T.C.
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ANIMATION PRODUCTION AND AN IDEAL ANIMATION STUDIO DESIGN

By

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ABSTRACT

Animation is an art form and a subject of science which has began researching in universities. Being an art form and a subject of science, animation needs to be taken from different perspectives. Besides it is an art form and a subject of science, animation has became an industry. Production of animation, by the artist has become a product of science and technology.

This research deals with the production states, the fields, the history, the evolution, the development, the producing artists and the structure of the production companies.

By the help of consumption power of the cinema industry, the animation studios are developing day by day. The structure of these successful companies have been examined during the research. It also examines the animation studios in Turkey which has failed to industrialize and the studios which are on the way to be industrialized.

A design of an ideal animation studio, presented in consern of Turkey's economical and socio-cultural state acording to the studies and resarches.

ÖZET

Günümüzde "Animasyon", üniversitelerde incelenmeye başlanan bir sanat ve bilim dalıdır. Hem sanat, hem de bilim dalı olması animasyon konusunun bir çok farklı açıdan incelenmesini gerektirmiştir. Dünya'da, özellikle Amerika Birleşik Devletlerinde bu konu sanat ve bilim dalı olarak incelenmesinin yanısıra bir endüstriye dönüşmütür. Animasyon, sanatçının, bilim ve teknolojiden yararlanarak oluşturduğu bir endüstri ürünü olarak değerlendirilmeye başlanmıştır.

Bu çalışmada animasyon ürününün, üretim aşamaları, kullanım alanları, tarihi, evrimleri, gelişimi, üreten sanatçıların değerlendirilmesi ve üreten kurumların yapısı incelenmiştir.

Dünyada sinema endüstrisinin sağladığı tüketim olanaklarından yararlanarak gelişen animasyon stüdyolarının yapısı ele alınmıştır. Türkiye'de henüz edüstrileşememiş fakat animasyon üretimi yapmakta olan ve endüstrileşme aşamasında olan kuruluşların incelemesi de bu araştırma içerisinde yer almıştır.

Çalışmada Türkiye'nin ekonomik ve sosyokültürel yapısı göz önünde bulundurularak, ideal bir animasyon studyosu tasarımı, yapılan araştırmalara dayanarak oluşturulmaya çalışılmıştır.

1 INTRODUCTION

Some people think that animation is used for keeping children busy. Some people think that it is a child's thing because it is simple and funny. But Animation is not something simple and not easy to produce. And it is definitely not just for kids. The idea of animating, giving life to still pictures has been around for thousands of years. From comic strips, ancient Egypt to the cell phone menus and to Hollywood, animation is a part of our daily life. It is an art form, with a lot of talented artists performs and it is also science, which great scientists work on it.

Today it is an industry in some countries, giving job opportunities to thousands of people and taking part in the economy of the country. And it is an industry giving thousands of products every year.

In this research we will be talking about the origins and traditions of animation though its history and the types of forms of animation. Then we'll discuss about the technical and artistically assets of the subject. In the part, which we are dealing with the industry, we'll see the studios in the USA, which the studios are above the production line. Then we will look at the studios in our country.

During this research I learned that the heart of this industry lies in Hollywood together with the movie industry. There are some other studios that are industrialized, but not that big in scale.

When we are talking about the studios in Turkey, there are some foundations on animation but it is very hard to call them studios. They have not been developed due to the economical and managerial problems.

In the last chapter we will be offering an "ideal animation studio design" from a managerial, technical and architectural perspective. It is a studio that can be formed in the economical conditions in Turkey.

2 WHAT IS ANIMATION

Animation means, literally, to breathe life into some thing. A simulation of movement created by displaying a series of pictures.

A forerunner of today's comic strip can be found in an Egyptian wall decoration circa 2000 B.C. In successive panels it depicts the actions of two wrestlers in a variety of holds. In one of Leonardo da Vinci's most famous illustrations, he shows how the limbs would look in various positions. Giotto's angels seem to take flight in their repetitive motions. The Japanese used scrolls to tell continuous stories.

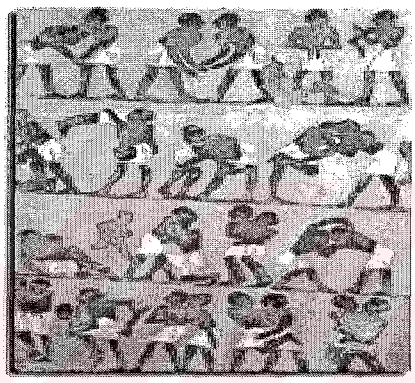


Figure 2.1 Early Egyptian drawings

Since the beginnings of time, human beings have tried to capture a sense of motion in their art. From the eight-legged boar in the Alta Mira caves of Northern Spain to paintings alongside the remains of long-dead pharaohs, this quest for capturing motion has been a common theme throughout many of mankind's artistic endeavors.

True animation cannot be achieved without first understanding a fundamental principle of the human eye: the persistence of vision. (Crafton,1993, p21)

2.1 Visual Perception

When a series of separate sequential images are momentarily placed in front of our eyes (such as when we use our flipbook) they appear to blend together and we no longer perceive them as separate but as a single blended moving image. (Kuperberg,2003 p4)

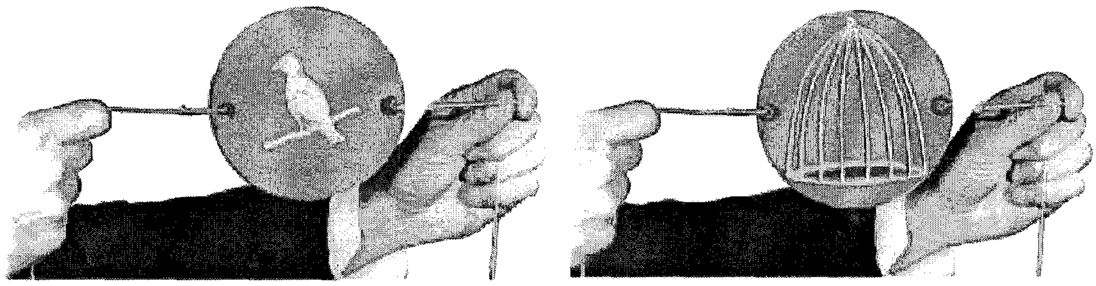


Figure 2.2 Bird in a cage illusion

This optical illusion is again due to the physiological phenomenon known as *persistence* of vision. It is simply that the retinas of our eyes retain the image of what we see for a fraction of a second after the image has been removed from our sight. It is this fact that allows us to perceive animation or motion pictures when in reality what we are viewing is a series of static images. The huge industries that rely on moving images (animation and motion pictures for cinema, TV, games, new media and Internet) are only possible because of this small quirk in our human 'visual apparatus'? We speak of a series of images being placed in front of our eyes in rapid succession. But how 'rapid' need this be to achieve the effect of a single moving image? That depends upon the individual but most people find that four images viewed per second appear to be clearly separate. Increase the speed to eight per second, and the images may blend together to some extent, but will seem very jerky. (Kuperberg,2003 p7)

