STORYTELLING THROUGH LIGHTING

A Computer Graphics Perspective

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ABSTRACT

This course is designed as a beginning, non-technical course to discuss the how lighting in computer graphics can be used to enhance visual storytelling for cinematic purposes. It collects knowledge and principles from the disciplines of design, fine art, photography, illustration, cinematography and the psychology of visual perception. Although much of the content of this course is not solely applicable to lighting on the computer, its special needs are always in mind.

1. Introduction

The desire to write these notes and to present a course on lighting for storytelling in computer animation arose from the shortage of available literature on the subject. Frequently I am asked to recommend a book or two on lighting, and although several good books are available, none are ideal. Most tend to focus on the equipment and mechanics of live-action lighting without explaining how to achieve the fundamental principles. The commonality between live-action lighting and computer lighting is chiefly the thought process, not the equipment. Computer tools vary with implementation, are continually evolving, and are not limited by physics. Tools in the future will be driven by the desire to see on the screen what we are able to visualize in our minds. This course is designed to focus on these thought processes, while providing not only practical information, but also the desire and resources to continue exploring.

The use of words alone is inadequate to describe visual concepts. Most books include many repetitive visual examples to drive the point home. Although a few crude visual examples are included in these notes, they are merely intended to serve as a reminder of the presentation of this course. These notes are also necessarily succinct, and may contain concepts which could not fit into the hour-and-a-half time allotment.

The term *lighting* in computer animation often includes the task of describing the surface characteristics of objects (often referred to as shaders), as well as compositing and the integration of special effects. For the purposes of this course, lighting is defined more in live-action terms as the design and placement of the lights themselves, but in a purely computer graphics environment.

Visual storytelling is a vast topic that reaches far beyond the realm of lighting. Most of it is not noticeable on a conscious level to the viewer, but adds depth and richness to the story and the visual experience. The lighting principles and techniques presented in this course are discussed in isolation from other visual storytelling devices. Ideally the lighting would be designed with these in mind, but would extend far beyond the scope of this course.

Cinematic lighting literature typically emphasizes live-action lighting issues and techniques, and in this discussion of lighting for synthetic cinema we will find that many live-action concepts apply. However, there are some differences in the approach, roles and responsibilities, the size of the crew, and the sequence in which tasks are accomplished.

In live-action, the lighting design, the staging, and framing of a shot are a collaborative and simultaneous effort between the director and cinematographer. Each activity affects the other, and it is important that they are fine-tuned together. Actors can rehearse the scene, staging and framing can be altered, and props can be redressed to take best advantage of the lighting design. This differs from the pipeline approach often employed in synthetic cinema, where the modeling, surface design, staging, framing, set dressing, and acting are accomplished sequentially, each usually established before the lighting designer begins to work. It should be kept in mind that the sooner in the production process the lighting can be designed, the more involved it can be in the storytelling process.

Another important difference between live-action and synthetic lighting can be the role of the art director. In live-action, the art director is absorbed in designing sets and props and is not usually involved in staging, framing, and lighting design. On the other hand, computer generated animation has a more stylized, illustrative quality, with its roots more in hand-drawn animation than live-action cinema. In addition to designing sets and props, the art director is also often heavily involved in the staging (layout) and lighting decisions. With the director, the art director is often responsible for determining the lighting style for individual sequences as well as the film as a whole.

2. Objectives of Lighting

The primary purpose of cinematic lighting is storytelling. The director is the storyteller and it is his vision that the lighting designer is attempting to reveal. To that end, it is important to understand the story-point behind each shot, and how it relates to the story as a whole. It is not enough that the lighting designer simply illuminate the scene so the viewer can see what is happening, or to make it look pretty. It is the lighting designer's task to captivate the audience by emphasizing the action and setting the mood.

The following six lighting objectives are important fundamentals of good lighting design. They also break down the thought process into a good course outline. They are borrowed and adapted from the book *Matters of Light and Depth*, by Ross Lowell.

- Directing the viewer's eye
- Enhancing mood, atmosphere and drama
- Creating depth
- Conveying time of day and season
- Revealing character personality and situation
- Complementing composition

3. Directing the Viewer's Eye—The Study of Composition

The primary objective of good lighting is to show the viewer where to look. Shots are often on-screen only briefly, which means the storytelling effectiveness of a shot often depends upon how well, and how quickly, the viewer's eye is led to the key story elements.

Learning to direct the viewer's eye is essentially the study of *composition*. Composition is a term which is used to collectively describe a group of related visual principles. These principles are the criterion employed to evaluate the effectiveness of an image. They are not rules to be followed, but define a structure by which to explore creative possibilities. They de- scribe a visual vocabulary, and provide meth- ods for breaking down a complex image into manageable characteristics for subjective analysis. Besides being of interest to artists, these principles are also an important aspect of visual perception and cognitive psychology research.

The seemingly simple act of placing lights can radically change the composition and focal point of a shot. Good lighting can make a well-com-

posed image stunning. It can also help rescue a less-than-perfect composition. The principles of composition are the tools with which the lighting designer can analyze a scene to devise ways to accentuate what is working and to minimize what is not. They are effective in both static or moving scenes. Pauses in camera moves and character poses are perfect opportunities to evaluate a kinetic composition using static techniques.

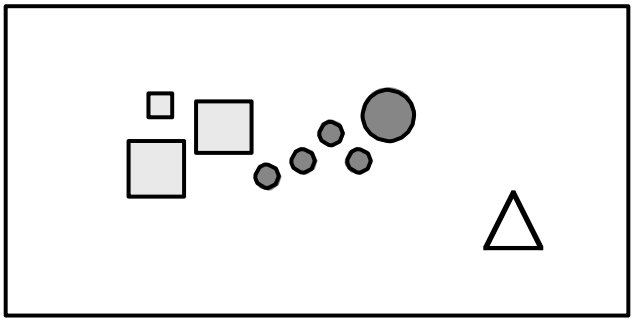
Rather than simply referring the reader at this point to consult a book on composition, a brief discussion of the primary principles needed to the lighting designer are presented here. Although each principle relates to the others, they are presented in isolation for clarity.

3.1 Unity/Harmony

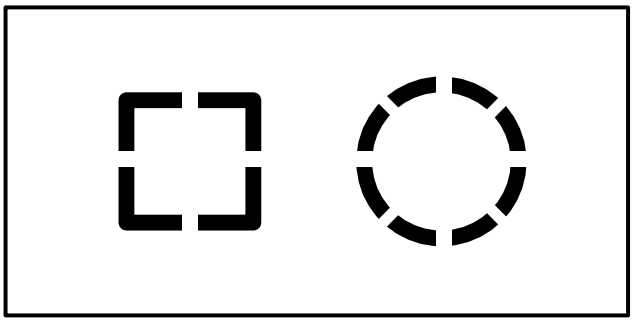
The name of this principle suggests that the elements of the composition appear to belong together, relate to each other, and to otherwise visually agree. Where other principles of composition break down the image into specific topics for study, the principle of unity reminds the artist to take a step back and look at the image as a whole.

Although most artists rely on intuition to decide if a composition is working, the cognitive psychologists offer a somewhat less subjective alternative. They study the eye and brain processes that lead to the artist's intuitive decisions. The cognitive psychologists have developed the Gestalt theory to help explain our perceptual tendencies. The term Gestalt means "whole" or "pattern." Gestaltists emphasize the importance of organization and patterning in enabling the viewer to perceive the whole stimulus rather than discerning it only as discrete parts. They propose a set of laws of organization that reflect how people perceive form. Without these organizational rules, our world would be visually overwhelming. They include:

- The brain tends to *group* objects that are close to each other into a larger unit. This is especially true with objects which share properties such as size, shape, color or value.



- Negative or empty spaces will likewise be organized and grouped.
- Elements are divided into planes, such as foreground and background planes.
- Patterns or objects that continue in one direction, even if interrupted by another pattern, are perceived as being continuous. The brain wants to perceive a finished or whole unit even if there are gaps in it.



- The brain attempts to interpret the world by finding constancies. If a person is familiar with an object, he remembers its size, shape and color and applies that memory when he sees that object in an unfamiliar environment. This helps him to become familiar with the new environment, instead of becoming disoriented, by relating the objects in the new environment to the known object.

By ignoring these principles, an artist risks creating an image which challenges the eye to organize it with little success. The viewer's eye will quickly tire and lose interest. Conversely, too much unity can be boring; if there is nothing to visually resolve, the eye will also quickly lose interest.

By understanding how the eye tends to group objects together, the lighting designer can help unify a disorganized or busy composition with careful shadow placement, or by minimizing or emphasizing certain elements with light and color.

3.2 Emphasis

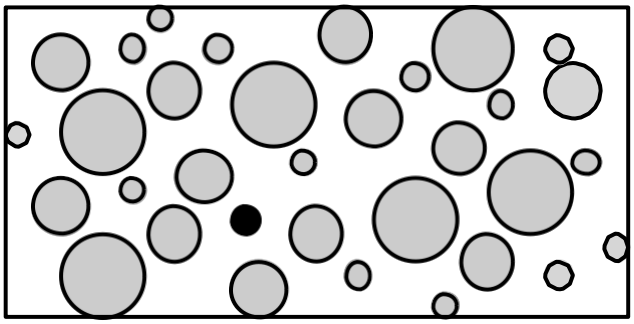
To direct the viewer's eye, an image needs a point of emphasis, or focal point. An image without emphasis is like wallpaper, the eye has no particular place to look and no reward for having tried. Images which are lit with default or uniform lighting similarly feel drab and lifeless. By establishing the quantity, placement and intensities of focal points, the lighting designer directs the attention of the viewer by giving him something interesting to look at, but without overwhelming the viewer with too much of a good thing.

A composition may have more than one focal point, but one should dominate. The more complicated an image is, the more necessary points of emphasis are to help organize the elements. Introducing a focal point is not difficult, but it should be created with some subtlety and a sense of restraint. It must remain a part of the overall design.

By first understanding what attracts the eye, the lighting designer can then devise methods to minimize areas which distract the viewer by commanding unwanted attention, and instead create more emphasis in areas which should be getting the viewer's attention.

