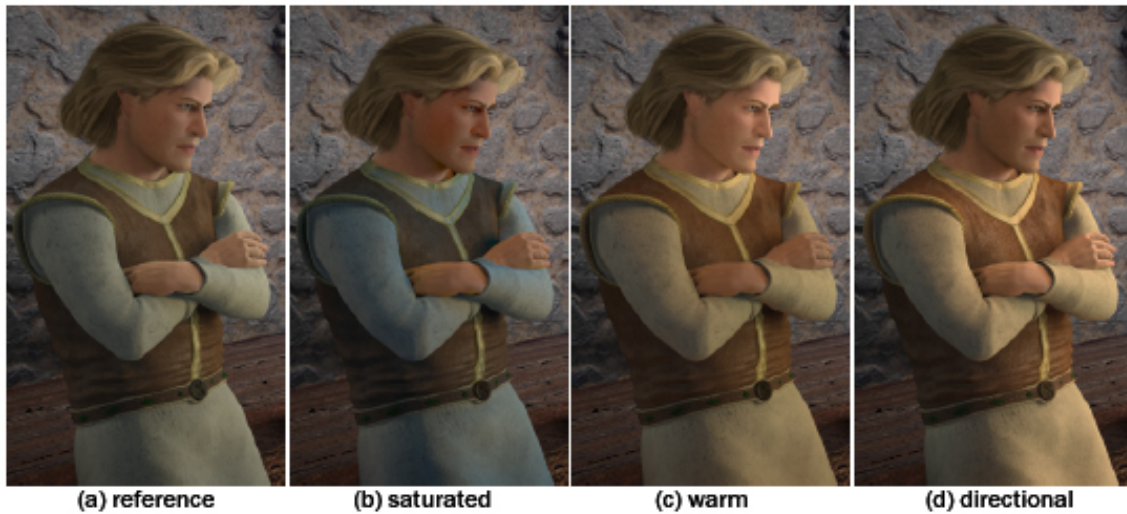
Fig. 13. Lighting variations created by PDI/DreamWorks' lighting model [21].

same look as global illumination techniques [4].

In the computer animated feature film *Shrek 2*, the proprietary PDI/DreamWorks lighting model allowed for efficiently and quickly achieving the look and style of global illumination. This very simplified radiosity-like approach was implemented by gathering the color data for indirect light using only a single bounce. This indirect illumination lighting model "was used to light primary and secondary characters in 78% of the shots and to light props and environments in 30% of the shots". Texture images were mapped into each surface in the scenes, and radiance values for each texture map pixel were computed and stored in a pre-processing stage. By referencing a specific indirect light shader in a scene, a special filter light with controls similar to a spot light was used to apply distance and directionality falloffs and also adjust brightness, contrast and saturation. Lighting adjustments, as shown in Figure 13, only required re-evaluating a shading pass. This approach provided an efficient workflow [21].

II.9.   Mimicking film effects

Film specific effects created intentionally or unintentionally by DPs like diffusion and blooming can be mimicked by digital lighters. Diffusion is a technique which changes the sharpness of the image and makes it softer looking [2]. "Fine nets, granulated or grooved glass, petroleum jelly or glycerine smeared on glass is positioned in front of the lens" by DPs to achieve the technique of diffusion [9]. Diffusion can be achieved digitally by significantly blurring the original image and adding a percentage of the blurred image back into the original image [5].

A blooming effect, where light appears to spread out from a bright local area in an image, is the result of film halation. Halation occurs where areas of the film are overexposed and "the light is so bright that it enters the layers in the film emulsion and scatters around in between the sandwich of the film back and the halide crystals" [5]. A blooming effect can be achieved digitally by creating a high contrast version of the original image, desaturating and significantly blurring it and adding a percentage of the manipulated image back into the original image [22].

CHAPTER III

PREVIOUS RELATED WORK

III.1.   Cindy Hong M.S. thesis

Cindy Hong analyzed the lighting in four paintings as well as one still movie image and recreated the same lighting digitally, using a simplified modeled and textured scene in her M.S. thesis entitled *Lighting Studies: Interpreting Lighting Styles from Traditional Media in Computer-Generated Imagery* [23]. Her analysis of the traditional media included determining where the key source of light originated, the key's color in warm or cool terms, and the time of day or year and its effect on the lighting. Also, Hong noted if the artists painted light that was not physically correct and its effect.

Hong used several helpful approaches when recreating the lighting. These consisted of doing a set of renders to view key, fill, and key-to-fill ratio intensities. Hong also viewed renders in a grayscale or value pass in order to make sure the subject was properly shaped by the light. Also, Hong showed and explained the lighting iterations and what improvements were made in each study.

Images that closely matched the original media in color, value, and surface modeling were the result of Hong's thorough analysis and consistent approach. Figure 14 displays Hong's utilization of the most visually interesting lighting elements for the main subject and scene, which yielded a beautifully lit image [23].

The process of setting up a similar digital composition compared to the composition in the reference image, as displayed in Figure 14, was used in the next chapter, IV. Lighting Studies. However, the analysis in the next chapter is related to the quality of light created with physical lights and the medium of film as opposed to the lighting illustrated in a painting.
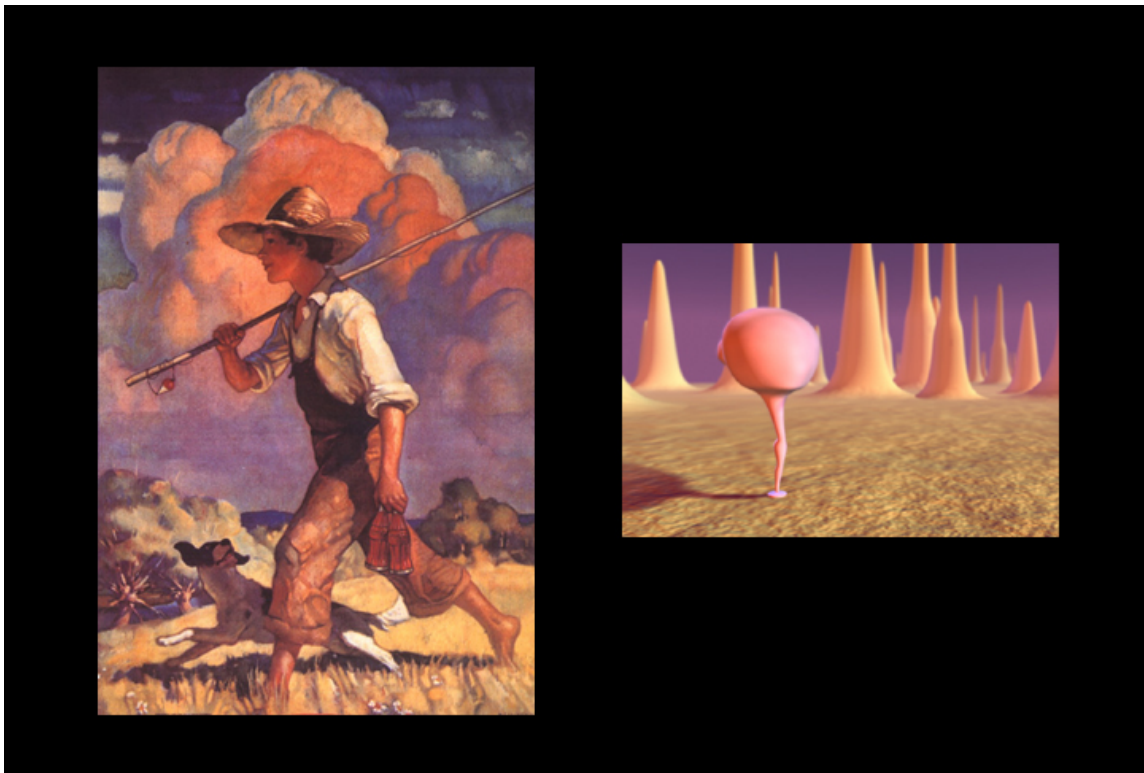
Fig. 14. Hong's interpretation of the lighting in *Wyeth's Boy with Pole* [23].