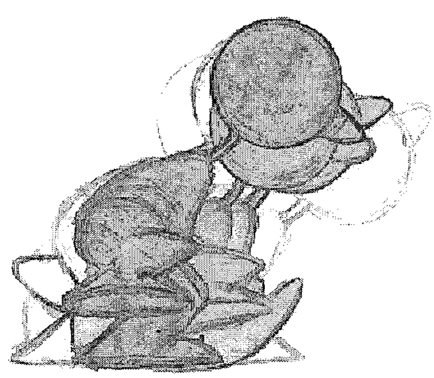


Figure 2.3 Frames in motion

At twelve images per second, the illusion of continuous movement is much better. Most of the Disney hand-drawn animation movies were shot at this speed: each frame shot twice and projected at the standard cinematic rate of 24 frames per second. In certain circumstances, such as when an object or character crossed the screen horizontally especially if the background had a number of vertical lines, e.g. a picket fence - the projected movie appeared to 'strobe'. For this type of sequence it soon became apparent that 24 f.p.s. produced a better, more fluid effect. Whereas the standard cinematic rate of film projection is still 24 f.p.s., TV images *are* 25 f.p.s. (PAL European system) and 30 f.p.s. (NTSC American system). (Kuperberg,2003)

Using the principles of persistence of vision to create the illusion of movement was one step in understanding the process of making movies. The other two main areas of understanding and technology that needed to be joined to this were the creation of a mechanism to shoot 'moving pictures' and finally a reliable mechanism to project these images.

2.2 History

2.2.1 Photography And Moving Pictures

From the mid 1900s the race was on to convert what today, we might term 'glorified toys', using the principle of persistence of vision, into a moneymaking entertainment medium. Many contributed along the way:

Joseph Nicephore Niepce, who in 1827 invented the very first film, using bitumen-coated pewter plate to capture the shadowy image of a rooftop near his window (it took eight hours to form), and William Henry Fox Talbot, an Englishman who in the 1840s took the next leap forward to create photography by producing images (using a wooden-box camera) that could be reproduced. He used paper coated with silver salts to produce a single image in the form of a negative - so that many more positives could be printed, the same basic process used today.

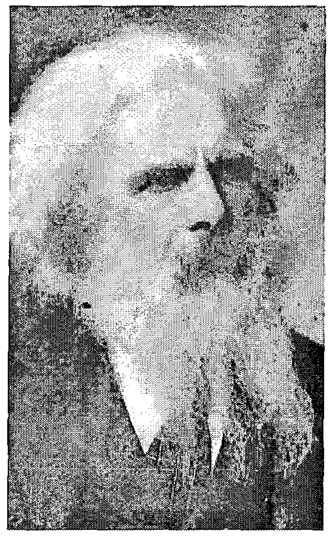


Figure 2.4 Eadweard Muybridge

2.2.2 Motion Through Imagery

Eadweard Muybridge the photographer, who conducted experiments to analyze different types of 1 movement of humans, birds and animals. (Kuperberg,2003)

Animation students and artists interested in frame-by-frame movement still refer to Muybridge's images to analyze frame-by-frame movement.

2.2.3 Capturing Movement With The Camera

The American inventor, Thomas Edison, and his young assistant, William K. Laurie Dickson, made the actual discovery of a way of making moving pictures using a photographic process.

Dickson began working on the project under Edison's guidance in 1888. They managed to make a movie camera, which was able to take steady pictures, which they called a “Kinetograph”. No one working in the field of creating moving pictures

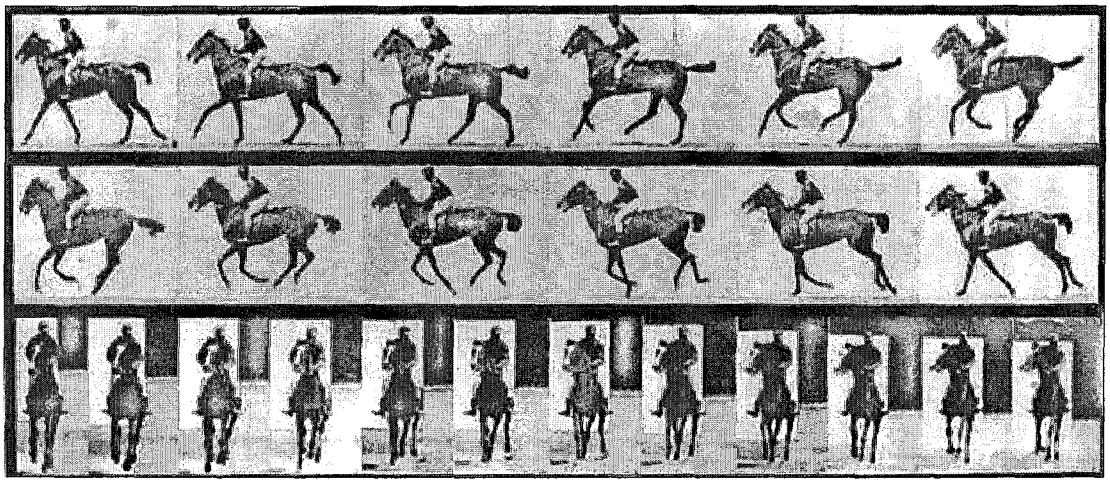


Figure 2.5 Still Photos of the horse

could possibly anticipate the impact that the movie industry would have in the next century. Nevertheless, Edison was well aware that the next logical step after the movie camera was to create a mechanical means of projection. It's easy for us to judge priorities in hindsight, and unfortunately, Edison asked Dickson to put aside the work on this project in favor of what he thought a better 'money earner' at the time - their 'kinetoscope', a coin-in-the-slot peepshow. Dickson later expressed regret that this left the field open to all and the Lumiere brothers soon stepped in with their own movie projection system. Only later did Edison put the finishing touches to his "home projecting kinetoscope"

Figure 2.6 Laurie Dickson

2.2.4 Group Viewing

Emile Reynaud was an artist, showman and inventor who was a contemporary of Muybridge, working in Europe. He invented a device that was a major step forward from the 'kinetoscope' in that an individual no longer had to peer through a peep hole or slot to see the illusion of movement: it allowed a group to see moving images that were reflected in rapid succession onto a prism by revolving mirrors. He called it a 'praxinoscope' and had it patented in 1877. Later, in 1892, he developed a further advance - his 'Theatre Optique', whereby images could be projected onto a screen and thus seen by a larger audience. Images were no longer confined to a short strip within a cylinder, they were painted onto a long ribbon that was wound from one reel to another. This projection equipment had two major defects:

- it was fragile and
- it had to be hand turned by a skilled operator, that ended up having to be Reynaud, himself.