3.2.1 Emphasis Through Contrasts

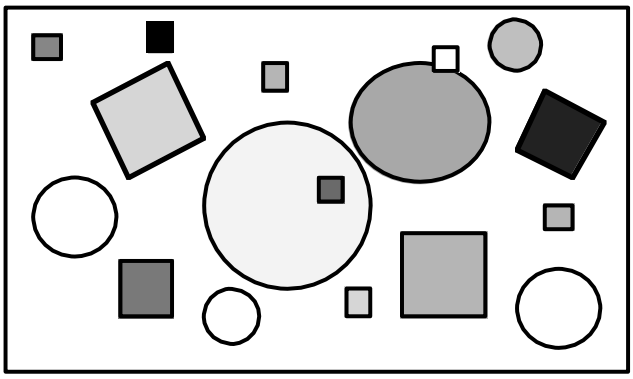
The primary method for achieving emphasis is by establishing contrast. Contrast can be achieved with shape, size, color, texture, brightness or even motion. A focal point results when one element differs significantly from other elements. This difference interrupts the overall feeling or pattern, which automatically attracts the eye. With one dark dot among thirty bright ones, there is no question which dot gets noticed, the dark one, for two reasons: it has the most contrast with its background, but also because it is the only one of its type. Unique or minority elements within larger groups tend to attract our attention.



Contrast in value (brightness) is easy for the eye to see, which is why black and white imagery is successful despite its lack of color. It also illustrates why lighting is a major tool in the establishment of emphasis and directing the eye of the viewer.

3.2.2 Emphasis Through Tangents

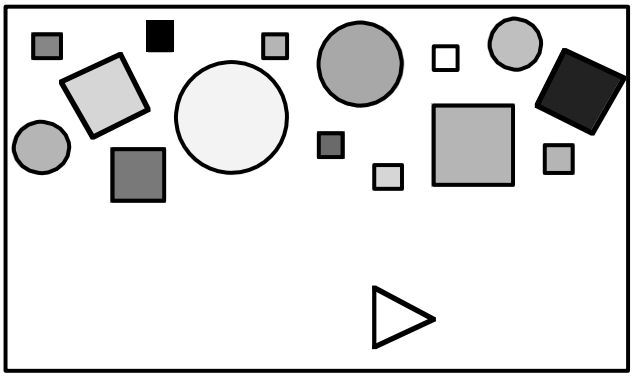
Tangents, where two edges just touch each other, can produce a strong point of emphasis



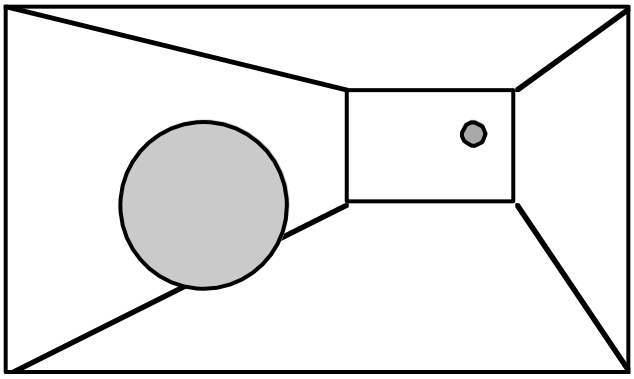
by creating visual tension. The eye is not comfortable with tangent edges and wants to move them apart. With care, tangents can be created intentionally to attract viewer interest; however, most of the time they are accidental and distracting. If a tangent is creating unwanted emphasis, it is best to try to move one of the shapes. It may be necessary to move an object in the scene if it falls tangent to another object. Another potential compositional problem is when an edge of a shadow or light falls tangent with an object or other geometric edge. In this case, it is preferable to move the shadow or light to avoid the tangency.

3.2.3 Emphasis Through Isolation

Emphasis by isolation is a variation of the Gestalt grouping concept. When an object defies grouping, by not being near or similar to any other object, it calls attention to itself and becomes a point of emphasis through tension. This tension is created by the feeling of unpredictability caused by the lone element not belonging to the group.



If this emphasis is undesirable, finding a way to link it to the larger group may help minimize attention. Using an edge of a shadow to point to the isolated element is one way to link it to the group.



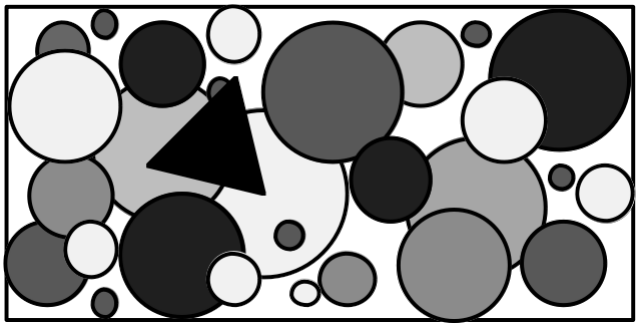
3.2.4 Emphasis Through Angles

A subtle form of emphasis can be achieved by using perspective angles and other edges which lead the eye to the focal point. However, they can just as easily lead the eye away from the intended subject. If perspective angles are leading the eye away from the focal point, it is necessary to attract or contain the eye more strongly using another method.

3.2.5 Emphasis Through Shape

The brain tends to characterize shape as either rectilinear or curvilinear. Most images are not comprised of strictly one or the other. By creating an image with primarily one type, the other type becomes a point of emphasis. In the simple example to the right, the triangle stands out from the field of circles because of its shape is unusual in this context.

As another example, a long straight shadow in an image with a lot of curves may need to have less contrast or a softer edge than usual to keep it from drawing too much attention. A busy shape among many simple ones, or vice versa, will also attract attention. This concept



may be helpful in recognizing why an object might be attracting more attention than otherwise expected.

3.2.6 Emphasis Through Recognition

Because of the human need for self-recognition, human or anthropomorphic characters will naturally attract more attention than inanimate objects. Furthermore, in our attempt to recognize a character, we naturally are attracted to look at his face, and especially to his eyes if he is speaking, to see what he is thinking and feeling.

3.2.7 Emphasis Through Motion

A static image has static points of emphasis and all principles of emphasis apply, but a moving image has the added bonus of being able to create emphasis through motion. Camera motion and character acting are topics unto themselves (see [Lasseter87]), but it helps to understand when the eye is attracted to moving objects and when it is not. If all objects are moving except one, the eye will be drawn to the one which is not moving. The opposite case, of only one object moving, is more common and even more effective in attracting attention.

3.3 Balance

When an object is unbalanced, it looks as though it will topple over. Instinctively the viewer wants to place it upright or straighten it. An unbalanced object is distracting and calls attention to itself. An entire image which is off-balance will make the viewer uncomfortable because he wants to balance it, but cannot. This discomfort can be desirable if it enhances the mood or storypoint. By knowing ways to balance or intentionally unbalance an image, the lighting designer can affect the mood of the scene.

A scale is balanced by putting equal weight on both sides. It doesn't matter how large or dense the objects placed on the scale are, they will balance as long as they have equal weight. The balancing of a composition is similar except that visual interest becomes the unit of measure. Visual interest comes in many shapes, sizes, values, colors and textures, each with varying density. The principles of emphasis and balance are therefore related since points of emphasis carry visual weight which must be considered when evaluating the balance of an image.

Visual balance is achieved using two equations. The first balances the image around a horizontal axis, where the two halves, top and bottom, should achieve a sense of equilibrium. Although it is desirable to have a sense of equal distribution, because of gravity, the viewer is accustomed to this horizontal axis being placed lower than the middle of the frame.

Besides helping to create a pleasing image, the top/bottom weight ratio can also have a storytelling effect. The majority of constant factors in our visual life experience tend to be horizontal in nature—the groundplane beneath our feet, the horizon in the distance, the surfaces of water. Where these horizontal divisions are, relative to where we are, tells us how tall we are, how far off the ground we might be, or whether we might bump our heads on something. Because we are accustomed to making these comparisons, the placement of a character within the image format and the angle that the camera sees him can imply the height of a character. And since we tend to associate height as a dominating physical characteristic, it can say something about the importance of the character in his current situation. In one shot a short character is placed high in the frame, in the next shot a tall character is placed lower in the frame. The shorter character in the first shot feels taller and more important to us than the character who is actually taller but is visually subservient. A character's eyes are usually placed above the center line, unless the character is looking up.

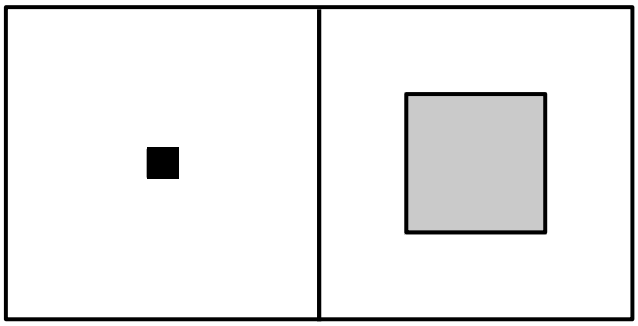
The second equation of visual balance divides the image around a central vertical axis. The horizontal format of cinema is most affected by this left/right ratio. And with the possibilities of action entering and exiting the frame, or camera pans and dollies, this ratio has the potential to be very dynamic.

The simplest type of left/right balance is *symmetrical* balance, where the two sides are mirror images of each other. Symmetrical balance is discussed here primarily because it is easy to understand and to achieve. Heavily used in architecture, symmetrical balance feels very formal, permanent, strong, calm and stable. In other forms of art, perfect symmetry is rarely seen. One distinct advantage of symmetry is the immediate creation and emphasis of a focal point. With two similar sides, there is an obvious visual importance to whatever element is placed on the center axis. Another asset is its ability to easily organize busy, complex elements into a coherent whole. In film, symmetrical balance is sometimes used to help portray a formal, official, or religious environment or mood. The Ingmar Bergman film "Winter Light" uses symmetrical balance to impart stiff, claustrophobic formality to the church setting in the opening sequence.

In contrast to symmetrical balance, *asymmetrical* balance is more commonly used, more natural in feeling, and much more challenging to achieve. Although asymmetry appears more casual and less planned than symmetry, its visual ease belies the difficulty in its creation. Balance must be achieved with dissimilar elements by manipulating the visual interest of each. Some of the variables to manipulate are value, color, shape, texture, position and eye direction. Each are discussed here individually for clarity, but keep in mind that the interplay of these variables will affect the end result. Color can balance value, or texture can balance shape, infinite combinations are possible.