CHAPTER IV

LIGHTING STUDIES

IV.1.   Overview

In this chapter, the style of each DP is first analyzed based on observing the lighting from various films. Interviews of DPs, their writing and the writing of others provide insight into the lighting qualities that defined their styles. Also, factors influencing the DPs' consistent, varied, or discontinued use of their lighting styles are addressed.

The lighting setup and quality in each reference still image for each DP is analyzed. Also, the way the lighting influences the storyline is discussed. A digital lighting study created from the analysis of the DPs' lighting style and still reference is displayed. The approach to setting up the lights, materials, and compositing for the final image for each DP is explained.

IV.2.   Lighting study for Conrad Hall, ASC

Conrad Hall received an Oscar nomination for best achievement in cinematography in 1975 for *Day of the Locust* [2]. In this study, Hall's distinct naturalistic style displayed in Figure 15 from *Day of the Locust* was analyzed and recreated digitally [24].

IV.2.1.   Analysis

Desaturating color was one way Hall achieved his naturalistic style. Hall related desaturating color to achieving a more naturalistic sense of reality by observing "the muting of color that goes on in life". Hall explained that instead of seeing light in primary forms of color he always observed the atmosphere of haze, smog, fog, or dust that existed between color

Fig. 15. A still image from *Day of the Locust*, shot by Conrad Hall, ASC [24].

and him [2]. The desaturation of color and the dusty atmosphere in the room is evident in Figure 15.

Specifically, Hall desaturated blue skies. Hall expressed his concern with the saturation of blue skies when he stated, "Blue skies are something that I have trouble dealing with. Blue is a tough color for me; I don't know why. It's probably because the sky is something that we understand so well visually and when it's not quite right, it's offensive to you [2]." Hall appears to have chosen daylight-balanced film because the blue sky is white in Figure 15 [20].

Road to Perdition shot by Hall in 2002 exhibits the same stylistic elements seen in *Day of the Locust*, shot 27 years prior. Desaturated colors are seen through the dusty atmosphere of Figure 16, a still image from *Road to Perdition* [25]. This figure also displays Hall's trademark use of desaturated blue skies.

Hall used his naturalistic style with several film directors throughout his career. In *Perdition*, Hall convinced director Sam Mendes to photograph the film with a naturalistic

Fig. 16. A still image from *Road to Perdition*, shot by Conrad Hall, ASC [25].

approach as opposed to a stylistic approach. Hall explained why his naturalistic approached worked for *Perdition* when he stated, "It's a sort of honest reality that doesn't try to be theatrical in any way. There is no blue moonlight, no green vistas, none of that kind of stuff [26]." Hall posthumously received an Oscar award for best cinematography for *Perdition*. In *Electra Glide in Blue*, Hall convinced the director to use a muted color palette. Hall explained, "I was trying to sell James Guierico on pastels and he wanted rich color." However, Hall claimed that the film was more saturated than he would have liked [27].

Hall's philosophy of maintaining financial independence allowed him to shoot many of his films in his naturalistic style. Hall chose to direct and shoot commercials not only for financial sustenance but also to provide himself with artistic freedom. Hall explained, "I want to not have to take a picture for any other reason than because I want to. So it's good to be financially stable or even independent so you can do what you want to do [2]."

Hall lit *Day of the Locust* with a romantic approach to naturalistic lighting even though the story is about the failure of people trying to make it in Hollywood. According to Hall, he chose to romanticize the lighting based on the lack of success of his previous work *Fat City*, shot in 1972 [2]. A still frame from *Fat City* is shown in Figure 17 [18]. *Fat City* and

Fig. 17. A still image from *Fat City*, shot by Conrad Hall, ASC [18].

Day of the Locust have common storylines about failure and despair. However in *Fat City*, the main characters are boxers trying to win big. Hall appropriately made the lighting very gritty, which meshed well with the seedy town and low-life characters of the story, and also maintained his naturalistic style [28]. While the movie was a box office failure, it was one of his most satisfying films [2].

Hall achieved a romantic look for *Day of the Locust* by choosing a golden color palette. "Now I thought that this was a story that involved everything that was golden, not only the times but the money, the sunsets, the idea of the moth to the flame," explained Hall about the predominance of golden tones in the film. Also, Hall used diffusion to soften the overall image. The result of Hall's romantic approach was visually beautiful compared to *Fat City* and possibly the reason for his Oscar nomination and the film's better reception at the box

office [2].

The reference image for this digital study, Figure 15, is from the last scene in *Day of the Locust* and is very dramatic. The lead actress walks into an empty apartment and sadly realizes her neighbor is gone. The scene is low key, but intense light punctures the room when she opens the door. Delicate surface modeling created by the low key style emphasizes a mysterious mood for the scene while the light cutting through the room adds high contrast and drama. Leaving the actress lit semi-silhouetted with low frontal lighting added to the mysterious and dramatic mood.

From observing the reference image, Hall imitated the effect of the sun using a warm golden upstage key. The position of the key was cheated to create a perfect rim of light around the actress. Also, the key was positioned outside the door and to the left side of the actress in such a way that the shadow cast by the actress was perfectly framed by the shadow cast by the door frame. The shadow of the actress is long and sharp, further revealing that the key was positioned at a low angle and that it was a hard source.

Also from observing the reference image, a warm reddish-purple color was used for fill light. The light coming through the doorway creates a rectangular area of light on the floor that acts as a logical fill source for the room. The closer each object is located to the fill source, the stronger its illumination. The floor is lightest around the edges of the fill source and gradually darker near the corners of the room. Faint and soft shadows cast by objects in the room reveal diffuse light sources were used for additional fill. The furniture on the right and left of the scene casts very soft edged shadows.

IV.2.2.   Synthesis

Setting up lights, adjusting materials' properties, and compositing were steps taken to create Figure 18, a digital lighting study of Hall's naturalistic style. Iterations of adjusting the

Fig. 18. A digital lighting study based on Conrad Hall's naturalistic style.

lights were based on observing differences in the lighting of Hall's original work and the digital study side by side, as displayed in Figure 19.

A desaturated blue was assigned for the sky color. Blue was chosen, as opposed to white, to maintain contrast between the lamp and the background. An intense golden tinted directional light was used for the upstage key. The key was positioned at a low angle to create dramatic shadows from the window, lamp and drafting table similar to the shadows cast by the door frame and actress in the original composition. Ray tracing was used to give the primary shadows sharp edges.