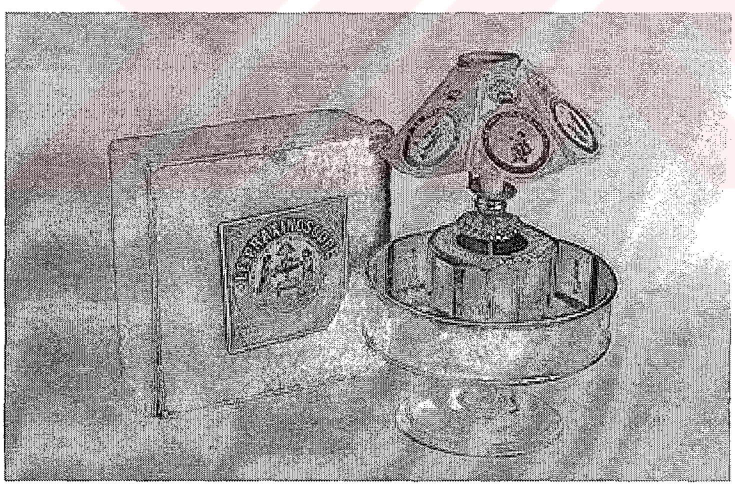


Figure 2.7 kinetoscope

2.2.5 Projecting Movies

The Lumiere brothers made the breakthrough of creating a means of mechanically projecting photographic images. The brothers ran Europe's largest factory producing photographic materials. Their film, called *La Sortie* des *Usines,* was

Presented to a scientific society in Paris in 1895 and showed workers leaving their factory. It was the first film to combine use of live action photography with mechanical projection. Louis Lumiere, himself, gave credit to those whose experiments in analyzing motion through imagery had contributed to his success, particularly Muybridge and Etienne-Jules Marey, who had been experimenting into the movement of abstract shapes photographed onto glass plates. At the same time, he pointed out that none of the instruments made by these men was able to achieve animation of more than about thirty images in projection.

2.3 Birth Of The Movie Industry

The first cinematograph screenings organized for a paying public took place in Paris on 28 December 1895 and were an immediate attraction, showing in London's West End a few months later. Within a year, Queen Victoria saw films made by the Lumiere brothers at Windsor Castle, which were accompanied by a full orchestra. These very early films were projected at 16 frames per second and were about 50 feet in length, lasting about 50 seconds. Within a few years the average length of films had increased, together with the number of cinemas and other exhibition venues.

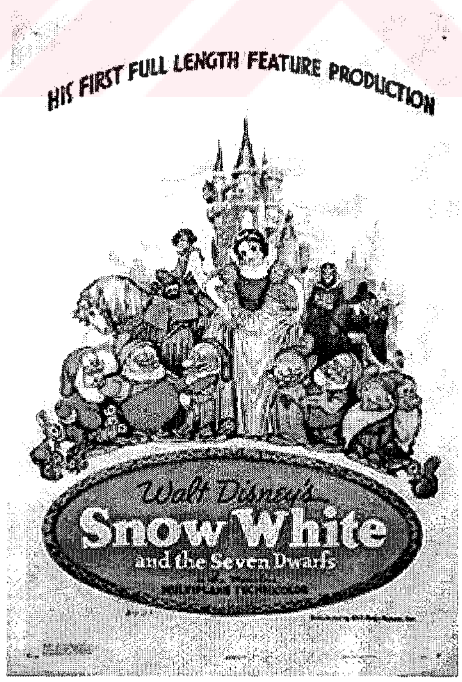


Figure 2.8 "Snow White and The Seven Dwarfs" the first full-length feature animated film

The movie industry was born: movies had suddenly become a novel form of mass entertainment throughout Europe and the USA. At this time audiences saw little difference between live action (real scenes shot with a movie camera) and animation (drawn or painted images photographed frame by frame). The fact that light and shadow on a screen created scenes and people that moved was enthralling enough.

In December 1937 Disney introduced the first full-length feature animation to a marveling audience the entirely hand-drawn, color *Snow White and the Seven Dwarfs*. In 1998, some sixty years later, the Disney Studios, with Pixar, achieved another milestone with the first full-length feature 3D computer animated film, *Toy Story*. This time, although the computer-generated toys looked exactly like real toys, the challenge was not so much to create the illusion of reality but to endow the 3D toys with individualistic character and personality, as was so clearly achieved with *Snow White*.

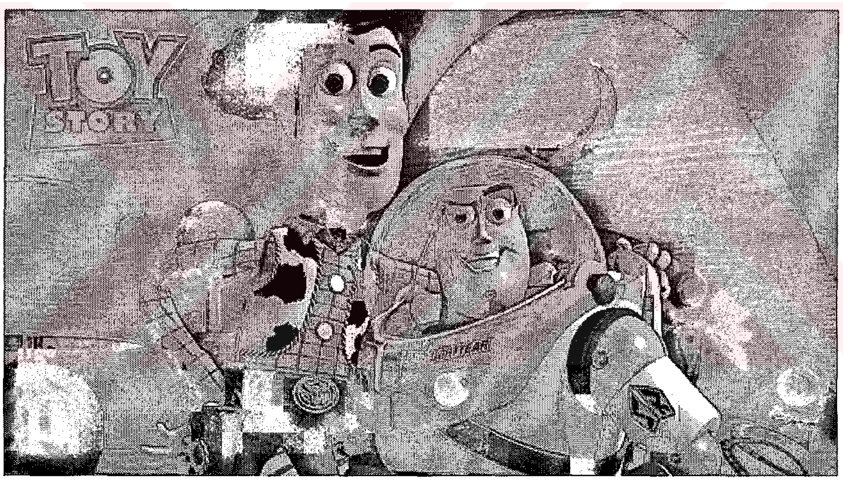


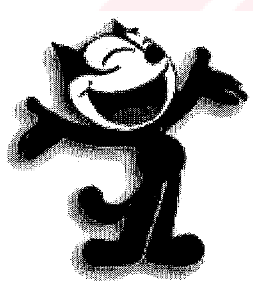
Figure 2.9 "Toy Story" the first full-length feature 3D computer animated film

Good characterization is often more difficult to achieve in 3D animation than in 2D work. From 1902 to 2002 and beyond we have seen the massive growth of an industry - and the growth of audience expectations. Initially people were enchanted just peering through a slot and seeing a cycle of hand-drawn images moving. Then they were enthralled by the vision of real things and people moving on a large screen. Now they expect to see the impossible happen and look utterly real.

3 ART OF ANIMATION

Animation is an image that changes over time. The element of time is the crucial ingredient in any definition of animation. Each art form has its own medium through which it communicates, but all can be grouped into two fundamental divisions: arts based in space, and arts based in time. Examples of the former include drawing, painting, sculpture, and architecture. Examples of the latter include music, dance, theater, and animation. (Crafton, 1993)

A painting exists on a two-dimensional surface such as a canvas or a wall; the image cannot be separated from its surface. The painting occupies a certain space, but exists outside of time. The image presented by the painter is still, frozen, emblematic; it is the culmination of a thought process. By contrast, animation exists in time. When we view animation, we see an image that begins at a certain moment, changes over a specific length of time, and then ends. Before and after the projection, there is no image or sound. Also unlike painting, animation exists separately from a particular surface; the same animation can be projected on a projection screen, on the side of a building, or on a computer monitor. So animation is a time-based event that happens again each time it is played.