3.3.1 Balance by Value

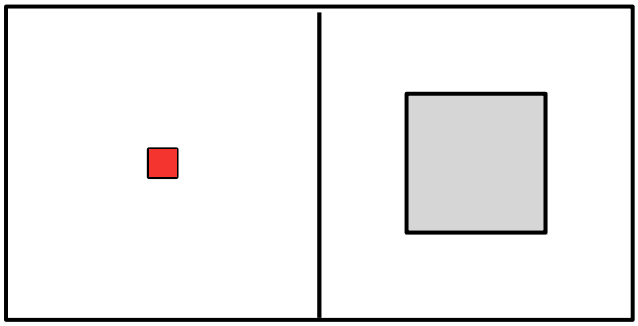
We have already discussed that the eye is attracted to contrasts, particularly that a high contrast area attracts more interest than one of low contrast. To balance the scale, a small area of high contrast will command an equal amount of attention as a large, low contrast area.



When it comes to projecting film in a theatre, the value scale isn't necessarily level to begin with. A theatre is dark to draw the viewers attention to the screen. In general, the eye is attracted to bright areas more than it is dark ones, and in a dark theatre, with our pupils dilated, a bright area will attract even more attention since it contrasts with the darkness of the theatre environment itself.

3.3.2 Balance by Color

Like value, color can be a balancing element. The eye is more attracted to a color than to a neutral image, the more saturated the color, the more attention it grabs. A small area of bright

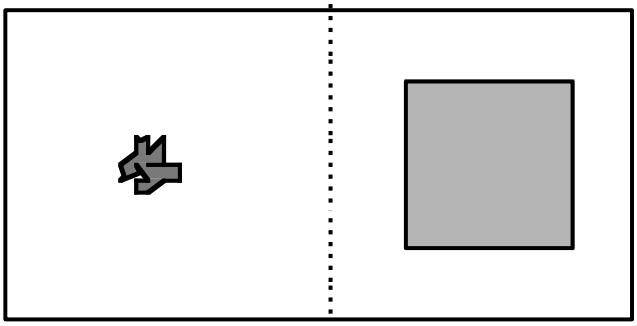


color can balance a much larger area of a duller, more neutral color. How colors are placed next to each other can also affect color balance. Complementary colors which are placed adjacent to each other will weigh more than two analogous colors would in the same situation.

If a surface color is attracting too much attention, its color saturation or diffuse light response may need to be toned down, or perhaps the surface can be placed in shadow.

3.3.3 Balance by Shape

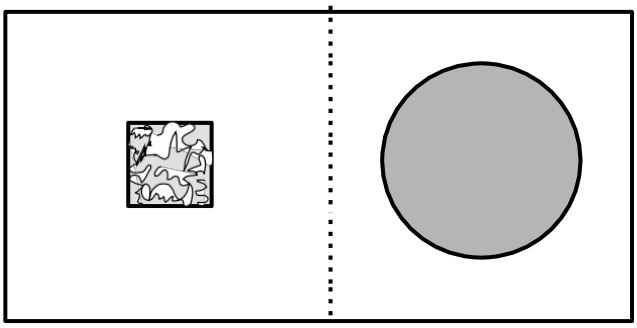
A large, simple shape can balance a smaller, more complicated one. Similarly, a large uncluttered area can balance a smaller busy area containing many shapes.



Busy areas can be minimized by placing them in shadow or enhanced with directional light placement. Large simple areas can be broken up with shadows or evenly lit depending on the visual need.

3.3.4 Balance by Texture

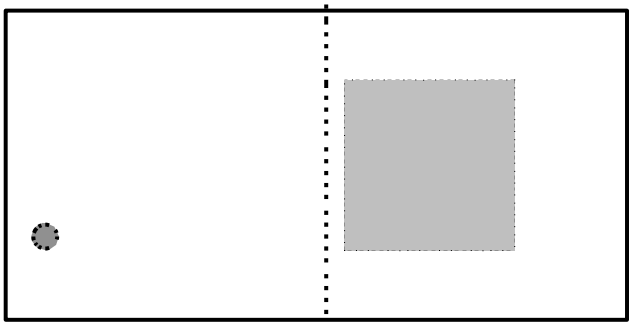
Texture and surface are similar to value, color and shape. A busy, high contrast texture on a small shape, will balance a larger shape with a smooth, matte surface.



Texture is an invitation to the audience's sense of touch. Even though they cannot reach out and feel the image, the textures in the image can trigger a sensory reaction. The surface quality of objects can help define the mood of the scene, where soft, fuzzy objects summon a warmer memory than do smooth, polished objects. Surface texture also gives the audience cues as to how close they are to the object surface, since texture becomes less apparent as the object moves farther away. A highly textured surface will attract more viewer interest than a non-textured surface, and these surfaces can be lit to highlight or minimize their respective surface qualities. A highly textured surface can be accentuated with hard light from the side or back, or it can be minimized with soft frontal lighting.

3.3.5 Balance by Position

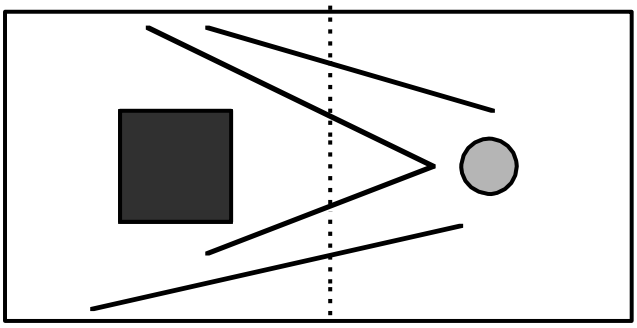
On a scale, a heavy weight can be balanced to a lighter one by moving the heavy weight closer to the scale center point, or by moving the lighter weight further away from the center. This principle is also true in composition. A large element placed close to the center of the image can be balanced by a smaller element placed near the edge.



Although it may not always be possible to move an object in the scene to balance the composition, affecting an object's visual weight can be achieved with lighting, either by changing the visual weight of the object itself, or by counter-balancing it with more visual weight elsewhere.

3.3.6 Balance by Eye Direction

Every edge, shape or group implies a direction of some kind, either straight or curved. It is the counter-balancing of one direction with another which stabilizes an image.



Directional lines, such as perspective angles, are a simple example of how eye direction can be used to balance a heavier side by pointing toward the lighter side, transferring visual importance. Perspective angles are an example which tend to be fairly subtle. A linear object, a shadow edge or the edge of a light can achieve a stronger directional effect. Eye direction also occurs when the eye is led from one side of an image to the opposite side when it finds the same color, or when the eye follows the gaze of a character.

3.3.7 Balance by Physical Weight

The perceived physical weight of objects in the scene also contributes to the sense of visual balance. An object known to the viewer to be heavy in physical weight will impart more visual weight than it would otherwise due to our tendency to factor mass and gravity into the equation.

3.4 Scale and Proportion

The term *scale* refers to overall size, whereas *proportion* is used to describe relative size. Scale and proportion principles help the viewer organize an image. They can also be used to create or minimize points of emphasis.

Scale and proportion are connected to emphasis and balance. If an object is out-of-scale or is oddly proportioned, it can create too much emphasis. Large scale elements, especially those large in proportion to the other elements, also create obvious visual weight. The brain automatically reads larger objects to be nearer and more important than smaller objects. As an example, in a close-up shot of a character, the viewer is rarely distracted by the background. But in a wide shot containing many elements, the viewer must create relationships between elements to establish perspective and to find a focal point. In addition to mere size grabbing viewer attention, the brain will notice an object which appears out of proportion, or unnatural in size, compared with other objects. The lighting designer may need to minimize large objects which should not be the focus of attention.

In a purely computer generated environment, the viewer works harder to establish and maintain size relationships since there is no direct comparison available to the real world. In "Toy Story", the architecture, furniture, props and characters were modelled and textured with an appropriate amount of detail for their relative size as well as to the distance they would be viewed from the camera. Great care was also taken in the staging and editing processes to avoid disorienting the viewer with unexpected changes in apparent size relationships. A consistent use of lenses for close-ups, medium shots and long shots helped to ensure spacial continuity.

Besides being useful for describing relative size, proportion also pertains to the pleasing design of objects and their placement in the overall image frame. Placing the focal point dead-center in the frame is not usually a very interesting or pleasing placement. The eye naturally prefers the focal point to be located within one of the four quadrants. This is especially true if the image contains another strong point of emphasis. This is only a general rule of thumb, however. Sometimes the lighting designer will be given a shot where the focal point is intended to be in the center of the frame. If the shot is a wide shot with many elements, the eye may have difficulty remaining in the center of the screen. It may be necessary to minimize other points of emphasis on the periphery to keep the eye from wandering.

Much study has been devoted to deriving ideal proportions for an individual entity as well as how to portion an image in the most pleasing form. The use of aesthetic formulas has a long history. Even before the Renaissance, when there was more overlap between the arts and sciences, artists and mathematicians perfected what they believed were the ideal proportions for human form, design and composition. One of the formulas they derived is the *golden section**. Once used heavily in architecture, painting and sculpture, it is described as "Traditional proportion which is supposed to express the secret of visual harmony. In its simplest form it consists of a line divided into two so that the smaller part is to the larger as the larger is to the whole." This proportion is expressed in mathematics as a Fibonacci sequence of numbers, or as a ratio roughly equivalent to 8:13 (j). The golden section is frequently found in nature and is very pleasing to the eye. When deciding where to place an edge of a light or shadow, formulas like the golden section may be useful to keep in mind.

3.5 Repetition and Rhythm

3.5.1 Repetition of Shape

The use of similarly shaped elements in an image, however subtle, is a strongly unifying force, as a product of the Gestalt grouping principle. Repetition is an aspect of visual unity which is exhibited in some manner in every image. The human eye is very good at making comparisons and correcting minor differences to equate two shapes as being essentially the same, and then grouping them together as a unit or connecting them in some way. Because of this tendency, two similar objects, even at opposite sides of the image, will lead the eye from one shape to the other.

Also, the shape of an object can acquire more visual weight if it is repeated, by its own shadow for instance. By looking for ways to repeat shapes with light and shadow, the lighting designer can help unify an image or redistribute visual weight

3.5.2 Rhythm

Visual rhythms are plentiful in nature: a stand of trees, a flock of birds, ripples in the sand, raindrops in a puddle. A person is so accustomed to natural rhythm that they *feel* it more than they *see* it.

As a design principle, rhythm is based on repetition, although just because something repeats itself doesn't mean it has rhythm. A small number of repeated or similar elements become visually grouped together to form a unit. To achieve rhythm, a larger number of elements are required, enough elements so as to discourage grouping as a single unit, but several. Groupings of three or more start to introduce rhythm, but only if they are not exactly the same. Rhythm also requires variation within its repetitive groupings.