Direct light from the key only hit parts of the lamp, table, and stool that were in front of the window. Additional spot lights were used to augment the coverage of the key and provide an outline around the lamp and on the sides of the table leg and stool similar to the

Fig. 19. A side by side comparison of Hall's work and digital lighting study of a similar
scene [24].

rim around the actress in the reference image. Figure 20 shows the effect of the key and
lights augmenting the key's coverage.

An array of 15 low intensity desaturated purple spot lights was used to fill the floor.
The spotlights were positioned around the ceiling and were oriented approximately at right
angles to the floor. Spot lights were used to create the look that the fill was brightest around
the rectangular area of light on the floor and gradually fell off near the corners of the room.

Six low intensity desaturated golden spot lights were used to fill the walls. Also a
lower intensity brown point light was used to provide flat ambient illumination for the
walls. Additional lights were used to augment the look that the fill was brightest around the
window and fell off into the corners of the room. These included four low intensity warm
purple spot lights used around the base of the window and two arrays of low and negative
intensity spotlights positioned to subtly darken the corners of the room.

Fill for the lamp, drafting table, and stool was achieved in the same way that the fill for
the floor and wall was approached. Objects closest to the rectangular light source, on the
floor, were given more warm and intense fill than objects farther away. The rectangular light
source emanating from the floor also acted as a logical key for the fallen desk, furniture in
the right corner, and objects not lit by direct light from the key. Figure 21 shows the effect
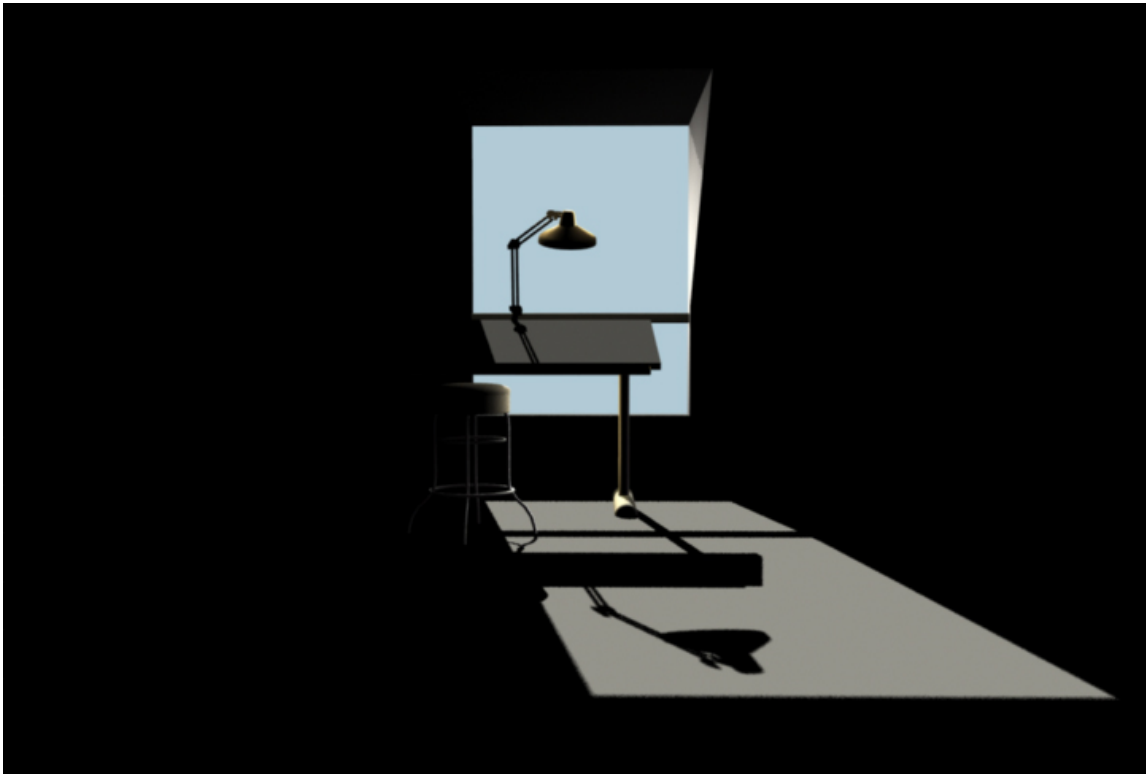
Fig. 20. The effect of the key and lights augmenting the key's coverage from the study for Hall.

Fig. 21. The effect of the fill lights from the study for Hall.

of the fill lights.

Material properties were adjusted to more accurately represent each surfaces' response to light. Materials for each digital object were chosen based on similar real world object materials. Adjustment of the material properties was minimal and no detailed texturing was done. The lamp's material properties were based on the properties of a similar real world lamp that had a lot of surface specularity compared to its diffuse value. In contrast, the wooden furniture was based on the dull wooden furniture in the reference image that had very low and spread specularity but showed a lot of its diffuse value. A whitish-yellow was used as the specular color for the wood material because it is a non-metal material. Non-metal materials have specular highlights that are always the color of the light [5].

Compositing was utilized to provide greater control over the shadows in the image.

Diffuse shadows cast by the furniture on the right of the scene, the fallen desk, and window sill were generated separately from the scene and composited. Also, compositing enabled making the shadow cast by the drafting table darker than the shadow cast by the bar across the width of the window. The drafting table shadow is darker because it is closer to the floor's surface. If the shadows were not composited, the drafting table and window bar shadows would be the same density because they are cast by one key. A soft shadow pass, or ambient occlusion layer, around the baseboard and floor junction was generated. Ambient occlusion creates soft shadows for each surface based on proximity with other nearby geometry. A contact shadow pass for the furniture was also created and composited. All of the shadow passes were composited over the background layer but under the furniture layer. The background layer consisted of only the walls, floor, baseboards, and window sill and bar. The furniture layer only contained the furniture.

In the reference image, the subtle glow around the actress' figure, the window, and the bright area of light hitting the floor is called bloom. The light appears to be spreading out from the bright areas of the image. The bloom effect was added to the digital lighting study after compositing. Bloom was achieved by creating a high contrast, desaturated, and significantly blurred version of the final composited image and adding a percentage of the result back into the final composited image.

IV.3.   Lighting study for Gregg Toland, ASC

Gregg Toland, called "Hollywood's greatest cameraman" by his contemporaries and successors, was the Director of Photography for *Citizen Kane* [29]. Figure 22 is from *Citizen Kane* which Toland received an Oscar nomination for best cinematography in 1941 [30]. Toland's contribution to Kane is evident in the display of Orson Welles', the director, and Toland's names on the same title card in the credits. Director John Ford also recognized

Fig. 22. A still image from *Citizen Kane*, shot by Gregg Toland, ASC [30].

Toland in the same manner for *The Long Voyage Home* which was Oscar nominated for best cinematography in 1940 [31]. Toland's dramatic style, displayed in Figure 22 from *Kane*, was analyzed and recreated digitally.