Change is a measure of time. We experience the passing of time by the changes that take place in our environment and ourselves. Time-based art forms use the element of change as their primary vehicle of expression. Imagine time as a canvas. Each time-based art form will paint on that canvas with a different set of tools. A musician changes pitch, dynamics, rhythm, and tempo to paint a sound picture on the time canvas. A dancer changes body position, using physical shape, placement, direction, and gesture to paint a movement picture in time. An animator changes the qualities of an image, using line, color, composition, and texture to paint a moving picture in time. (Crafton, 1993)

Cinema (also called movies, film, or motion pictures) is the art of moving images. All cinema is based on the illusion of movement that occurs when a series of images are exchanged quickly enough that the human eye no longer sees them as separate images, but as a single motion. The images that make up the sequence are recorded on a medium such as film, videotape, or optical disc and then replayed on a monitor or projected onto a screen. In this sense, all cinema is animation. But cinema is commonly divided into two major categories: live-action, which includes fiction, documentary, and some experimental works; and animation, which includes cartoons, feature animations, some experimental works, and special effects. Where live-action and animation diverge is in the illusion of reality. In general, live-action cinema creates the illusion that what we see on the screen is real, while animation generally does not. In live-action, film or video cameras capture action as it happens in the world or on a movie set. These real-time recordings are then edited down to create a simulation of the original event, so viewers feel that they are witnessing the essence of the real thing. In animated cinema, by contrast, a sequence of pictures is built one at a time from materials that are clearly not alive. The materials are obvious; drawings, paintings, and sculptures, for example, are moved incrementally frame-by-frame to create the illusion that they are moving, but as viewers we are aware that we are looking at moving artwork. Awareness of the illusion is part of the attraction of animation. Special effects are a third category that overlaps both live-action and animation. The technique of special effects is frame-by-frame image manipulation, like animation; but the goal of special effects is the complete illusion of reality.

Animation is an art of movement. In this, it is related to such activities as dance, athletics, and clowning. Many animators have a well-developed kinesthetic sense, the ability to feel the quality of a movement the way that a painter feels the quality of color, or a poet feels the quality of a word. Each of us has this sense, although it may not always be developed. Animators develop their kinesthetic sense by observing movement in the world around them and by discovering their own innate sense of movement. If you watch people walking, you will see that people move in slightly different ways; some people may walk loosely, with arms and legs moving far out from their bodies, and others may walk in clipped steps, tightly wrapped around the core of their bodies. Or watch the movement of birds in flight; a swallow swoops and turns in small, quick spins, but a hawk glides and circles in wide, slow arcs. Each of us has our own innate sense of movement, which can be developed by being aware of our own bodies in motion. Some animators dance, play sports, or take acting classes. However it is developed, this sense reveals itself in visual choreography, in character acting, and above all, in timing.

Timing is the art of moving in meaningful ways. To understand how timing works in animation, consider someone waving to you from a distance. Why is the person waving? If you look at the timing of the waving, you may get a clue. Are they waving gently and smoothly? This might mean "bon voyage." Or are they waving frantically? This might mean that the ship is sinking. How does an animator create these different kinds of waves? The animator learns how to break down the action into a sequence of positions that show the significant stages of the movement, and then the animator determines how long each position should be held on the screen. These positions will be different depending on the quality of the action. For example, a gentle wave might consist of a sequence of fairly evenly spaced arm positions close together; to make the wave smooth and slow, each position might be held on the screen for two frames. On the other hand, a frantic wave might consist of unevenly spaced arm positions wide apart from each other, and the positions may be held on the screen for different lengths to create a more stuttered movement. With practice, an animator can recreate different qualities of movement by controlling timing.

Animation is also the art of combining image and sound. Sound dramatically influences how a viewer looks at images. Here are some examples. A loud sound occurring on a specific frame can make the image on that frame more noticeable than the images on surrounding frames. A sound can draw the viewer's attention to a particular part of the screen. Sound effects or voice recordings that are in sync with an image will make the image seem more real, and different musical compositions can impart different emotional qualities to a sequence.

Animation is not just a series of funny drawings strung together in movement. At its most creative, it is a truly beautiful art form. Yet the tradition j of drawn animation is a relatively short one compared with other visual arts. It has only been in this century that the technology to produce any film (let alone an animated film) has been available. Indeed, I have often thought that many of the Old Masters, from Leonardo da Vinci to Rembrandt to Hokusai, might well have committed themselves to animation, had the knowledge of filmmaking been available to them in their time.

Animated filmmaking, in its widest expression, is not, however, traditionally an art form of individual genius. A large team of dedicated, talented, and cooperative artists is required to complete a high-quality animation film. Successful animation demands a collective creative approach, within which each individual, no matter how talented, must harmonize and communicate with others for his or her work to be given its fullest expression on the screen. Problems can arise when the methods and terminology used by any one individual on the team are not compatible or familiar to the others. Although it is impossible to demand that all individual creative artists work in an identical manner one objective of this workbook is to offer a standard terminology and method of approach for all beginning animators as well as existing practitioners to work with confidently.

Admittedly, no one person can have a perfect understanding of animation. As in life, the animation artist may come to view only one or two facets of the greater whole. Style, taste, content, and objectives are many and varied, and this book cannot and does not provide all the answers. It is a guide to the accepted, traditional animation techniques devised over many years, and strives to be no more than that.

At its best, animation is a wonderfully varied art form, which potentially has no limitations on imagination or technique. Sadly, exciting ideas are often spoiled by inadequate animation ability and fall into a pit of undisciplined sloppiness. In addition to being an art, animation is a craft and, as with any craft, it takes time for apprentices to master it. The rudiments of the craft, however, can be taught relatively quickly. What then needed is patience, commitment, and effort, to make the basic principles come alive with new life and fresh ideas. In the early days of animation, Walt Disney established a fine tradition of craftsmanship, which we can only look up to, from our more humble position of expertise. What has been achieved once, however, can theoretically be achieved again if the will, the financial support, and the working knowledge are there.

3.1 Three Basic Principles Of Animation

Animation is the frame-by-frame control of images in time. The three most fundamental frame-by-frame principles are image change, registration, and timing. An image on the screen can change its size, its shape, or its surface qualities (color, texture, etc.). The illusion of movement is created by changing the relative position (or registration) of a sequence of images on the screen. And how an image moves (its timing) determines the feeling conveyed by the image's motion.

3.1.1 Image Change

Image change is the difference between any two images in a sequence of animation. In the most abstract terms, these changes can be in size, shape, or surface (for example, color, pattern, texture). For example a collection of blocks of different sizes and shapes are going to animated, and painted with different patterns. How the blocks are organized in time will determine the quality of their animation. For example, if we arrange them by size from smallest block to largest block, our animation will seem to show a block growing larger. On the other hand, if we arrange them by shape, starting with a tall rectangular block, progressing to a square block, and finally to a horizontal rectangular block, we will create the illusion of a block collapsing. Or imagine a single block with squares painted on it sitting in the middle of the screen. If we exchange it for a block with circles on it, and then a block with diamonds on it, we will create an animation of a block with a flashing surface.

3.1.2 Registration Points

A registration point is an imaginary point that follows the main path of action in a character or object. For example, the registration point of a pinwheel would be the center of the wheel. If you lined up all the images of the pinwheel so that their centers were in the middle of the screen, the pinwheel would spin in one place. On the other hand, if in each successive image you moved the center along a straight line from right to left, the animation would show the pinwheel moving across the screen as it spun. Another example might be a swinging pendulum. The pendulum consists of a weight at the end of a rope, and the rope is attached to a hook in the ceiling. In this case, the registration point is the hook the fixed point from which all other movement follows.

This idea can be applied to human movement as well. A child turning cartwheels is similar to a pinwheel, and a child on a swing is similar to a pendulum. Complex movements might require using more than one registration point. The primary registration point follows the primary line of action, and secondary points follow secondary lines of action. A human walking is an example of a complex movement; in this case, the animator might pick the center of the pelvis as the main registration point. Secondary registration points might be a knee joint for the bending of the leg and an ankle joint for the bending of the foot.