**p. 90;* The Thames and Hudson Dictionary of Art Terms, *by Edward Lucie-Smith: Thames and Hudson, 1984.*

Rhythm can be established using colors or textures, but shapes and their arrangement are more common repetitive elements. Rhythmic patterns can help lead the eye through a composition, but they can also evoke an emotional response. A succession of curvilinear forms can be calming, whereas a pattern of angular lines may be stimulating.

3.6 Line and Contour

The human eye is very sensitive to change, and can find even very subtle distinctions. It then mentally connects these demarcations to create a line or boundary. The imagination and past memories then quickly fill in missing details in an effort to recognize these lines as a known shape. In addition to filling in the missing bits, the brain also ignores visual stimuli which may be competing for attention.

The careful placement and emphasis of edges and linear elements play an important role in leading a viewer's eye through a composition, directing it to the intended subject. A practical example of how lighting can be used to control the placement and emphasis of edges might be the angle of a shadow, highlighting the edge of an object, or even deliberately allowing the edge to blend with the background.

There are three types of edges or lines, an *actual* line, an *implied* line, and a *psychic* line. An actual line is the easiest to recognize because it usually defines a shape. A line is implied by positioning a series of points so that the eye tends automatically to connect them. A psychic line is not a line which is seen, but one which is felt as a mental connection that exists between two elements. The eyeline of a character is a good example. If a character looks toward an object, the viewer will also look. These psychic lines are very powerful and can be difficult to minimize if they are distracting.

How and where a line is terminated can also affect its importance. A line which points to an object, but doesn't quite touch it will create tension and attract attention more than one which continues.

The boundaries of shapes and other linear elements portion a composition for proportional analysis. They also have an emotional role. Horizontal lines imply stability, vertical lines imply potential motion, and diagonal lines imply dynamic motion and depth. When working within the rectangular cinema format, horizontal and vertical lines work as stabilizers and reduce feelings of movement since they mirror the format boundaries. A common camera technique is to roll the camera to introduce a feeling of instability.

3.7 Shape

The computer animation environment is three dimensional as it exists within the computer. Three dimensional objects move and deform freely, changing shape and position, in their three dimensional world. And although the sculptural form and motion of the objects affect how light is reflected and shadows are cast; ultimately, it is the placement and definition of the resulting two dimensional shapes, within the image frame, that becomes the final product. Camera placement and lighting are what control this transition from the original design space to the image the audience sees projected on the screen. This may seem obvious, but it also appears to be forgotten at times.

A composition is primarily an arrangement of shapes. The brain not only strives to recognize shapes, it also attempts to organize them into *figure and ground* relationships, or positive and negative space. This happens on several levels. Just as the brain distinguishes between background and foreground planes, it also looks for positive and negative relationships within each plane. The focal points and busy areas of the plane become the positive space, while the other areas become relief for the eye, or nega-

tive space. Negative spaces are not necessarily empty flat areas, but they do not tend to attract attention. In a well crafted image, as much care is given to the shape and placement of the negative spaces as is given to the subject itself. However, the shape of a negative area, particularly an enclosed one, can be so interesting that it may take on a life of its own, attracting attention instead of deflecting it.

A lighting designer is constantly balancing the need for readability and the need for integration. An image which has all of its shapes clearly defined is easy to understand. However, it is not as interesting as an image where shapes fall in and out of definition, by falling in and out of light and shadow. Similarly, clear definition between foreground/background, and positive/negative space is easy to read, but is not a particularly interesting spatial solution. It is often desirable to blend together, or integrate, the spaces in some way to avoid the harsh juxtaposition of forms as is evident in a bad matte. The use of a similar color or value along an edge can help the eye travel more easily between the spaces.

An important concept for the lighting designer to keep in mind, is that the brain is very good at recognizing shapes with a minimal amount of information, especially if this shape is already familiar to the viewer. By just hinting at a shape with a minimal amount of light, the viewer's imagination becomes engaged, and a mood of mystery and suspense is evoked. This is a concept that is apparently foreign to advertising agencies who want to see the entire product label evenly lit.

Shape distortion can be a powerful emotional tool. The viewer is so accustomed to seeing the world in a natural fashion that when shape is distorted in an image, it signals an altered state of reality. An emotional response will range widely depending on the shape being distorted and its context. The baby in "Tin Toy" is distorted, using refraction through a cellophane wrapper, with comic relief to the plight of Tinny. In another context the same technique may be eerie and unsettling. The individual parts of the mutant toys in "Toy Story" are not themselves distorted, but in combination they represent a distorted vision of a life-like toy. The combined effect is disturbing and repulsive, which helps us believe that they may indeed be cannibals.

3.8 Value

A black and white image can often work as well as a full color image because enough visual information exists for the viewer's imagination to fill in the missing color information. In fact, a black and white image can sometimes be more powerful than color precisely because it requires the use of imagination.

Contrast in value provides spatial cues for depth perception. Areas of greater contrast appear to advance into the foreground, while areas of lesser contrast tend to recede. The angle and direction of a shadow helps define the location and orientation of the surface on which it falls. If a shadow does not fall as expected from its source, the result can be disorienting as the viewer tries to reconcile the surface plane to the shadow.

Lighting is ultimately how the values of the scene are controlled as the camera will see them. In live-action, the aperture of the camera lens will also affect the final result by selecting a tonal range within the capabilities of the film stock.

The interplay of light and shadow and the relationships of tonal values is a major contributor to the style and mood of the scene. This is discussed in more detail in Section 4.

3.9 Color

Value and color are related to each other since the light which falls on reflective surfaces, or shines through translucent materials, produces various brightnesses. On black and white film

they are reproduced as gray values. On color film, the apparent brightness is greatly influenced by the hue and saturation of the colors, but the final outcome is still a range of values. Every color has a value, but color, which is based on wavelengths of light, offers a much broader field of visual differences and contrasts.

The color of a surface is determined by how it reflects the light that illuminates it. The apparent color of a surface depends upon the lighting situation. Unfamiliar objects appear just as the eye perceives them, that is the apparent color and value are determined by the actual wavelength of the reflected light. For familiar objects, the principle of *color and brightness constancy* takes effect. Here the brain uses previous experience to augment the strictly physical perception of the eye. If the color of a familiar object differs from that in memory, the brain assumes that the color of the object is affected by its environment. For example, if the viewer sees a purple apple, chances are they have never seen an actual purple apple, and will assume they are viewing a red apple as seen under blue lighting or through a blue filter.

A color is also perceived as a certain hue, saturation and brightness as it relates to the color next to it. A color on a neutral background may appear very different than it would in context with other colors. Similarly, two complementary colors, when juxtaposed will accentuate each other and appear more intense than they would if either were placed adjacent to an analogous color. Neutral colors can be heavily influenced by a stronger color next to them, where the neutral color will tend to go toward a hue which contrasts the strong color. In other words, a grey square next to a red one will tend to go a little greenish.

Color can play a big part in visual storytelling, both in terms of the set, props, and wardrobe design, but also in the lighting. Section 4.7 contains a brief discussion on color and our emotional responses to it. An exhaustive discussion of color, however worthy, is beyond the scope of this course. Many books on color theory and the psychology of color exist for the reader who is interested in exploring these subjects in further detail.

3.10 Compositional Mood

A pleasing composition evokes a sense of well-being, a feeling that everything is happy and going to stay that way. A composition which is a little unbalanced, or otherwise feels awkward, can create a feeling of tension and apprehension. This feeling can be useful if the intent is to build story tension or to portray the emotional state of a character. A progressive building of visual tension can foretell that something bad is going to happen whether it actually does or not. A sudden change in visual tension can accentuate the shock of a dramatic change. Sometimes the composition and lighting design will intentionally be in contradiction with the subject matter. Soft, warm, beautiful lighting can be used to light a violent, ugly subject matter. This contradiction can aid in viewer discomfort because it feels especially out of context and shocking.

Whether or not the composition is busy or simple will also have some emotional impact on the viewer. A well-composed simple scene will feel elegant and noticeably beautiful compared to a cluttered scene. An element in a simple scene will also feel more important than the same element in a busy scene.

3.11 Transitions

While it is necessary to direct the viewer's eye to the intended subject within a shot, it may also be desirable to "lead" the viewer's eye into the next shot. An effective transitional device is to use lighting and compositional elements from the current shot to transition into similar elements in the next shot. The audience is already visually prepared for the next shot before the cut or dissolve occurs.

3.12 Putting it Together

Even with the intent of discussing the principles of composition as isolated topics, it is easy to see how they interrelate. Figures 3.12a, 3.12b and 3.12c illustrate a few examples of using a few of these techniques together to direct the attention from one character to another. Figure 3.12a shows a simple shot of Woody and Buzz over a plain grey background. The same basic lighting is applied to both Buzz and Woody, the direction of which is arbitrary. If you were to guess which character is supposed to hold our attention, which would you choose? Initially we may think that it is supposed to be Buzz because Woody is looking at him which naturally draws our attention to Buzz. Ordinarily we would consult with the director to find out his intention, but for the purposes of our example, we will light one to highlight Buzz and then relight it to focus our attention on Woody. In these examples, only the background has been relit, because the result is clear to see.

Figure 3.12b uses several techniques to help draw our attention to Buzz. A shadow line was introduced on the background to reinforce the eyeline from Woody to Buzz. It is sharper behind Buzz and softens as it reaches Woody to provide more contrast near Buzz. The contrast of the shadow line is low enough so that it does not attract attention to itself. This dark shadow area behind Buzz allows him to "pop" from the background while Woody tends to blend into it. Also, this shadow line is positioned so that it is almost tangent with Buzz's head to add tension to that area. Woody does not have a rim light to aide in his blending into the background, while Buzz has a nice bright one which helps him separate.

Figure 3.12c shows the shift of attention toward Woody. For this image, we will use the proximity of the grey wall to help us. The shadow of Woody on the wall provides us with more contrast areas around Woody's head and the repetition of his shape on the wall gives him more visual weight and drama. The wall behind Buzz is lit to help him blend into it. The rim light on Buzz has been toned down while the rim on Woody has been brightened. As you can see in this image, the psychic line created by Woody looking at Buzz is very difficult to overcome.

Exaggeration is a familiar device used by character animators to enhance the life-like quality of a character. Purely natural or physically correct lighting is often not interesting enough to create drama and captivate the audience. Pushing the limits of reality can create magic and beauty that connects the imagination with the story being told.