IV.3.1.   Analysis

Toland's dramatic lighting style has been described as high in contrast, having broad sweeps of light and dark, and remarkable tonal separation between the foreground and background [32]. Toland's dramatic style is exhibited in scenes from *Wuthering Heights* (1939), *The Grapes of Wrath* (1940), *The Long Voyage Home* (1940) as well as *Citizen Kane* (1941). The seriousness of the films' subject matter provided Toland with the opportunity to use
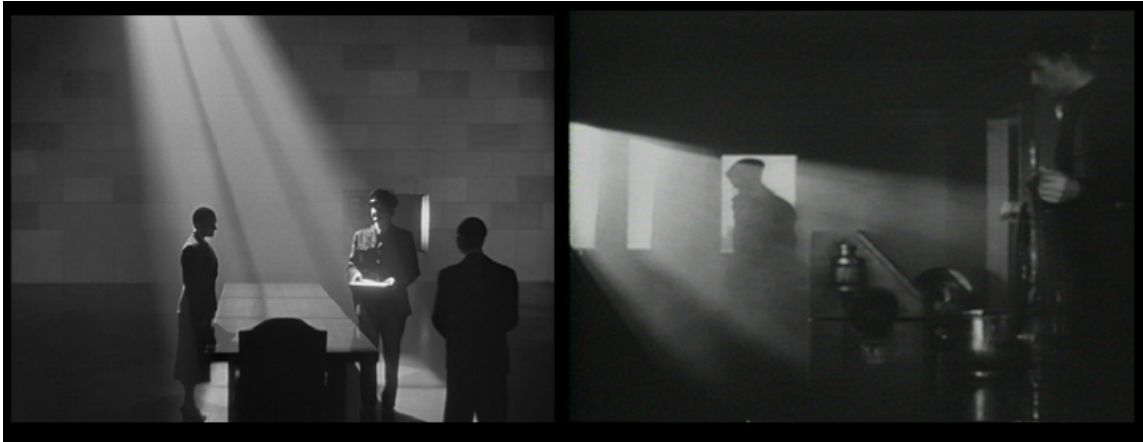
Fig. 23. Still images from *Citizen Kane* and *The Long Voyage Home* [30], [33].

dramatic lighting, although the treatment of each film varied based on the story. The scope of the story of *Citizen Kane*, about a larger than life newspaper tycoon, demanded photography with startling effects [32]. While *The Grapes of Wrath* had some extreme effects in low key, recreating the despair of the great depression required eliminating any atmospheric treatments. Toland decided that a more realistic lighting approach was appropriate for *The Grapes of Wrath* [29].

Figure 23 displays Toland's dramatic style used in *Citizen Kane* and *The Long Voyage Home* [30], [33]. Low key lighting with intense shafts of light illuminating foggy atmospheres, silhouettes, and a high contrast or coarse lighting balance are stylistic elements used in scenes from both films. Toland's atmospheric treatment is attention grabbing. At the same time, detail is visible where Toland judiciously used fill light.

Toland's career work is not defined only by his dramatic lighting style. None of his earlier work stood out in any way from other competent Hollywood cameramen [32]. Toland became intent on breaking away from the 'studio look' created with diffuse lighting and shallow depth of field that was typical in the 1930's [31]. In *I Broke the Rules in "Citizen Kane"*, Toland stated, "the day of highly stylized cinematography is passing, and is being

superseded by a candid, realistic technique and individual approach to each new film subject [34]." Toland's experience as a photographer during World War II, after *Kane*, exposed him to uncontrived lighting conditions which he thought were better than the 'ideal' conditions of the studio. For *The Best Years of Our Lives* in 1946, Toland changed his style radically to using high key lighting that he described as more realistic and honest. Toland died at the age of 44, in 1948, only seven years after he shot *Kane* [32].

Toland's lighting technique for *Kane* was affected by unconventional camera and set innovations. Toland was able to achieve greater depth, or sharp focus maintained over a far depth for a camera shot, than ever before with his masterful use of deep focus photography. More light was employed to accommodate a minimized aperture required for deep focus. Toland used twin-arc broadside lamps which were developed in the 1930s and were more powerful than the conventionally used soft incandescent lights [31]. Powerful lights were also necessary because ceilings, used to enhance the realism of the set, eliminated overhead rigged lighting. Toland explained in *I Broke the Rules in "Citizen Kane"* how ceilinged sets, which were not conventionally used, made the lighting more realistic because it did not come from unnatural angles [34].

Toland's use of the latest developments in film and lenses to compensate for a minimized aperture used for deep focus also affected his lighting technique. Toland utilized the Super XX Eastman Kodak film stock introduced in 1938 which was four times faster than Super X. In addition, lens efficiency was increased using the Vard "Opticoating" system, introduced in 1939, which eliminated lens refraction and permitted light to penetrate instead of scatter [31], [34]. In *Realism for Citizen Kane*, Toland stated, "The fast film tends to flatten contrast; but the coated lenses and reduced apertures both tend to increase contrast. As a result, one must light scenes made in this manner with much less contrast than would be customary under more normal circumstances [35]."

In the reference image for this study, Figure 22, the seriousness of the action is rein-

forced by the lighting to create a somber and mysterious mood. Thompson, a journalist, enters a secured room in the Thatcher library seeking to read a manuscript stored in a vault. The librarian, on the left of the screen, and guard are very strict. The room is lit in a low to very low key lighting style. Extreme depth is achieved by silhouetting Thompson in the foreground and semi-silhouetting the librarian in the middle ground against the illuminated back wall. Scene elements are lit more brightly in the background than the foreground creating the illusion of depth. In *Citizen Kane*, Thompson's character is never developed and it is not important that he is well lit. The same follows for the librarian and guard. The librarian and guard are lit by light streaming through a window from above. The shadows cast by the mullions of the window onto the fog, table, and floor create vertical bars that are reminiscent of a jail cell.

In the reference image, an intense key from above casts hard light on the librarian, guard, table, and floor. The shadows cast by the mullions, librarian, guard, and table are sharp and clear cut. The cell-like throw pattern suspends the viewers' disbelief that a window in the ceiling exists. Possibly a window frame was used to simulate the existence of a real window. The shortness of the shadows cast by the librarian, guard, and table, as well as the shaft of light created by the key streaming through fog are clear indicators that the key was positioned at a very high angle. Also, the direction of the shadows indicate that the key was positioned similar to a back light. The key creates a rim of light around the silhouetted librarian on the left. The key also provides side lighting for the guard in the middle.

Thompson, the librarian, and the guard receive the most fill light when faced toward the beam from the key light. Their faces receive fill from the reflective table and the floor below. The fill levels of the librarian and guard increase when they walk behind the shaft of light. Also, the foggy atmosphere brings up the ambient lighting in the dark room. The back wall has been lit spottily by off screen sources. The fill for the back wall must have

been a powerful hard light because the guard casts a sharp shadow as he walks back to the vault. The floor has been left relatively dark.

IV.3.2.   Synthesis

A digital lighting study of Toland's dramatic style is displayed in Figure 24. Figure 25 shows that the digital scene was set up based closely on the original composition. The effect of the key light was created with several lights. An intense spotlight was used as the key light to cast the main illumination for the two characters representing the librarian and guard. To represent the shape and shadows of the window cast onto the table and floor, barn doors shaped the key into a rectangle, and a sharp edged grid pattern was projected by the key. Barn doors confine physical and digital lights with up to four sides to possibly shape the light into a box. The grid pattern was produced by spatially varying the intensity of the key.