3.1.3 Timing

Timing adds feeling to a movement. Imagine a tree falling in the forest. With proper timing, the tree's fall can convey a sense of the resistance of cracking wood, the tree's size and weight, and a feeling of the impact as it crashes to the ground. The event can be separated into a number of movements. First, there is the beginning of the action as the tree slowly begins to topple, then there is the middle part of the action as the tree falls more quickly, and finally the end of the action as the tree hits the ground. There are two ways to control timing. One is in the drawings themselves (using both image change and registration), and the other is in the number of frames each drawing is held on the screen. For example, we can slow down the speed of the tree's fall by making more drawings of the movement, or by holding a drawing on the screen for more frames.

3.2 Importance Of Animation Techniques

Anything can be animated: drawings, puppets, cutouts, objects, and clay are only a few examples. The choice of a technique is a personal one, based on an affinity for materials. For example, Alexandre Alexieff worked as an. engraver of book illustrations. When he came to animation, he invented the pin screen, which simulated the look of his engravings. The following discussion presents some broad categories of animation techniques. These categories are not a definitive list; they are meant to start your thinking about materials. Play with materials. Explore the potential inherent in them to find techniques that excite you and spark your imagination.

3.2.1 Objects

Objects can be animated by replacing one for another, or by moving them frame-by-frame across the screen. Replacement animation requires finding a group of objects that have some feature in common. For example, a group of seashells can be animated according to size or shape. Replacing a small seashell with progressively larger shells of the same shape will create the illusion that the shell is growing. Alternatively, you could take a single seashell and animate it by moving it incrementally across the bed of a scanner or under a DV camera. In this case, the animation creates the illusion that the shell is moving across the screen. Any objects can be used with this technique beads, stones, trash, cloth, or just about anything else. Because of their physical presence, objects retain their identity as objects, and the animator may choose objects that suggest the idea of the animation. For example, in his film *Dimensions of Dialog,* Jan Svankmajer used fruits, vegetables, and other foods to create a surrealistic animation of two characters alternately eating and regurgitating each other. In this case, actually creating the characters out of food reinforced the presentation of a conversation as a form of cannibalism.

3.2.2 Cutouts

Cutouts are a subset of object animation that use pieces of flat material to create animation. The simplest cutout is a single shape without any moving parts. An example of this might be a collaged character cut out and glued together from newspapers or magazines. You could move this type of cutout across the screen as a solid shape. An alternative that allows for more complex movement is made from separate shapes. For example, you can create a character out of various body parts (arms, legs, head) and then move these individually on a scanner bed one frame at a time. These body parts could be separate, loose pieces, or they could be connected to each other with thread, wire, or some other method to create a hinged cutout. The cutouts could be created from almost any flat material, including paper, cardboard, plastic, cloth, wood, metal, and they can be painted, collaged, glued, or sewed together. In Yuri Norstein's films, characters are made from pieces of clear acetate eel (an example is *Hedgehog in the Fog).* The pieces of eel are treated in various ways painted, for example, or scratched to create a texture. The semitransparent cutout pieces create a sense of depth when they are layered on top of each other. Cutouts can also be used without creating characters. In *Frank Film,* Frank Mouris animated thousands of images of objects (food, appliances, cars, furniture, etc.) that he cut out of magazines.

3.2.3 Puppets

Puppets are moveable objects that can stand up on their own. They may be molded from clay, or they may be constructed from materials such as wire and wood. A popular example of clay puppets is the Wallace and Gromit characters in films by Nick Park and Aardman Animation Studio. Another choice is to make a puppet from aluminum wire. This wire (called armature wire) comes in a variety of thicknesses, and the wire skeleton can be covered in cloth, foam, paper, or clay to "dress" the puppet. The most durable type of puppet construction uses jointed armatures. These are hinged skeletons that can be used over and over again.

However you make your puppet, you will need some way to make the puppet stand up. You can depend on gravity, using the weight and balance of the puppet to keep it upright. Other options depend on fixing the puppet's feet to the floor. One of the simplest methods is to attach pins to the bottom of the puppet's feet and stick them into a foam core or Styrofoam floor. Other methods include screwing bolts into the puppet's feet from below a wooden floor, or fixing magnets to a puppet's feet and using a metal floor.

3.2.4 Pixillation

In pixillation the animator uses live actors as if they were puppets. Instead of moving a clay or wire puppet frame by frame, the animator asks a live actor to break down a movement into a series of still positions and hold each position while the camera takes a frame. This technique can be used to reconstitute a natural movement, such as a person walking across a room, or it can be used to create impossible movement, such as a person slithering like a snake over furniture. An example of pixillation is Norman MacLaren's film *Neighbors,* in which he tells a story about two men fighting over a flower. In this film pixillation is used to create stylized and speeded up action. MacLaren even paints expressions on the actors' faces, emphasizing their role as "puppets."

3.2.5 Rotoscoping

Rotoscoping involves tracing over live-action film frame by frame. In this technique, the animator begins by shooting live-action video. That sequence then is brought into a program like Flash, where the animator can draw on top of the live-action frames to copy natural movement. In Walt Disney's *Snow White,* for example, the characters of Snow White and the Prince are both traced from live-action footage of real actors. As a result, Snow White and the Prince move naturalistically (like real people) while all the other characters move in a stylized, cartoony way.

3.2.6 Time Lapse

Time-lapse animation is normally used to record and speed up natural phenomena. The camera is mounted on a tripod to prevent movement, and pointed at some natural subject (for example, clouds in the sky, a plant in a pot, or a pumpkin sitting on a table). Then a single frame is taken at regular intervals (for example, one frame every minute, every hour, or every day). The result will be a recording of compressed time. Clouds skitter across the sky, a flower blooms, or a pumpkin decomposes in a few seconds. Time lapse can tie up a camera and computer for a long time, but software such as Premiere can be set to take frames at regular intervals so that the animator does not have to manually take each frame.

3.2.7 Drawing

Drawing is the most common method of animating. By drawing, I simply mean making marks of some sort. This definition is a very broad one and can include a wide variety of techniques. For example, you could draw on paper with pencil, ballpoint pen, marker, crayon, charcoal, brush, rollers, or twigs. You could make marks with stamps, mono printing, or frottage (for example, rubbing a crayon over paper against a textured surface such as tree bark). You could use ink, watercolor, acrylic paint, smeared clay, or coffee grounds. You could collage by incorporating torn paper, stickers, tape, thread, and pieces of packaging in your drawings. You could include mechanical processes such as typing on an old typewriter or enlarging images on a copy machine. Drawing can include inscribing lines in clay, wood, metal, or plastic (in his films, Piotr Dumala creates animation by scratching into prepared blocks of plaster).

Just as you have many choices with mark-making tools and materials, you also have many choices in surfaces on which to make marks. You can draw on 8 1/2" x 1 1" sheets of white office paper, you can draw on *A"* x 5" index cards, or you can draw on large sheets of archival printing paper. You can draw on clear acetate eels, you can draw on photographs, or you can draw on sheets of metal. You can also draw on furniture, walls, or people.