It would be possible to fill volumes with examples, but let's move on. The next five lighting objectives draw upon our knowledge of these principles of composition and illustrate further how they can be used in lighting for storytelling.

4. Enhancing mood, atmosphere and drama

Many aspects of an image affect its mood and dramatic qualities. The sets; the costumes; the actors and their acting; the staging; the score; the weather; the time of day; and the lighting, are all components which can illustrate the mood of the story being told. Lighting design can pull it all together into a cohesive mood, or it can provide a contradictory mood of its own for the sake of contrast.

The emotional role of lighting is not always obvious, even though it is profound. This emotional effect can be accentuated by juxtaposing complementary lighting situations. An overcast day will evoke vague feelings of oppression and melancholy, but might not be noticeable until it is compared with the uplifting quality felt at the first brightness of a spring sun. It probably wouldn't be appropriate to light a sad and gloomy scene with lots of bright light, nor

would it seem right to light a comedy with harsh high-contrast light.

Lighting vocabulary is based on studio lighting. This long-established vocabulary breaks down the infinite possibilities of light into manageable topics for discussion. It is therefore useful to take a look at the studio method of explaining lighting design and relate it to our synthetic tools.

The establishment of mood and drama through lighting is the sum of the properties of the lights themselves as their motivation, purpose, placement, direction, range, color, quality, quantity and intensity. This section is primarily devoted to the discussion of these light properties, how they relate to each other and how they influence the emotional qualities of the scene. Each property is presented in the logical order that lighting decisions are usually made.

Often, the first decision to be made is to determine the *style* of lighting to be used for the scene.

4.1 Lighting Style

An infinite number of combinations of lighting properties can be created for a wide range of visual and emotional effects. In order to simplify the endless possibilities, some generalizations have been drawn which are used to label and describe lighting in terms of style. Lighting styles are described by their tonal range, which is the range of values from the darkest dark to the brightest highlight and the grey values in between. Lighting styles are also described in terms of the overall color, motivation, placement, and quality of the lights and shadows.

The character and mood of an image is dramatically affected by the range of tone values from light to dark and by their distribution within the frame. This tonal range is decided early in the lighting process. This decision is usually motivated by the dramatic quality of the story and can be consistent throughout the entire movie or vary with the location and time of day.

A light-hearted or comedic story might dictate a *high-key* lighting style. High-key lighting is characterized by a scene that is mostly well lit with a lot of soft fill light and no heavy or hard shadows. The sets and costumes also tend to be light in color. This doesn't mean that there aren't any dark areas, but the overall brightness tends to be light, contrast is low, and the dark areas are soft and few. The result minimizes suspense since nothing is left to the imagination of the audience.

At the other end of the spectrum is *low-key* lighting. In a low-key lighting situation, most of the scene is darkly lit, with the emphasis on the few areas which are brightly lit. The sets and costumes are also usually dark in color. The overall impression is dark but not murky. What is seen is equally important to what is not seen. The detail only hinted at is much richer than it would be if it were well lit. Light is used to direct the viewer's attention, the darkness to stimulate his imagination. Of course, these are the polar opposites, with many possible tonal ranges in between.

Aside from the overall brightness or darkness of the style, its contrast range can evoke mood and meaning. Unlike a low-key scene where most of the frame is dark, *high-contrast* scenes contain a wide range of light and dark areas with a narrow middle range of greys. A high-contrast image, with many hard edges of light and shadow, has a dramatic graphic quality and can evoke a sense of energy or unrest. A low-contrast image, composed of a range of shades of middle tonality, can convey a feeling of calmness or bleak oppression.

Even before the viewer has understood the story-point, the lighting style can suggest a feeling for a scene, especially in comparison with adjacent scenes. Or within a single shot, one character may be modeled in bright tones and another in shadows and dark tones to suggest their individual personalities or their emotional or dramatic situations.

4.2 Quality of Light

The creation of varying degrees of softness and directionality are important aspects in creating mood through lighting. In addition to considering the tonality of image, lighting style is also often defined by the *quality* of the lights, especially the key source. The quality of a light is comprised of three characteristics, the primary one being its hardness or softness, with the other two being its angle of throw, and its color. A soft source is diffused which scatters light in many directions and creates very soft shadows, whereas a hard source is not diffused and casts very crisp shadows. A light source, even a soft one, will become harder as it moves farther away from the subject. The apparent size of the source becomes smaller, and as its rays become more parallel, causing its highlights and shadows to become more crisp.

In addition to the actual hardness or softness of the sources themselves, the contrast range of the resulting image also contributes to the overall feeling of hard or soft lighting. Subjects of limited tonal range, with middle tones of gray, appear softer than subjects with deep blacks and brilliant whites.

The quality, or character, of light will initially be influenced by the scene location and the time of day but may vary to accentuate mood or storypoints. Daylight scenes are usually softly lit except for direct sunlight. Night scenes, especially exteriors, tend to be lit with harder lights. The character of a light is also heavily influenced by the *motivation* of its source.

4.3 Lighting Motivation

Once the character of light is chosen for a given scene, the next task of the lighting designer is to decide the practical and hypothetical sources of light and their orientation to the set and subject. These decisions will be influenced by the script, the set, and the camera locations within the scene. Lights are characterized as being either *logical* or *pictorial*. A light is logical if it appears to be motivated by an actual source of light (practical source) that the viewer can see or is implied, such as a window or table lamp. Logical lighting, also called naturalistic, motivated, or method lighting, generally follows the natural, logically established visible sources in a scene. On the other hand, pictorial lighting generally uses lighting directions simply because they produce a pleasing picture.

Most of the time, there is a compromise between the logic of the source and the compositional requirements of the frame. Sometimes the light direction is established by what feels natural, even if the logic of the source is slightly violated. It is the overall character of the light, its color, softness and direction, that matters. The exact angle and intensity of the light will never be scrutinized by the audience as long as it is not disorienting.

Practical sources which are visible to the viewer need to be well placed. If there is a visible source of light within the image frame, the viewer expects the overall light direction to emanate from the source they see, even if the lighting originated from a different source in the previous shot.

4.4 Quantity of Lights

The number of logical sources chosen will also help determine the mood of the scene. A soft one-light scene, for instance from a candle, can feel very warm and romantic. A big bank of fluorescent lights can feel sterile, cold and overlit. There are many possibilities in between, but in general, the number of logical sources are usually kept relatively few to be able to establish overall direction.

The number of logical sources may be small even though the actual number of lights used to achieve a look may be many. This is true in live-action and even more so in synthetic lighting since no ambient or bounce lighting comes for free (unless of course a radiosity renderer is used). In general a light should not be added to a scene without an intended purpose, and the temptation to use one light to serve two purposes should be avoided.

4.5 Quality and Quantity of Shadows

The number and quality of light sources also help determine the number and quality of shadows. This is one area where synthetic lighting has a great advantage over live-action. In a live-action situation, each hard light casts a distinct shadow. Great care is taken to minimize multiple shadows and to establish one dominant shadow. Conversely, in synthetic lighting, it takes effort to create multiple shadows and penumbra effects, and the tendency is to overdo it. One shadow should still dominate, but it is usually necessary to introduce a secondary or contact shadow to help ground a character onto the shadowed surface.

Also in live-action situations, the quality of the shadow is determined by the placement and quality of the light. A hard or distant light will cast a crisp shadow. The softest light will not cast any shadow. The density of the shadow is determined by the amount of bounce and fill light in the scene. In synthetic lighting, shadow direction, quality, color and density controls can be independent of the light attributes, but they should still feel naturally motivated by the sources in the scene.

4.6 Light Type, Purpose, Placement, Direction and Intensity

The desired tonal range of the image, and quality and motivation of illumination have now been established. The next task to consider is the specific type, purpose, placement, direction and intensity of each light.

4.6.1 Types of Lights

Three basic types of lights are used for live-action lighting. The spotlight, the floodlight, and the area light. The spotlight has a narrow beam and is usually used as a hard light source. It casts crisp shadows and a crisp bright highlight. The floodlight has a broader beam and is usually diffused and used as a softer source. It casts a soft shadow and a broader diffused highlight. An area light is either fully diffused through a diffusion material or is bounced off another surface such as a white card. It casts very faint shadows, if any.

The use of diffusion and focusing materials creates a wide range between a very soft scattered light and a very hard directional light. Light placement also affects the apparent hardness of the light, since even a soft light will appear harder as it moves farther away from its subject, as its rays become more parallel. These three types of studio lights are designed to emulate nature. Sunlight is an example of parallel rays which cast very crisp shadows. An overcast sky is an example of very diffused light casting soft shadows. And the shadow areas under a clear blue sky is an example of a big area source which casts faint shadows.

The synthetic lighting designer attempts to recreate these real light properties with a different set of tools. Many renderers currently support all three basic light types. Spotlights (point) and solar (parallel, infinite, or distant) lights are pretty standard stuff, area lights are more difficult to find since they are more computationally expensive.

Without the availability of area sources, the overall soft look can be emulated using more standard techniques. The parallel rays of a solar light have a softer feel than a spotlight because the illumination is more evenly distributed over a surface. And since the shadows can be controlled independently, a blurred shadow with partial density can help this cheat. The specular quantity and quality from a source also describes its apparent softness. By using an environment map, with blurring and color filtering controls, to define the highlights, the cheat can be taken a step further.

Many renderers support control for diffusing the specular highlight for each source independent from the surface roughness, but specular highlights are really just a cheat. It is often more convincing to use an environment map which contains representations of the sources instead. Gratuitous specular highlights impart a plastic, computer-generated quality; highlights should be placed, shaped and colored with care.

The quality of a light's shadow provides the most information in describing the quality of the source. In computer lighting, much control and creative freedom can exist for manipulating shadows. The color of a shadow can be enhanced, and the density and softness of a shadow can be set uniformly or be varied across its surface.

The softness of the shadow suggests the softness of the source as well as the distance of the source from the subject. But, even though a hard distant light will cast a hard shadow, softening the shadow can suggest atmospheric diffusion. The softness of the shadow also gives us visual cues about the distance from the shadow-casting object to the surface on which the shadow falls. The nearer the subject to the shadowed surface, the more dark and crisp its shadow will appear.

4.6.2 Light Functions and Placement

The function of a light is independent of its type, its quality and even its placement. A light's function is particularly meaningful for describing how it is used on a subject. For this reason, light function and placement are discussed here together.