Four additional spotlights emitting fog were used to create the look of the beam of light itself. The color, brightness, decay, and beam angle are all controllable attributes of the fog for these spotlights. A ramp with sharp dark gray bars was projected by one of the fog lights to create the look of the vertical bars cast by the mullions of the window. The ramp was produced by spatially varying the intensity of the fog light. Using four fog lights allowed for layering of the fog to create a thick but feathered edged beam similar to the original beam.

The librarian character is backlit by the key light and fog lights. Two additional intense spotlights were used to create a more defined rim around the character. Also, an additional intense spotlight was used to augment the coverage of the side lighting received by the guard character in the middle. Hard depth map shadows were cast by the key and the fog lights. The key light cast hard shadows created by the left character and table. Also the fog

Fig. 24. A digital lighting study based on Toland's dramatic style.

Fig. 25. A side by side comparison of Toland's work and digital lighting study of a similar scene [30].

Fig. 26. The effect of the lights representing the key's coverage from the study for Toland.

lights cast subtle shadows of the characters onto the fog. Figure 26 shows the effect of the key, fog lights creating the beam of light, and lights augmenting the key's coverage.

Toland's dramatic high contrast lighting style called for the use of subtle fill lighting. Each of the three characters received fill from two to three low intensity spotlights positioned under each of their faces. Also, all of the bodies of the characters were filled from the front with one low intensity spotlight each. The character in the foreground, table, and chair received less intense frontal fill than the characters in the path of the beam. Positioning the left and middle characters behind the beam of light increased their level of fill illumination. Very low intensity environmental fog lights were used to fill the room with fog, raise the ambient lighting, and unsharpen the image. The wall was lit with five low intensity spot lights to recreate the spotty look of the fill in the original lighting setup. A

Fig. 27. The effect of the fill lights from the study for Toland.

very low intensity point light was used to provide flat ambient illumination for the wall. The items in the vault received the same wall fill in addition to fill from the fog. Fill for the floor was created with five very low intensity point lights positioned around the area of the floor. Figure 27 shows the effect of the fill lights.

Applying simple textures and adjusting material properties provided better matching of digital elements with the original composition. The bodies of the characters had no specularity, but their heads had low level spread specularity to better represent the skin's response to light. The table was textured with a wood pattern. The wall was textured with a brick pattern and was given a low level spread specularity to represent the marble material in the original image. The floor was textured with a grey checkered pattern. The floor was also made more reflective near the junction of the wall and floor and less reflective away

from the wall. Also a bump map was applied to the floor to allow light to break up its large monotone surface and reveal some of the checker texture.

Compositing reflections and shadows allowed more control over the final image. A reflection of the left and middle characters in the table was generated and composited on top of the main layer containing the table. The main layer included the furniture, characters, and fog. The shadows cast by the throw pattern and character on the left were generated separately and composited on top of the main layer. The reflection of the vault door was generated and composited over the floor layer but under the main layer. Also the back wall and vault comprised a separate layer that was blurred to better match the slight loss of depth of the camera in the original composition.

IV.4.   Lighting study for Zhao Fei

Zhao Fei was the Director of Photography for *Raise the Red Lantern*. A still image from this film is displayed in Figure 28 [36]. Fei's unique style for the film was recognized by directors Woody Allen and Chen Kaige which lead to his employment for their respective films, *Sweet and Lowdown* and *The Emperor and the Assassin* [37], [38]. Saturated color, contrasting complimentary hues, and colored diffused fog are stylistic elements exhibited in Fei's films. Fei's saturated style shown in Figure 28, and other images from the same scene, will be analyzed and recreated digitally.

IV.4.1.   Analysis

Fei used contrasting complimentary saturated colors to create surrealistic atmospheres for 1920s China in *Raise the Red Lantern* and third century BC China in *The Emperor and the Assassin* [37]. Fei created these atmospheres with the practical light that would have been used during the time period and setting of each film. Figure 29 displays an exterior
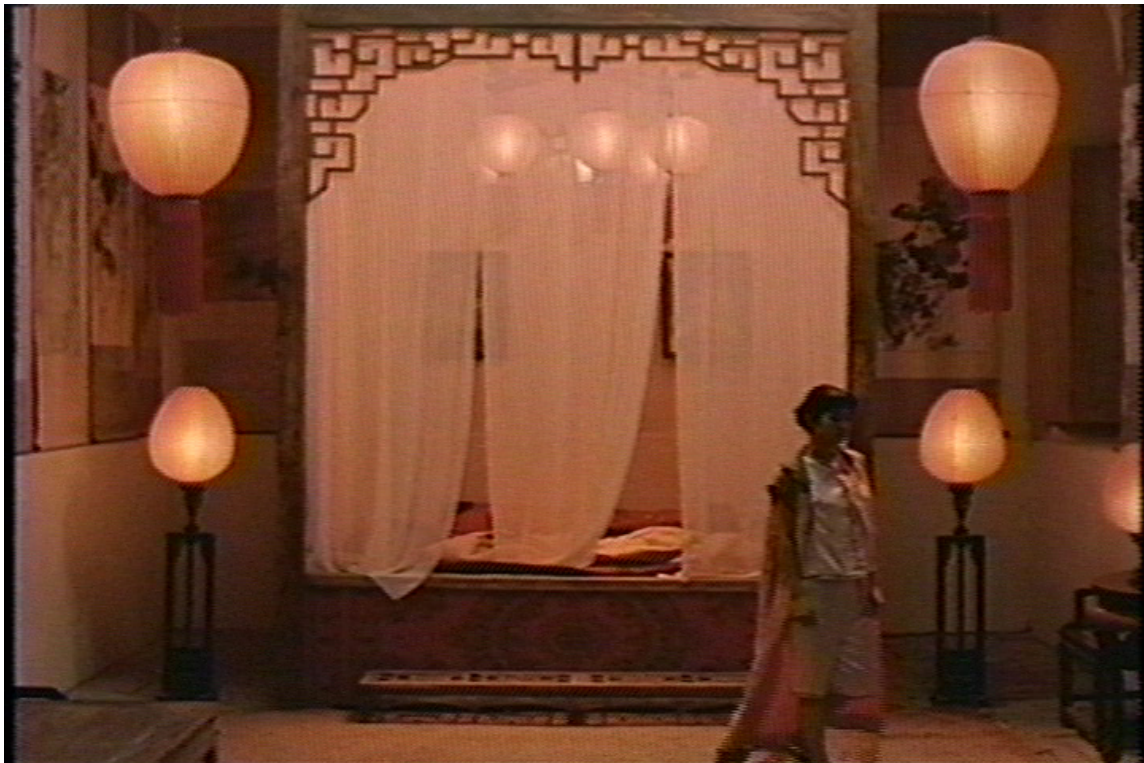
Fig. 28. A still image from *Raise the Red Lantern*, shot by Zhao Fei [36].