4 PRODUCTION OF 2D ANIMATION

Animation, at best, is a costly procedure, in both time and money, and anything that eases its birth process should not be ignored. If audiences only knew all that is involved in any animated production, their respect for what I consider one of the most creative art forms would increase.(White,1988, p12)

American cartoon animation, or *character animation,* as it's now called, created not only a brand-new art and industry but also the first truly international audience for animated films. Cartoons have entertained viewers for almost three quarters of a century, and some contemporary psychologists might argue that the fantasy world of full-cell animation has reshaped the imaginations and the inner imagery of successive generations of children the world over. (Layburne, 1998, p171)

On a large-scale production, it is important that the team function efficiently. A typical team for the production of a large-scale animated film includes a lot of people: a director; a producer; a number of animators and assistant animators; possibly a team of in betweeners; a whole assortment of cleanup artists, tracers, painters and Tenderers, and special-effects artists; plus several checkers, editors, and rostrum cameramen. In addition, there is the production and administrative staff. Considering all the personalities involved, it is often a miracle that any animation films get made at all. (White, 1988)

The process of animation should follow certain structured procedures. But failing to respect these guidelines can prove extremely costly in time and money, regardless of the individual skills of the personnel involved.

4.1.1 Script

The first stage of any film production is the creation of the script, and, as for any other production, the script for an animation film is extremely important. This film script differs, however, from the live-action film script. With live action, dialogue is of great importance to the actor's performance. With the animation film script, on the other hand, dialogue is less important, and, indeed, complicated dialogue should be avoided as much as possible. It is the visual action in plot and performance that is paramount. The best animation is achieved through a form of mimed action, where dialogue is nonexistent and the visual invention captures the imagination.

4.1.2 Storyboard

Drawing the storyboard is the first step of visualization process.

From the script, the director produces a storyboard, a series of drawn images that graphically portray the action described in the script. Often, while producing the storyboard, deficiencies in the structure and format of the script are detected and corrected by the director. The storyboard, then, allows the writer, director, producer, and animation team to see and appreciate the content of the project. (White, 1988)

The storyboard should serve as a blueprint for any film project and as the first visual impression of the film. It is at this stage that the major decisions are taken as far as the film's content is concerned. It is generally accepted that no production should proceed until a satisfactory storyboard is achieved and most of the creative and technical problems that may arise during the film's production have been considered. (Whitaker, Halas, 1981)

The storyboard is the blueprint for the animation. The storyboard contains drawings, measuring at least 3 by 4 inches (7.5 by 10 centimeters) with accompanying text. The text describes the animation, any sound effects or music, and any dialog or narration. Within the animation studio, the storyboard serves to organize the creative aspects of the production. It establishes the level of detail required, the list of objects required in each scene, and the degree of texturing, effects, and other complexities that will be needed. Outside the studio, the animator uses the storyboard as a means of presenting his or her ideas to a client before initiating the expensive process of computer design. (Avgerakis, 2004, p28)

Figure 10 The Storyboards of "The Matrix Revolutions" by Steve Skroce

4.1.3 Soundtrack

The right choice of actors during casting, combined with a great performance during the recording, are two of the most critical steps in the production process. Since the voice track serves as a guideline and a source of inspiration for the animators, if it's weak, not even the best animators can produce good performances. The animation, timing, and overall success of the project, therefore, hinge on the quality of the voice track. (Winder, Dowlatabadi, 2001, p175)

After the script and storyboard are completed, the recording of any dialogue or key music is undertaken. Since animation relies totally on perfect synchronization of the picture to the soundtrack, the animator must receive the final recorded track before beginning to draw. Without it, the animator cannot time the action accurately. When the action is in sync with music, it should be possible to record a simple guide track, with a minimum of musicians, to indicate the essential beat and the basic melodies. A click track (which has a predetermined click, or beat, overlaid onto it) serves this purpose. (White, 1988)

4.1.4 Breaking Down

The midpoint of drawings between key frames; basically, the first inbetween drawing from which character positions on the other inbetweens are derived. In walk cycles, this midpoint is called the "passing position" because both legs are directly beneath the body, with one passing the other. (www.cbuilders.com)

An editor assembles it into the precise working length of the film and then breaks down the track when the soundtrack has been made. Basically, the breakdown is a simple process of analyzing the dialogue phonetically (by sound rather than by spelling) and documenting the precise position of each sound in relation to the film frames. If, for instance, a character begins to cough after one second of film time (35mm movie film is projected at 24 frames per second), the editor marks the beginning of the cough on the 25th frame and then indicates the subsequent frames through which the cough continues. The entire track breakdown is transferred to the bar sheet, a preprinted sheet designed to allow every frame of soundtrack and film to be identified and analyzed visually. (White, 1988)

4.1.5 Designs

While the soundtrack is being broken down, the director selects one or more film designers to produce visual interpretations of all the characters featured in the film. When these interpretations are approved, each character is drawn from a multitude of angles and placed on a single sheet of paper, called a model sheet, for all the animators to use as a reference. In addition to the character designs, at this stage, ideally, the background styling for all the principal sequences in the film is produced.

4.1.6 Leica Reel

An early version of the entire feature, which serves essentially as a filmed storyboard. A layout artist, shot, and synchronized with a dialogue soundtrack, redraws rough storyboard sketches to full size. It allows the director to get a feel for timing and how the film will look, and to make changes in visual content before the actual animation work begins. (www.cbuilders.com)

Using the bar sheets and storyboard, the layout artist (under the supervision of the director) proceeds to produce a Leica reel of the whole film. A Leica reel is, in essence, a filmed storyboard, which can be projected in synchronization with the final soundtrack. Rather than filming the storyboard drawings (which are often merely scribbles), the layout artist carefully draws each scene to the size at which it will eventually be animated. In addition, the layout artist draws the characterization in the precise style created by the film designer and describes, perhaps in more than one drawing, the action in that scene. When all the scenes of the film have been completed in this way, the director (using the bar sheet to obtain the relevant timings) has each scene shot on film. The director then views the finished Leica reel to get an impression of the way the film is shaping up. At this point the director can, of course, still make changes in the visual content of the film, before any of the costly animation work is undertaken. Indeed, the Leica-reel viewing is often the last chance the director has to change the film without affecting time and money costs on what is normally a tight schedule and budget. (White, 1988)

4.1.7 Line Tests

When rough pencil drawings comprising a complete scene (both key frames and inbetweens) are completed, they are shot to precise timing and checked. If the animation is working, the line test is cut into the Leica Reel, which, as more tests are added, slowly becomes a rough version of the entire film. (www.cbuilders.com)

When the Leica reel is acceptable to the director and producer, the animators finally become involved in the film and begin to produce a line test of each scene. Line tests are the animation drawings, produced in pencil on paper, filmed to the precise timings of the scene, as indicated on the bar sheet. Sometimes it is necessary to alter the animation several times in a particular scene, if the line test shows that the action is not quite working. Usually, however, the line test works the first time and the scene can be cut into the Leica reel by the editor, thus replacing the drawings originally produced by the layout artist. Gradually, as each pencil-animated scene is added, a line test of the whole film becomes available for viewing and for fine adjustment. Any major changes from this stage onward may prove extremely damaging to the overall film budget. (White, 1988)

4.1.8 Cleanup

Also known as "assistant animation," this is finalizing of art, with rough character action and background being retraced with a final smooth line in preparation for digital painting. (www.cbuilders.com)