4.6.2.1 Ambient—or base lighting

The overall brightness of the shadow areas is usually determined first by the use of base lighting. In live-action this might be achieved by suspending a white cloth over the set and top-lighting it, bathing the entire set in a wash of light. In the computer this is accomplished by using a combination of an ambient light and diffuse lights. The ambient light adds a slight amount of light everywhere to prevent any absolute black areas, but is extremely flat. The use of a few diffuse lights can add a little bit of directionality to ambient base lighting. A radiosity renderer eliminates the need for adding a flat ambient light, but does not necessarily eliminate the need for base lighting.

4.6.2.2 Key light—for modeling of surface and setting of mood

The key light is the brightest light striking a subject. It defines the brightness and shape and texture of the subject.

As the dominant source, the placement, color, intensity, and textural quality of the key light are important attributes in setting the mood for a scene. But it is the placement of this light that most affects the mood and dramatic quality of the image by controlling the direction of the light as it strikes the subject. The direction of the light can vary the apparent shape and volume of the subject, by accentuating or minimizing certain features. This is referred to, in lighting terms, as surface modelling. The character of this modelling is also affected by the softness of the light and its shadows.

Although there are no hard and fast rules for the placement of the key light, it is conventionally placed 30-45 degrees to the side and above the subject relative to the camera axes. However, this light can be effectively placed as far back as 135 degrees from the camera as a *three-quarters-back* key light. Another convention is to place the key light so that it is on the opposite side of the actor's eyeline from the camera. These conventions are interesting, but only serve as a loose guideline since the direction of light is usually dictated by the relationship of the subject to the motivation of the source, the chosen style of lighting, and the mood of the scene.

By controlling the direction and quality of the key light, it is possible to change the appearance of the subject as well as to suggest something about the subject's personality or dramatic situation. A beauty-shot of the heroine may have a softer, more frontal key light than the villain who is chasing her.

In live-action lighting, the addition of a *filler* light is often added to fill in the key light shadows. This light is placed near the key light, but a little lower. On the computer this light is not

usually added since the same effect can be achieved by lessening the density of the key light shadow.

4.6.2.3 Fill light—for subject contrast control A fill light is a low-intensity, diffuse light used to fill in shadow areas. This light does not call attention to itself. In pure terms, it does not cast noticeable shadows, nor does it produce a noticeable or sharp specular highlight.

Although a fill light can be placed almost anywhere, it is traditionally placed nearer to the camera axes than the key light. Since the fill light is often near the camera, it tends to fill in the key light shadows and reduce the surface modelling created by the key light.

The ratio of the key light plus the fill light to the fill light alone is called the *lighting ratio* and is one way of controlling the contrast range of the scene. In a high-key lighting situation, a lot of soft fill light is used to bring up the overall level of illumination. In low-key lighting situations, the fill light is frequently omitted.

4.6.2.4 Backlight— for separation from background and setting of mood
Also referred to as rim, hair, or separation lights, backlights are traditionally used in black and white cinematography for foreground separation. In color cinema they are needed less for separation, but they are also effective for creating a romantic mood.

A true backlight is traditionally placed behind the subject so that it is pointing directly at the camera resulting in a thin rim of light around the edge of the subject. They are also placed at higher angles to highlight hair and clothing. Back cross-lighting is frequently used to put a rim on both sides of the subject. A soft backlight can look natural even if it has no obvious motivation. A hard backlight, unless it is motivated by direct light, will look unnatural, but they are still often used anyway. Backlighting should be used with thought since it tends to be overused.

Backlighting is easy to achieve in live action, often with one light. However, many shading algorithms ignore light which strikes the back of an object and do not try to simulate the halo effect that results from backlight hitting a surface which is not mirror smooth. Without special shaders which comprehend backlighting, creating this effect in CGI requires a bit of cheating and patience. It helps to have roughness controls on the specular highlight of each light source, so that the backlights can have as broad a highlight as possible. Exact light placement can be tricky to control especially with moving or multiple characters, and multiple sources. If a localized effect is desired, a spotlight may be easier to control than a solar light which is more effective over a broad area. Consistent backlighting is also tricky to achieve in a wide-angle shot, especially if a character is moving across the frame. It may be necessary to animate backlights in these situations.

4.6.2.5 Kicker—for surface modeling and character enhancement
A kicker light is an *optional* light usually used to define the non-key edge of a subject. This light typically works from a three-quarters-back position and is placed nearer to the floor than the backlight. This light can be soft and diffuse or hard and specular, depending on need and the intended lighting style.

A kicker light is a more general name for a variety of lights which perform slightly different functions. The three main types are a kicker, a liner, and a glow light. When used to create a sheen (specular light), on a cheek for instance, they are frequently referred to as a kicker light. When far enough forward to contribute more diffuse light, it is sometimes referred to as a liner light. A glow light is a little farther forward still and is softer, non-specular, and shadowless. On people, it is usually desirable to avoid having a hot kicker light hit the tip of the nose.

4.6.2.6 Specials—to accent an area for either subject or background

A special is any type of light that is used for background and set lighting, or for highlighting an area on the subject.

4.6.2.7 Bounce Lights—to simulate radiosity effects

In computer graphics lighting, unless a radiosity renderer is used, extra lights usually need to be added to simulate the light that normally bounces off nearby surfaces. These lights are usually localized, non-specular, low-intensity and colored to mimic to the surface they are reflecting.

4.7 The Color of Light

4.7.1 Color Palettes

A lighting style is described as a chosen tonal range, but it also includes a color style as well. Color style is often discussed in terms of palette, consisting of hues and tones. In order to set a style, a fairly small selection of colors are chosen according to how they relate to each other. This selection, or palette, may consist of complementary colors, analogous colors or another of an infinite variety of combinations. The sets and costumes already have an established palette which the lighting designer may try to accentuate or minimize.

Naturalistic lighting mimics the complementary palette found in nature. The range is from yellow/purple to orange/blue to red-orange/blue-green in varying degrees of saturation. For a daytime scene, the key light is warm, simulating the sun, while the fill light is cool, simulating the natural fill of blue sky. A nighttime scene might reverse this sense with a strong blue key light acting as moon light with a soft warm fill emanating from incandescent indoor lighting. The eye is accustomed to seeing this warm-cool relationship in a wide range of color intensities. The contrast between warm and cool is minimized during the early to middle part of the day, and grows as the day nears dusk as dust particles in the atmosphere filter the color of the light A natural feeling still can be maintained even when using a strongly colored light which falls outside of this natural palette, as long as it appears to emanate from a visible practical source.

The similarity or contrast between lighting hues and saturation can help suggest the mood of the scene. Scenes which are lit with similar colors tend to be more somber than scenes which use extremes. The color of individual objects, sets and costuming evoke emotional responses of their own. The combination of these elements into a whole image also presents an overall color for emotional consideration. Lighting can be used to accentuate or minimize individual areas of color as well as setting the tone for the overall scene.

The placement and intensities of the lights also have an effect on the overall color. A low-key, almost black and white effect, can be achieved by minimizing object color saturation with the use of strong directional lighting. The emphasis falls on the shapes of objects rather than their surface colors.

Many new lighting designers are intimidated by using and mixing brightly colored light sources because they don't do what the designer expects. Most people have had experience with *subtractive color theory* since they have mixed colors together as paint or other pigments. It is called subtractive because if you mix the three primaries (red, green, blue) together, the result would be black. If you mix the three primaries of light together, the result is white light. This is called *additive color theory*. A quick study of additive color theory would give the new lighting designer confidence to explore the mixing of colored lights.

4.7.2 Color and Emotions

Early man's use of color was largely symbolic and emotional, based in mysticism and religion, and not necessarily chosen for aesthetic reasons. The palette for a culture was estab-

lished and adhered to within that culture, and was used to identify themselves by dynasty, race or tribe. Not until the Renaissance was color appreciated as an aesthetic choice.

Colors evoke physiological, psychological and emotional responses. These responses are a reaction to associations we make with our past experiences and cultural heritage. Two people can have very different reactions to the same color, and one person can have a varied reactions to the same color depending upon its context. Even so, there are enough common life experiences and contexts within which to draw some generalizations about how color affects us emotionally, especially in American culture where many of them have been stereotypically reinforced by advertising.

Colors are often referred to as being *warm, cool or neutral*. Warm colors are generally agreed to be those which fall within the red-orange-yellow spectrum, and cool colors to be within the green-blue-violet range. Neutral colors are those which are near grey in saturation value. Cool hues tend to recede and induce calm. Warm hues stimulate the nervous system and raise the heartbeat. Pure, saturated colors tend to advance and excite, while duller neutral colors tend to recede into the background.

Specific colors evoke more specific associations and responses. Red, for example, is an emotionally charged color which has many associations: anger, passion, fire, blood, violence, sunset, sex, adultery, aggression, power, creativity, embarrassment, and courage. It is also used as a universal symbol to stop or to denote when an error is encountered.

Green recalls calmer memories: nature, water, trees, mountains, meadows. It is an introspective, reserved color which evokes feelings of security, constancy, normalcy, balance, civility, convention. It is a suburban color for active healthy people. It is the color of money. Green is generally a positive color, although it does have negative associations, we have all heard the expression "green with envy". Green lighting can look eerie, chemical, artificial and unhealthy.

Blue can feel heavenly and religious and is associated with Western culture weddings. It feels spacious as it reminds us of the sky and oceans. It is a rational, conservative color which symbolizes authority, loyalty, order, peace, conformity, success, caution, and patience. Blue lighting can look gloomy, electric, and cold if there is no warm light to counterbalance it.

Violet and purple have been associated with royalty since the Roman Empire when only the emperor was allowed to wear it. It can feel magical, exotic, sensitive, sophisticated, idealistic, and cultured. Violet lighting in shadow areas can be very beautiful.

Yellow feels sunny, happy, and reminds us of summer days and flowers. It is also associated with intellect, wisdom, timidity, cowardice, and hunger. Yellow lighting is associated with midday and interior settings.

Orange is the social color, full of fun and cheerfulness. It is urban and outgoing. It has also recently become known as the safety and construction color due to its visibility. Orange lighting is associated with evenings, and interior lighting.

Brown is a homey and down-to-earth color, full of duty and responsibility. It is often associated with poverty and the lower class and is easily disliked. It is also associated with the past since objects tend to turn brown with time and exposure.

Pink packs more punch than other pastel colors. It can immediately portray someone as feminine, silly, delicate, floral, pampered, tender, healthy, wealthy, vain, and indulgent.

Black can look formal, elegant, and sleek. It can feel evil, empty, mysterious, anxious and fearful. It is associated with night, death, and inevitability.