Fig. 29. Contrasting complimentary orange and blue hues from *Raise the Red Lantern* [36].

scene from *Raise the Red Lantern* using colored lanterns lit, in theory, by candles. Warm saturated reddish-orange lanterns illuminate the scene against a cool saturated blue tinted exterior. Figure 30 and Figure 31 are images from *The Emperor and the Assassin* [39]. Warm orangeish-yellow light from a believable practical fire light source contrasts with the blue sky in Figure 30. Also, warm yellow candle light lines the hall in Figure 31 and contrasts with purple fog. In both films, Fei's lighting style creates surreal atmospheres that suit the grandiose architecture.

Fei created warm and cold atmospheres for *The Emperor and the Assassin* with saturated colored lighting. Fei achieved a saturated look by working with the costume and set dressing designers as opposed to using colored filters. Fei stated, "I cannot achieve that kind of color with filters, so I rarely use them." Instead, Fei created soft glowing colored

Fig. 30. A still image from *The Emperor and the Assassin*, shot by Zhao Fei [39].

Fig. 31. Contrasting complimentary yellow and purple hues from *The Emperor and the Assassin* [39].

Fig. 32. Warm amber lighting from *The Emperor and the Assassin* [39].

light using thin white paper over glass windows in front of tungsten or other tinted lights [38]. Figure 32 displays the warm amber lighting of Lady Zhao's chambers. Figure 33 shows the same scene cast in cold blue lighting with Lady Zhao wearing a purple robe. Fei explained his use of cool lighting for the scene by stating, "Lady Zhao is homesick, and we wanted to evoke that in the lighting design [37]."

Fei also used similar stylistic elements, but to a lesser extent, to create naturalistic atmospheres for 1930s Chicago jazz clubs in *Sweet and Lowdown*. The fog in Figure 31 and Figure 34 is the same color purple and has the same density [40]. However, the fog used in *Sweet and Lowdown* only covers a small portion of the back of the room as opposed to most of the scene. The purple fog contrasts in brightness and color to the dark warm tungsten lit room. Interestingly, red lanterns were used in this scene but perhaps only by choice of the production designer and not Fei. The lanterns contribute no apparent effect to the lighting of the scene unlike the bright spots of soft lighting in images from *Raise the Red Lantern*.

Fig. 33. Cold blue lighting for the same scene [39].

Fig. 34. A still image from *Sweet and Lowdown*, shot by Zhao Fei [40].

After talks with the director Woody Allen, Fei applied a naturalistic lighting treatment to *Sweet and Lowdown* as opposed to a more saturated look [37]. Scenes from Allen's films have been characterized as generally bright and well illuminated. Fei described Allen's preferences stating, "I know he is very particular about his light and color. He favors soft and warm lighting; he doesn't prefer cold. He likes [the lighting] very subtle [41]."

The reference images for this study, Figure 28 and Figure 35, show an intimate scene that takes place on a wedding night [36]. The lighting effectively creates a mood of intimacy. The whole room appears orange, tinted by reddish-orange lanterns that brighten the room with warm soft lighting. The bright lanterns contrast with the dark room and add visual appeal. Figure 35 is from a wide camera shot. This composition makes the subject appear like a new gift and reinforces the storyline of her objectification. The selective focus of the lighting and her satin orange gown make her almost the brightest element in the scene, second to the lanterns. The light also directs the attention of the viewer toward the bed structure. The camera angle frames the symmetry of the architecture and interior elements with her in the center.

The warm orange cluster of lanterns, directly above the bed, act as the key providing the brightest illumination in the scene for the interior of the bed structure. Fei appears to have augmented the coverage of these lanterns with another warm orange light positioned overhead and in front of the bed structure. This additional key illuminates the bride, bed structure, elongated foot stool, and floor. This is apparent from the orange spill in front of the bed structure. The foot stool casts a hard shadow because it is close to the floor.

Warm orange soft light from the lanterns provided fill for the room. Lighting from the lanterns fill the dark corners of the room with orange. The lanterns positioned around the room also provide fill for the furniture. The foreground seems to have been filled with additional and less saturated lights positioned above, in front, and to the right and left sides of the camera. An indicator of this is the angle of the slight hard shadow cast onto the left
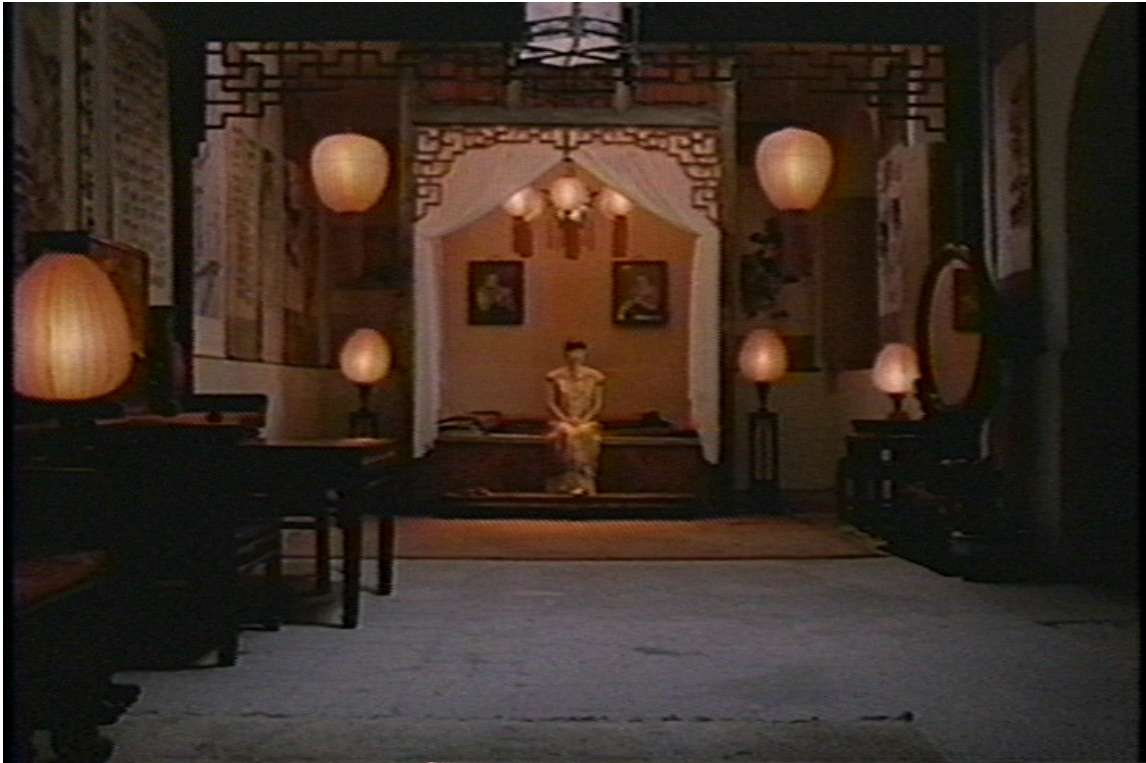
Fig. 35. A second reference image from *Raise the Red Lantern* [36].

Fig. 36. A digital lighting study based on Fei's saturated color lighting style.

wall by the lantern and stand on the left of the screen in the reference image.