On a major production it is ideal to have a team of cleanup artists on staff. They take all the animation drawings and clean them up, to give them a consistent visual style. This is important because, when many animators are working on the same character, there is an inevitable variation in the look of the character. After the entire cleanup is completed, it is best to line-test the drawings again, just to check that no additional mistakes have slipped in. (White, 1988)

The key clean up lead collaborates closely with the animation lead to draw the final clean up model sheets for character designs and poses. Before a production gets underway, the lead teaches team members how to draw the characters and their specific nuances. Once the scenes are ready for clean up, the key clean up leads are responsible for managing their crew, their assignments, and the workflow. Each scene first goes through the lead, who draws key character poses. The scene is then passed on to the key clean up assistant, who adds in more key drawings, preparing the scene for the artists to follow. The lead's and the key assistant's drawings function as a guide for the rest of the team. Their work illustrates how to translate therough animation and how to handle the scene based on its length, the size of the character, lighting, and camera movements. Not all drawings require detail. This is the case in scenes in which the action takes place in semi-darkness, for example. The reverse would be true of a close-up "acting" shot where the animation takes center stage. The assistant creates secondary keys while closely following the drawings completed by the lead and the key assistant. Next, the breakdown artist takes on the scene and produces more secondary keys, filling in the gap and readying the scene for the inbetweener. As indicated by the title, the inbetweener creates the drawing between drawings with the aim to match all the preceding artwork and wrap up the scene. This is an entry-level position that enables an artist to become acquainted with the principals of animation and learn the necessary drawing skills to move up the ladder. (Winder, Dowlatabadi, 2001, p227)

4.1.9 Trace and Paint

When a cleaned-up line test is finally approved, each drawing is transferred to a thin sheet of celluloid and painted in the colors of the original design. In the early days of animation, transferring the drawings to reels involved large teams of trained artists, who carefully traced each drawing required in a varied range of line techniques.

Today, however, it is possible to quickly photocopy a drawing on the reel or for the cleanup artists and animators to draw directly on the reel itself, avoiding the pencil stage altogether. After the animated image is on eel, and in preparation for the final shoot, a team of artists paints the eel in opaque colors on the reverse side to the drawing, thus keeping the paint from going over the lines and producing flatter, smoother colors.

4.1.10 Backgrounds

While the animation is being traced and painted, another team of artists produces the backgrounds everything behind or, sometimes, in front of the moving characters that does not move. Each background artist must achieve a continuity of style by producing work identical to the original film design style. (White, 1988, p15)

The background painter is a combination lighting expert and set painter. At this stage, the setting that has up to now been in black and white is finally ready for the world of color. The background painter's job is to take the cleaned up layout and apply color, thereby giving the objects weight, dimension, and texture and creating mood and atmosphere. (Winder, Dowlatabadi, 2001, p230)

4.1.11 Checking

As the finished animation reels and backgrounds are completed scene by scene, they are passed to the checker, who makes sure that everything is correctly drawn, traced, painted, and prepared for the cameraman who is to finally film it. It is essential that the checker is efficient; incomplete or incorrect work discovered during the final shoot results in wasted time and money. (White, 1988, p15)

An animation checker flips the scene's drawings, verifying whether the animation is inbetweened properly and works with the clean up layout. They check the clean up drawings to determine whether they are on model and accurate in terms of scale. The checker also studies the actual cleaned up animation and visual effects drawings for line quality and color demarcation lines, which are not apparent on pencil tests. The checker is responsible for catching any continuity mistakes and correcting them. If, for example, a character has a bandaged left arm in one scene, but in a subsequent scene, the bandage is on the right arm, the animation checker asks a clean up artist to remove the bandage from the wrong arm and redraw it on the correct arm. If, for example, an explosion occurs in a scene and continues into the next scene, but the intensity of effects is inaccurate, the animation checker enlists the help of a visual effects artist to add, delete, or alter additional drawings for continuity purposes. (Winder, Dowlatabadi, 2001, p232)

4.1.12 Final Shoot

When the checker is satisfied that all the artwork for each scene is right, the artwork is passed on to the rostrum cameraman, who shoots the completed scene. As its name implies, the final shoot is the final stage in the actual filming procedure related to the artwork. (White, 1988, p15)

the final checker retrieves and assembles all artwork specifically created for the scene. The checker makes sure all elements such as mattes are in place and that the scene is ready for final output. Taking one last look at the scene, the final checker makes sure that it is literally picture-perfect before it is rendered at 2000 dpi or 2K output. (Winder, Dowlatabadi, 2001, p238)

4.1.13 Answer Print

Depending on the production, the scene is then transferred to film and/or video in preparation for final color sweat box approval and completion of the production phase. (Winder, Dowlatabadi, 2001, p238)

From the double head, the editor orders an answer print from the film laboratories. This involves merging the sound and picture on one piece of film after an extensive session of picture grading (checking, scene by scene, that the colors of the picture are accurately reproduced). The sound aspect of an answer print, called an optical track, entails the transfer of all the sound elements of the film to a varying-intensity visual format. There is now a thin, visual strip along one side of the film and, when light is projected through it, the variations in light intensity are converted by the sound system to variations in sound intensity. (White, 1988, p15)

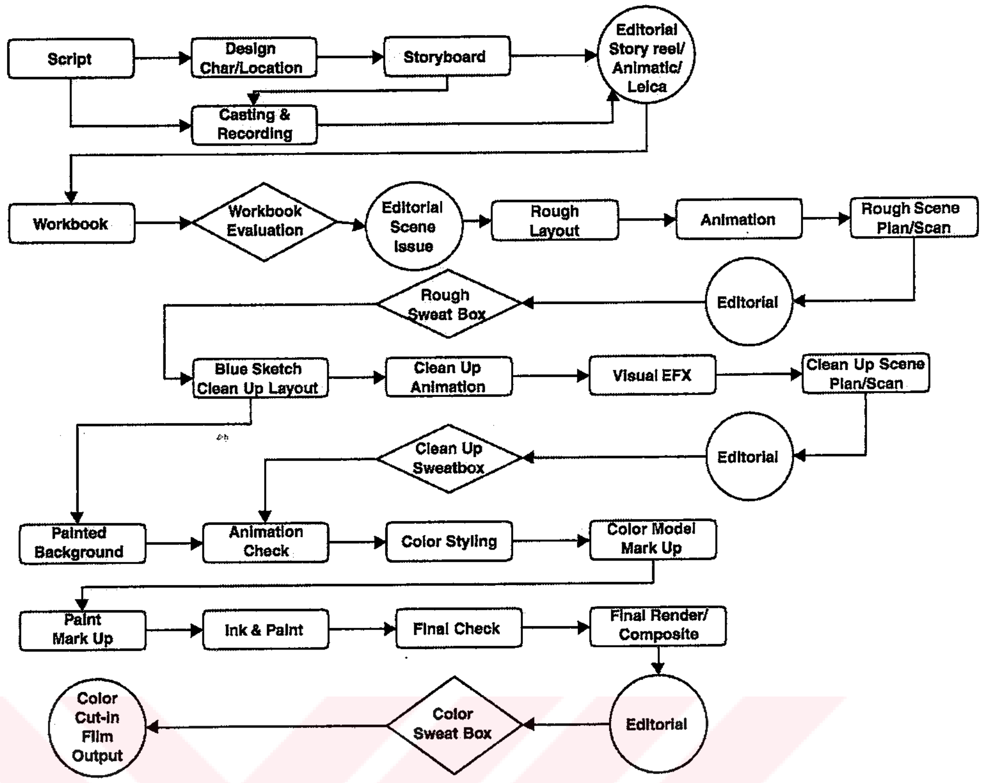


Figure 11 Animation production work flow

4.2 Japanese Animation

While for most western people manga is a word which is related almost exclusively to a style of film and children's animation, the origin of Japanese cartoon drawing was almost eight hundred years ago, and began in temples.