White can feel pure, virginal, innocent, classical, and youthful; but it can also feel sterile and emotionless. White lighting is associated with high afternoon sunshine and daylight interiors.

Grey is the color of oppression and isolation. It can feel institutional, indifferent, sad, cold and heartless.

A person's response to a color is immediate, but is usually short-lived. After continued exposure to a color, the effect wears off or sometimes even reverses itself. It is the change from one color to another which triggers an acute response.

Researchers who study human response to color have established that people remember skin tones as being warmer or pinker than they really are. Human skin (real or computer generated) is more appealing in warm light and we like to remember it that way. Films are usually lit and color-corrected during printing to make skin tones look "rosy", and in general, films are usually color-corrected for the skin tones rather than for other colors or objects in the scene. Overall skin tones which are colored more realistically tend to give an image a documentary feel.

4.7.3 An Example Palette and Usage

The movie "Crimson Tide" is a terrific example to illustrate these points because it takes them to the *extreme*. The chosen color palette is pure saturated primary colors, red, blue, yellow, with the addition of pure green. The set and costumes are dominated by neutral tones with accents of these primaries. The main part of the submarine is lit with nearly neutral light as well. The overall intensity is fairly dark, with hotter rim lights, giving it an enclosed, submerged feeling. The intensely colored lights are used to place the viewer in different locations within the sub. Green light is used near the sonar screens, blue light in the transition areas, red light in the weapons room, and yellow hazard lights flashing everywhere to heighten the sense of urgency. The brightly colored scenes intercut with the neutral ones, which can be somewhat jarring, but you never get confused about where the shot is taking place (even with the sound turned off watching it for the first time). This intercutting also tends to heighten tension, mimicking the attitude of the flashing hazard lights.

4.8 Shaping and Controlling Light

Of equal importance to the placement and direction of light, is shaping and controlling it, illuminating the intended subject without spilling into unwanted areas. It is sometimes also desirable to create a defined light shape, either to mimic a logical source, or for dramatic or compositional purposes.

Many of the techniques used to control and shape light synthetically can be similar to those of live-action because the problems are also similar. These problems include controlling the light's size, shape, distribution, isolation, and coverage over distance.

It is desirable to break up large or even surfaces with varying light and shadow. Sometimes this can be achieved with deliberate, recognizable shadows from actors or props and sets, other times a more subtle overall variation will be appropriate. Barndoors, the four flaps attached to the sides of a light, can be used to shape and trim a source. The use of freestanding flags to block lights, can be used to shape light at various distances from the source, which allows control over the hardness of softness of the shaping. A cucaloris (or cookie), a rigid board with squiggly holes cut into it, can be used in front of a light to create a more random, organic light pattern.

A good computer lighting toolkit will offer a variety of light shapes along with sizing and soft barndoor controls. Further light shaping

can be accomplished with the use of blocker flags, slides and cookies, as well as light attenuation over distance.

Computer lighting has several benefits which do not exist in live-action. Lights and flags can exist anywhere in space without interfering with the camera or subject. It is also possible to illuminate a subject and not have the light affect other characters or the background, negative intensity lights can used to softly subtract illumination and shadows can be independently colored, blurred, and given an arbitrary density value. The apparent softness of a light can be independent of its distance from the scene, and resulting shadows do not necessarily have to be projected from the source point of the light.

Shadow quality and shadow placement to remove light from certain areas are methods for controlling light, creating emphasis, and establishing mood. The "Film Noir" lighting style often used superlative examples for controlling light to establish mood and influence composition. The film "Mildred Pierce" offers wonderful examples of not-so-subtle plays of light and shadow on both subject and background.

5. Creating Depth

The film medium is a two-dimensional surface through which light is projected. Any feeling of depth and three-dimensionality achieved is merely an illusion. This implied depth must be created; it does not happen automatically simply because the subject matter is three-dimensional.

5.1 Planes of Light

The separation of planes is a significant aspect of achieving depth through lighting. Most literature on live-action lighting discusses the necessity of creating *planes of light*, often without really explaining what it means or how to achieve it. A lighting plane is essentially a collection of objects or subjects which are parallel with the camera plane and are lit as a unit to contrast with other planes. These planes can be any distance from the camera and are defined with light for the purposes of creating the illusion of depth through layers.

As an example, a simple scene might nicely break down into four planes, from back to front: the view out a window, the wall of the room, the subjects, and a near-foreground object such as a vase of flowers. Lighting each of these planes in reference to each other will enhance depth. The foreground vase of flowers could be dark in silhouette, the subjects brightly lit, the background in partial shadow, with a bright view out the window. Each plane is clearly defined by its brightness.

This separation can be further accentuated by color variations between planes, with the subjects being in warm light while the background wall is lit with cool light. The subjects can also be further separated from the wall with a little backlighting motivated by the window. And as another step, the vase of flowers and the view out the window might be out of focus.

By finding ways to create planes of light, a scene becomes easier to visually organize. It also gains much added richness and beauty.

5.2 Volume and Space

Depth is also implied by feelings of volume and space. Volume can be created for individual subjects or other objects in the scene. Space is created by how these subjects and objects are compared to each other.

For individual subjects, volume can be accentuated using back and side lighting, by highlighting prominent features, and leaving the rest in shadow. In contrast, any light which emanates from the general camera direction tends to reduce the illusion of volume.

The three-dimensional quality and the feeling of space in a set can be augmented by using pools of light separated by dark objects or areas. For example, a long hallway has more apparent depth if only a few parts of it are lit with shadow areas in between. A subject which moves in and out of light imparts a greater feeling volume as the light travels over its surface, and a greater feeling of space as the subject travels over distance.

5.3 Perspective and Depth of Field

The motion picture image is a window into a world where the viewer makes intuitive comparisons to determine what they are seeing. Some of these comparisons are easy. If an object is bigger than another, it is probably nearer. If an object overlaps another, it is decidedly closer. At this point, the comparisons start to become more complicated. Does the object appear small because it is a small object or because it is far away? The brain looks for other monocular and binocular clues to establish size and distance. The converging lines of linear perspective are very helpful, but can be altered with the use of various camera lenses. As an example, a long telephoto lens tends to condense distance, making faraway objects appear very near. Focus and depth of field are also important clues, but are dependent on the lens focal length and aperture used. Aerial perspective is helpful, but it can vary depending upon atmospheric conditions. The brain also uses the angle between a light source and where its shadow falls to help determine object-to-object proximity. The viewer uses all of these comparisons to organize the image and to establish depth.

Depth of field is an inherent feature of binocular eyesight, hence it feels natural in a monocular camera lens. With a live-action camera, depth of field is determined by the focal length of the lens as well as the aperture used. Each lens has its limits within which it can operate effectively. With these limits in mind, a lens is chosen depending on the story-point, mood, filmstock, available lighting intensity, the actor's features, and compositional reasons. The choice is a technical decision as well as an artistic one. A synthetic camera has the technical restrictions removed, which makes the choice a purely aesthetic one. This doesn't mean that the choice becomes any easier. The lens and its depth of field determines how the viewer interacts with the subject. Two close-ups with similar subject framing can have dissimilar effects resulting from the perspective and focal depth caused by the choice of lens. One lens can place the viewer uncomfortably close to the subject while the other places the viewer at a more detached distance simply through depth of field. A close-up where the background is out of focus will feel more intimate than one where the background is sharp.

Depth of field is also important in establishing depth. A shot with varying levels of focus will have more apparent depth than a shot which is uniformly crisp. In addition, depth of field is useful for directing the viewer's attention to the subject which is in focus. Depth of field rendering is very convincing, although it can be expensive and is not supported by all renderers. Pseudo depth of field can be created by rendering the scene in planes and then blurring them by varying amounts during compositing. This solution is adequate for many close-ups where it is more frequently used. Another solution is to use a depth buffer image of the camera view and blur the final pixels based on their distance from the camera. It is even possible to pull a convincing rack-focus with these techniques, although it should be kept in mind that some blurring filters are more convincing than others.

5.4 Atmosphere

The use of atmospheric effects can enhance both depth and mood. Except for a windy day or immediately following a rain storm, some dust and water particles hang in the air which reflect and scatter light. These particles are particularly noticeable in direct sunlight where they create shafts of light. The mood these

shafts create depends largely on context and light color. Bright, warm shafts of light feel warm and cozy while cool shafts feel misty and foggy. Dingy, warm, irregular shafts feel smoky.

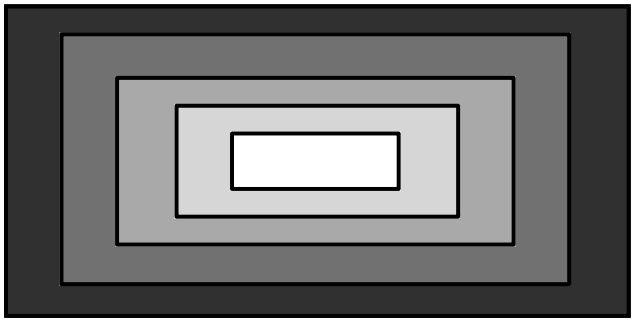
Atmospheric effects are also noticeable over distance where they create aerial perspective by minimizing color saturation and contrast. Smoke and fog machines are heavily used in live-action cinema to heighten these effects. In the computer aerial perspective can be created simply by adding a percentage of a fog color into the shading calculation for each pixel based on surface distance from the camera. For more complicated, three-dimensional effects, volumetric light shaders can be used.

5.5 Lens Effects

Other effects that enhance atmosphere and depth which are often used in live-action are lens effects. Diffusion filters or nets can be used to slightly soften a scene and glow the highlights. These filters can be used overall or just around the edges leaving the center clear. On the computer, gaussian filters and other image processing techniques can be used to reproduce these effects during compositing. Lens diffusion effects create a soft, sensuous, romantic quality. They are often used in close-ups to beautify actors, with less diffusion on medium shots, and none on long shots. Other filters frequently used are grad filters which darken or alter the overall color or density as a ramp across the lens, or as a vignette.

5.6 Depth Using Color and Value

Depth can be enhanced with chromatic and luminance separation. A warm subject over a cool background will impart more apparent depth than a subject and background with the same color temperature. Similarly, if the brighter side of a subject is placed against a dark background area, it will help define the shape of the subject, and keep it from blending with the background.



A further feeling of depth can be achieved by lighting the background more brightly than the foreground, with a blending of tonal ranges between. This is especially effective in a dark theatre environment.