IV.4.2.   Synthesis

Figure 36 is a digital lighting study based on Fei's saturated style displayed in *Raise the Red Lantern*. The composition of the study is symmetrically arranged similar to the reference image as shown in Figure 37. The cluster of lanterns above the bed structure acted as the practical key for the scene. The lanterns were modeled and textured similarly to the lanterns in the reference image and illuminated by intense white spherical volume lights. The volume lights, placed inside of the lanterns' geometry, only illuminate the volume within their boundaries. The translucency of the lanterns' material made the volume light visible. The lanterns above the bed structure were lit more brightly than the other lanterns

Fig. 37. A side by side comparison of Fei's work and digital lighting study of a similar scene [36].

around the room. The exterior of each lantern was also lit with two orange soft spotlights.

A soft orange spotlight was used as the key for the scene. It was positioned at a high angle above the lanterns and cast light on the back wall, interiors of the columns, baseboards, drafting table, lamp, and floor. Two additional less intense orange spotlights were used to extend the coverage of the key onto more of the lamp and the stool.

The overhead lighting created by the key, cast shadows directly beneath the furniture. Ray tracing was used to create soft and spread shadows. The shadows cast by the lamp and stool were made larger than normal by creating a duplicate of the geometry, scaling, turning off the primary visibilities, and having the invisible geometry cast shadows. Enlarging the shadows was a personal artistic choice independent from the reference image.

Additional lights were used to augment the coverage of the key for the interior columns, back wall, floor, and ceiling. Two less intense orange spotlights were positioned similarly to the key but illuminated the interior of the columns. An intense saturated orange spotlight created the brightest spot on the back wall with frontal lighting from a position perpendicular to the back wall. Ten subtle orange frontal spotlights were used to create the effect of the fall off of the bright area of light created by, in theory, the cluster of lanterns. The spotlights

Fig. 38. The effect of the key and lights augmenting the key's coverage from the study for Fei.

were given lower intensity the further they were from the lanterns. The same treatment was applied to the interior of the columns, floor, and ceiling of the room. Figure 38 shows the effect of the key and lights augmenting the key's coverage.

Six saturated orange spotlights were used to create the subtle spotty fill cast by, in theory, the other lanterns around the scene onto the columns and walls of the corners of the room. Twelve lower intensity orange spotlights were used to fill the walls and baseboards of each dark corner without spilling into the center of the scene. Two low intensity orange spotlights were used to fill in the floor of the corners. All of the spotlights were placed perpendicularly to the surface they illuminated.

Two more intense and less saturated orange spotlights were used as the main fill for the foreground of the side walls and floor. Each fill light was placed at a high angle and at

a distance far from each wall for maximum coverage. The fill lights for the left and right walls cast soft shadows of the left and right column structures onto each respective wall as well as the floor. The fill light used for the left wall cast a soft edged shadow of the standing lantern onto the left wall.

Fill lighting for the lamp, drafting table, and stool was created with low intensity orange tinted frontal spotlights. Subtle orange tinted spotlights from the side and below were used as additional fill for the lamp. The legs of the drafting table were additionally filled more brightly near the ground than closer to the table top. The table in the foreground was lit with a saturated orange spotlight originating from the cluster of lanterns in the center. Additional less intense and saturated spotlights were used to fill the top and side of the table. The chair on the right of the scene was lit with three saturated orange spotlights originating from the cluster of lanterns. Figure 39 shows the effect of the fill lights.

Simple textures, compositing, and a bloom filter were also used to create the final image. All of the furniture, except for the lantern stands were assigned orange colored materials that had low and spread specularity. The lantern stands, walls, and floor of the scene had a matte material with no specularity.

The scene was composited with several layers. The base layer consisted of the structure of the room itself. A soft shadow pass, or ambient occlusion layer, around the baseboard and floor junction was generated. Contact shadows and shadows cast by the furniture were generated as a layer. All of the shadow passes were composited on top of the room layer. The furniture comprised a separate layer and was composited on top of the shadow layers. Also, a reflection of a lantern onto the foreground table was generated, blurred, and composited on top of the furniture layer. A percentage of a high contrast, desaturated, and significantly blurred version of the final composited image was added back into the original final composited image to create a bloom effect.

Fig. 39. The effect of the fill lights from the study for Fei.

CHAPTER V

FINAL ANIMATION

V.1.   Overview

A warehouse interior was modeled and textured as the setting of the final lighting animation. Three lighting setups representative of the styles of Toland, Hall, and Fei were created and viewed from a stationary camera position. The light is animated within each setup and lighting dissolves were created to make transitions between each lighting setup. Information about the animation is found in the Appendix.

V.2.   Lighting for Gregg Toland, ASC

The digital lighting setup representative of Toland's dramatic style, displayed in Figure 40 and Figure 41, was inspired by Figure 42 from *The Long Voyage Home* [33]. Several lights were used to create the effect of the key, similar to the scene study done previously for Toland. Two hard intense fog emitting spotlights were animated together to sweep back and forth through the room. The lights were positioned outside and to the left of the room and cast dramatic shadows. These lights were animated by rotating them about the center of the room. A 3D cloud texture was placed on the density of the fog of one of the lights and its position was slowly animated to create the effect of fog drifting in the room. A third soft intense spotlight was placed and animated similarly to the two other key lights to create bright illumination in and around the dramatic shadows cast by the two other key lights. Barn doors were used to shape the third key light.

Additional spotlights were used to augment the effect of the key light. Three soft intense spotlights were used to create bright rims of light around the barrels close to the

Fig. 40. Digital lighting representative of Toland's style from the final animation.

Fig. 41. The key lights were animated to create a sweeping effect.

Fig. 42. A still image from *The Long Voyage Home* [33].

left wall. The lights were positioned behind the stacks of barrels. A soft intense spotlight was used to increase the illumination on the left window sill and positioned above it. A soft intense spotlight positioned outside and behind the back wall was used to create a rim on the window sills of the back wall. Three additional soft spotlights were used to create rim lighting on the right columns and were positioned behind and to the left of the right columns. The intensities of the lights increased for the columns closer to the foreground.

Fill light was done subtly as in the scene study for Toland. A low intensity environmental fog light was used to compliment the fog emitted from the key lights and increase the fill illumination in the room. The back wall was lit with two soft subtle spotlights positioned from the front. The columns on the right wall received less frontal fill the closer they were to the foreground. Also, as the key light sweeps in towards the right wall, the intensities of additional spotlights were animated to fade in and illuminate the barrels in the right corner and parts of the back and right walls. The ceiling bars were filled from below and more intensely closer towards the right side of the room. The left wall was left unfilled.

V.3.   Lighting for Conrad Hall, ASC

The digital lighting setup representative of Hall's naturalistic style, displayed in Figure 43 and Figure 44, was inspired by Figure 45 from *Road to Perdition* [25]. An intense white soft spotlight was used as the key and positioned outside and to the right of the scene to act as light coming through a window on the right of the room. A spotlight with similar attributes and position shaped by barn doors was used to augment the effect of the key, by casting a rectangular shape onto the left wall. Several additional soft spotlights were used to fill the back wall. Their intensities were higher the closer their positions were to the key.

A low intensity white environmental fog light was used to increase the fill illumination in the room. Also soft desaturated blue spotlights were used to fill the dark areas of the room

Fig. 43. Digital lighting representative of Hall's style from the final animation.

Fig. 44. The lamp turns on to illuminate the dark foreground.

Fig. 45. A still image from *Road to Perdition* [25].

not covered by the area affected by the key. Several white soft spotlights were used to fill the ceiling. Their intensities were higher near the center of ceiling and key. The barrels in the scene were filled using low intensity desaturated blue soft spotlights.

The lamp in the foreground turns on in this lighting setup. All of the intensities of the lights representing the effect of the lamp were faded in. An intense desaturated yellow spotlight originating from the lamp illuminates the dark foreground. The barrels receive light from above from the direction of the lamp and cast slightly sharp shadows. A non-shadow casting light was positioned inside of the lamp to light the interior of the lamp when it turns on.

V.4. Lighting for Zhao Fei

The digital lighting setup representative of Fei's saturated style, displayed in Figure 46 and Figure 47, was inspired by Figure 48 from *Raise the Red Lantern* [36]. A saturated intense cool blue spotlight was used for the key and was placed outside and to the left of the scene. The key creates dramatic lighting on the floor. However, for compositional purposes, the columns and window frames of the left wall do not cast shadows. A spotlight with similar attributes and position, shaped with barn doors, was used to augment the coverage of the key for the right wall. Five additional spotlights, slightly more intense and saturated were used to increase the illumination of the window sills of the left wall. These lights were positioned at various angles outside and to the left of the interior.

A low intensity blue environmental fog light was used to increase the fill illumination in the room. Three soft blue and low intensity spotlights were used to fill the shadow areas of the floor from various positions directly above. Three other similar spotlights were used to fill each group of barrels from an angle below the camera. Intense orange spotlights were used to fill the window sills of the back wall and act as spill from the light coming from

Fig. 46. Digital lighting representative of Fei's style from the final animation.
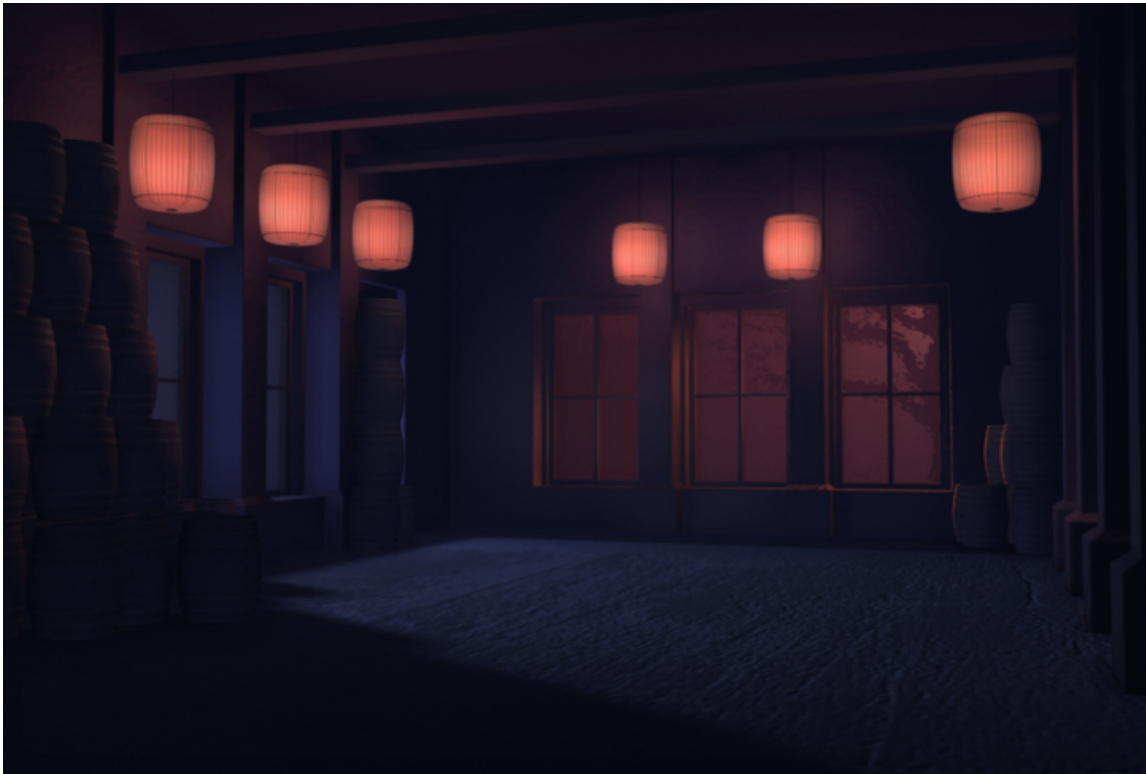
Fig. 47. The intensities of the lights representing the lanterns' illumination were animated.

Fig. 48. A still image from *Raise the Red Lantern* [36].

outside and through the orange tinted glass.

The illumination of orange lanterns hanging around the perimeter of the room was faded in by animating the intensity of the lights representative of the effect of the lanterns. The same approach to lighting the lanterns was achieved as in the lighting study for Fei. The lanterns were illuminated by intense white spherical volume lights. The exterior of each lantern was also lit with two orange soft spotlights. Soft intense orangish-red spotlights were used to illuminate the walls close to the lanterns. The groups of barrels were lit with similar bright red spotlights positioned from above, to appear as if they were lit by the lanterns. All of these lights' intensities were faded in to make it appear that the lanterns were turning on.

CHAPTER VI

CONCLUSIONS AND FUTURE WORK

VI.1.   Conclusions

An animation lit in three distinctly different styles was created by understanding approaches and philosophies of three Directors of Photography. Each lighting setup for the animation was achieved by following the specific lighting principles and consistent approaches that define each DPs' style. Digital lighting studies were created to aid in understanding and expediting the process of recreating each DPs' lighting style for the final animation.

The desired goal of successfully translating traditional cinematic lighting into the digital realm was accomplished. In the animation, three styles of lighting transform the scene into recognizable styles of each DP. Mistakes made in the lighting studies phase allowed for better lighting setups to be achieved for the final lighting animation. Although almost none of the lighting setups from the lighting studies were reused for the lighting setups for the final animation, the process of matching the lighting style of each DP was learned. Also, the scene for the final lighting animation was not strictly compositionally tied to a reference image which allowed independent lighting choices to be made.

VI.2.   Future work

Varied future digital lighting research projects can be explored. The changes in light during the day in a specific place could be observed, recorded, and recreated digitally. This project would have the benefit of matching various lighting setups based on very good reference material.

Another digital lighting research project could be to digitally recreate the lighting

styles of Directors of Photography similar to this research project except global illumination techniques would be utilized instead of just using basic digital lights.

For a more technical approach, research into producing better digital lights based on the various physical lights used by DPs would be useful. As illustrated in Chapter IV and Chapter V, several digital lights were often needed to create the look of one physical light. Recognizing the shortfalls of the current digital spot, directional, and point lights versus real physical lights would provide a good starting point to creating new digital lights.

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APPENDIX

A downloadable animation accompanies Chapter V. In the animation, the light is animated differently within three different lighting styles. The lighting styles are representative of the styles of Gregg Toland, Conrad Hall, and Zhao Fei. The animation is 48 seconds, in MPEG format, and approximately 47 MB.

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