6. Conveying time of day and season

Conveying the time of day and season is important to place the story and to illustrate passages of time. The time of day and season are major factors in determining the quality, quantity, motivation, direction and color of light sources for a scene. They also are major components in setting the mood.

For daylight scenes, being too literal about placing lights for the hour's sun position is not necessary and is often not aesthetically desirable. A general feeling for dawn, morning, afternoon or dusk is usually sufficient since light positions often need to move to be able to light subjects attractively, and the subtle time distinctions would be unnoticeable by the viewer.

At dawn, the light is blue, warming as the minutes pass. Slightly later, in the early morning, the rising sun casts long shadows, and the color of the light is slightly blue. At noon, when the sun is overhead, the lack of shadows tends to flatten the images and make color appear less vivid and interesting. The light tends to be very white in color, becoming more warm as the day progresses. In the evening, at sunset, the shad-

ows are long, and the color of the light appears more red. The low sun at both dawn and sunset rims figures and objects with light that separates them from the background and, depending on the position from which the scene is photographed, creates dramatic or romantic effects. For winter scenes, the light is usually colder all day and the light angles remain more horizontal. Light nearer to the poles tends to be cooler than light nearer to the equator.

Morning light feels optimistic and cheerful. The day is beginning with high hopes for what the it will bring. The air is fresh and you feel rested and rejuvenated. Evening light is romantic, but it is also a little melancholy. The day is coming to an end, slowing down, and you are getting tired. These daily cycles are repeated on a yearly scale as well; spring is a new beginning and the light is clear and cool, autumn light is warmer and nature is winding down for the year. An old person portrayed in a morning spring setting will feel more energetic and youthful than when the scene is set in afternoon autumn.

Day interiors are usually lit with soft lights except for any direct sunlight which may be shining through a window. The light sources are usually motivated by windows rather than practical sources in the scene. Day exterior lighting is motivated by the weather and the setting. There is much more license to modulate the light outdoors. Dappled lighting effects through trees or a cucaloris are frequently used, especially on the background.

For night scenes, hard, directional lighting is more justified, although soft light is also frequently used. The practical sources which are visible in the frame should determine the quality of the light. The illusion of night is created by the angle and the distribution of light. The angle of the light tends to be less frontal for a night effect, a three-quarters-back key light is frequently used with little frontal fill. Because there is less ambient and fill light in general, the percentage of well-lit areas in the frame is smaller, and specular glare becomes more noticeable.

7. Revealing character personality and situation

The quality, color, and direction of light can indicate to the audience impressions about the personality or character of the subject. It can also say something about the dramatic situation, or emotional state of mind, in which the subject currently finds himself. When a character is narrating a scene, he can describe his thoughts and how he sees the world; visual representation of his thoughts is not necessary. Most of the time, however, we require the use of our imagination to decipher the motivations and feelings of the characters by observing their actions, watching them emote, listening to them interact with other characters, and surveying their surroundings. It would be confusing to listen to a movie with the picture turned off, we rely so much on our vision to tell us what is happening, which is probably why we "watch" television or go to "see" a movie.

Visual clues are an aide for the viewer to help him understand the story more quickly or completely, getting him emotionally involved with the characters and their predicaments. Visual clues are comprised of tangible elements such as location, sets, props, wardrobe, time of day, time of year, that are almost taken for granted, but without which the viewer would have no context. Is it Elizabethan England in the dead of winter, high noon on the chaparral, or a humid summer night in New Orleans?

Besides establishing context for scenes, visual clues can also impart an emotional impression on the viewer by employing symbolism. My on-line computer dictionary describes symbolism as "expressing the invisible or intangible by means of visible or sensuous representations" as "artistic imitation or invention that is a method of revealing or suggesting immaterial, ideal, or otherwise intangible truth or states". Some of this is absorbed on a conscious level (the good guys wear white hats, right?) while much of it is subliminal.

Light itself expresses symbolism as life, freedom, clarity, hope, enlightenment, truth, and guidance. Darkness represents the opposing forces. The source type can also express emotion. Candles, for instance, are associated with happy occasions such as weddings and social dinners, as well as contemplative locations such as church. They are also nostalgic since they remind of us of times before electricity. Warm, soft, flickering candlelight is sensuous, flattering, seductive and romantic. Windows and doorways represent transitions. Our hopes "fly out the window", and "opportunity knocks" on, and comes in through, the doorway.

Light placement and direction impart emotional significance as well. Hard underlighting is commonly used to signify an evil or criminal character or situation. Soft underlighting can look very sensual. Lighting from directly overhead can look dreary when the subject is looking down, but spiritual, uplifting and hopeful as the subject looks up toward the light. Completely illogical lighting is often used in dream sequences or hallucinations, the more illogical, the better.

Whether we realize it or not, we attach symbolic meanings and react emotionally to virtually everything. Some reactions are innate, others are dependent on our culture, and still others are uniquely personal.

As a lighting designer (and visual storyteller) we can take advantage of these emotional reactions in how we choose to portray characters in a scene. The best way to learn how to do this is to study films (with the sound off) to experience how you are emotionally affected by what you see.

8. Complementing composition

The seemingly simple act of placing lights can radically change the composition and focal point of a shot. Good lighting can make a well-composed image stunning. It can also rescue a less-than-perfect composition. As an example, start with an unlit, staged scene and add just one light with its shadow. Move this light around the scene and change its direction, observing how the composition changes. As the light moves, shapes transform into different shapes as they become defined by light or lost in darkness.

Every shot is unique and requires its own analysis, particularly considering that each shot has its own story-point to convey. What works well for one shot might not be the answer for another shot. Most of the time, a shot will require the lighting designer to address several problems. The background is too distracting, too busy or too plain, the main compositional lines all point to a different character than the one with the dialog, or maybe it needs special care for it to cut well with the next shot. Trying to figure out where to start is often the most daunting dilemma for a new lighting person. The establishment of the focal point is the best place to start. In the process of creating emphasis for the focal point, distracting elements will need to be minimized. Once this has been achieved, how the remainder of the scene is lit will largely be determined by the lighting style.

9. Continuity

It would be wonderful if there were enough time to craft each shot as its own masterpiece, capable of surviving scrutiny on a gallery wall. But there isn't enough time, and sometimes it is also not appropriate. A complex composition takes time to study, and the eye can take its time meandering to various points of emphasis. A thirty frame shot needs to direct the eye quickly. The audience does not have time to guess where to look, the shot needs to have immediate impact.

The desire to craft each shot as a masterpiece also needs to be balanced with the necessity of a consistently lit sequence. It is very important to constantly check the lighting progress on other shots being lit in a sequence, especially if they are being lit by other people. Lighting will inevitably and necessarily vary from shot to shot, but the overall feeling of the shot should be consistent with its sequence and especially with its adjacent shots. Sometimes this means that lights need to be brighter, darker, warmer, cooler, or even repositioned to achieve a unified feeling as camera angles change. However, the more similar two shots are that cut directly together, the more important it is for the lighting to be same.

An establishing shot which shows a wide view of the set for a sequence, will usually require broad lighting strokes and often more light in background areas to establish the set. When the camera moves in for the close-ups, it is often desirable to darken the background slightly or move a shadow line to help the foreground subject to separate from the background. These changes should be unnoticeable to the viewer, and fortunately changes in camera angle and cut-away shots help hide these alterations. You can get away with more than you might think, but the only way to know for sure is to be able to view the shot in context. The computer lighting environment offers immediate feedback, as well as preview and comparison capabilities not found in live-action.

10. Film Considerations

Once a shot is lit on the computer, it is rendered and exposed onto film. It is then developed, printed and projected onto the screen, sometimes with surprising results. Colors and values can sometimes change drastically. Film can only capture a small range of the available light and color range of the real world. Film recorders may not even be able to reach the range of the filmstock. Video monitors vary widely and may not match the final result. For these reasons, it is preferable to view lighting tests on film whenever possible.

Although it is desirable to get as close as possible at exposure time, the printing process offers great latitude in altering color and density (brightness). This process is called *timing* the print. Each shot can be timed individually, but not varied over time. The timing is applied over the entire image, it is not yet possible to tweak isolated color areas as is possible in digital film-to-tape transfer sessions. It should be kept in mind that it is usually much easier to time a print darker than brighter. By brightening a print, more light is pumped through the negative which can result in a washed-out "milky" quality.

11. Conclusion

One of the most creative aspects of lighting is in finding ways to unify a screen-full of characters, objects and sources into a readable and believable shot. This is where everything discussed thus far comes together and starts bearing fruit. But, it takes practice to be able to look at an image and quickly know how to make it better. It helps to learn from other people, and to learn to look at images objectively. In art class critiques, instructors frequently turn all of the students' paintings upside down or sideways and then start the critique. The point is to teach the students to see things they wouldn't otherwise think to look for. It also helps to study classical painting, illustration, Disney animation, still photography, and to watch movies with the sound off. Observe the world around you at various locations, times of day and weather conditions.

Learning to light is learning to see, but requires more than keen observation. The most difficult and most important aspect to learn is visualization, the ability to see the final result in your mind before you begin. It is also important to be comfortable with what your tools can do. The final consideration is one which cannot be taught as inspiration. This you must find within yourself to nurture with experience and experimentation.

12. Suggestions

- Think about the story-point of the shot and the overall mood you are trying to evoke.
- Think about what logical sources might be in the scene which can help motivate the lights you are using.
- When attempting to complement a composition with light and shadow, it might help to first break up the composition into its planes. If the foreground or main character element is working well, it may help to try to take advantage of it as much as possible.
- A large flat shape does not always need added interest, it depends on the rest of the composition, but it often adds depth to modulate or ramp off the light.
- Very saturated colored lights will particularly alter a composition as they reflect unexpected hues back to the viewer. Some colors will go very dark and murky while others will leap from the screen and steal the show.
- Avoid the temptation of lighting dark shots too dimly. At least part of the image needs to be well-lit.
- Avoid placing a bright light which emanates from near the camera lens.
- Remember that one light cannot always solve two problems.
- Think about shot-to-shot continuity, but don't be too limited by it.
- Consider that lights which animate in position, unless they are attached to a moving object, will not look natural, use with care.
- Don't be too literal about the physics of it, go with what looks and feels right.
- Remember that there is *always* more than one right way to do anything.
- Investigate new ways to do things.
- Ask for new features in your tools.
- Experiment and get a second opinion.
- Share your successes and discoveries.
- Keep it as simple as possible.

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