Around the beginning of the thirteenth century pictures began to be drawn on temple walls, depicting images of the afterlife and of animals. These pictures were crude and deliberately exaggerated representations, and bear a remarkable similarity to modern manga. This phenomenon continued over hundreds of years, branching out to include numerous other subjects, although the style remained the same.

Around the start of the 1600s these pictures were made attractions in themselves for the first time, they were not drawn on temple walls but on wood blocks. These were known as Edo, and the subject was less religious, often graphically erotic, although they branched out once again to include various other subjects, particularly buildings and satire. At around this time the word manga was first used to describe the artistic style. The pictures were by now generally composed in monochrome, with simple outlines and rudimentary blocks of color, which forewent shading. The subject took precedence over the method of representing it.

In 1702 Shumboko Ono, an early celebrity manga artist, made a book out of prints of these pictures with captions, although it was a collection of pictures rather than a progressive story. This method developed over the next hundred years, in books, which combined stories with illustrations for every paragraph, allowing the art to be just as sequential as the narrative and the narrative to be more frenetic and pacy. The tradition of Toba-e, as these comics were called, grew over the next century, until they were the main form of literature for most of Japanese society. (http://oror.essortment.com/mangahistory_rioh.htm)

Figure 4.12 Osamu Tezuka

"Walt Disney of Japan", "God of Comics", "A Legend in his Own Time". Many of these phrases will forever be used to describe Dr. Tezuka, but mere words cannot even begin to describe his work, or how it changed an industry, or even the incredible wealth of material produced by this one man. As I began to research this article, friends sent me copies of magazines that attempted to detail his works, and among them, I discovered that the more I learned about him, the more I realized how little I knew. This single person output more Manga than can be detailed in these pages. The sheer volume of his works could fill several warehouses. There are those much more qualified to explain his Manga history, and I will leave that task to them, and instead, I will concentrate on his animation career.

Osamu Tezuka was born 1926 in Osaka, Japan, the son of a doctor. According to Tezuka:

"My career as an animator began when at the age of 4 I copied a picture of Popeye. My house was full of comics when I was a schoolboy. Because we were able to obtain a projector and several films, I was able to see Mickey Mouse, Felix the Cat, Chaplin, and Oswald Rabbit at home. When in the third grade in primary school, I drew comics in my notebook, which was immediately taken away by the teacher. Later, however, he encouraged me with praise..." The then still young Tezuka was heavily influenced by Disney and especially the Max Fleischer cartoons of the period. The early 1930's character designs coming out of the New York based Max Fleischer studio featured round heads, and large round expressive eyes. (http://www.tapanime.com/info/history.html)

Today the main exports of manga are either children's television or manga films for a more selective audience, but in Japan manga is still primarily used in the form of paper cartoons, and for purposes other than entertainment. A guide to economics has been printed in manga, and most magazines targeted at all age groups are framed in manga.

The difference between the styles of animation in the USA and Japan is primarily down to this audience difference. Japanese children's manga has many similarities with American Disney animation, with simple color schemes, minimal backgrounds and the characteristic enlargement of the heads of characters. The animation is also minimal, allowing the way the characters are drawn to be more important than the way they move.

However, manga films like the classic Akira, which are aimed at an older audience, have a very different style, using intricate backgrounds to set the story, and complex animation to give the illusion of reality while being able to manipulate characters and physics more easily than would be possible on real film, while retaining the empathy with characters. The most significant difference tends to be in the shading, while western animation uses two tones per surface and keeps the movement of color consistent with the general stillness of the animation, manga animation tends to be shaded with three tones which contrast more with each other, and to allow this shading to fluctuate between frames, giving an illusion of constant movement and realistic unpredictability both in the light and the actions of the characters it illuminates.

Overall manga is becoming more and more prevalent in Western animation, both in children's animation and in animation for adults, which is becoming more of a presence in America and Britain every day. (http://oror.essortment.com/mangahistory_rioh.htm)

4.2.1 What is Anime?

Anime (pronounce as ah-nee-meh) refers to Japanese animation. The actual word is borrowed from the French term for animation. Japanese animation is a distinctive form of animation that is almost always noticeable by either the style or quality. Unlike American animation, **not all anime is targeted to young audiences**. Subjects in anime range from the obscene to the insanely cute, this is because Japanese censorship laws are different from many other countries. Related to anime is **manga** (pronounce as mah-n-gah). Manga is what comics are called in Japan. The word manga was coined by the artist Hokusai in 1815, usually translated to mean "irresponsible pictures."

Anime and manga are significantly different from their counterparts in America. For the most part, cartoons and comic books in America are thought of as geared toward youngsters. Cartoons and comics books in Japan are geared towards all ages. While there is a large amount of American animation and comics, which are intended for older, more mature readers without the need for bulging superheroes, they are seen as something separate from the conventional line of comic books (hence DC Comic's Vertigo label as a separate entity from its normal titles). Millions of subway riders in America pass their time reading novels on the train. In Japan, you're just as likely to see someone reading a comic book.

4.2.2 Not Necessarily for Kids

Many people assume that since anime is a style of animation cartoon it means that they are simply cartoons for kids only. While there are anime made with a younger audience in mind many can appeal to people of any age group. In fact a single anime can appeal to both kids and adults at the same time. The younger viewers may like it for the action, humor and the general "look" of it. At the same time older viewers will enjoy it for these reasons and the certain subtleties that kids just couldn't fully grasp or appreciate.

Since anime is designed with more than just kids in mind there are brands of anime that contain levels of violence and sexual reference that most North American people would never expect to find in an animated show or movie.

Why do fans *love* anime and manga?

That depends upon the taste of the individual viewer. However, some of the contributing factors, not in any particular order, may include:

Intricate plots and storylines. *Most* anime and manga consist of a great storyline, and there is a great amount of detail, which you have to look out for. In general, Japanese culture is less hung up on nudity and violence, but this *does not mean*, however, that anime and manga have less plot; quite the opposite in fact. Anime and Manga are *usually* less cliche'd, and contain much more variety and life than most western animation and comics, not to mention quite a few live-action shows and movies.

Wide variety of topics and styles. There are anime and manga to fit any and every subject, ranging from the very silly to the very serious. Be it action/adventure, comedy, fantasy, horror, martial arts, science fiction, or sports all genres are represented. Also, anime and manga are *usually* not specifically intended for any particular age group, which adds to their broad appeal.

The Emotions. Anime and Manga tend to be very emotional. Be it an action/adventure, comedy, romance, or tragedy, anime and manga fire up emotions that other animation and comics and even non-animated shows fail to do.

Great artwork. The animation and artwork in anime and manga *usually* far surpasses other animation and comics, both in detail and style. Anime and Manga characters are drawn to fit an environment, and don't appear like two-dimensional add-on's. And yes, everyone notices the big eyes that some anime and manga characters have. Though many traditional animation fans see Disney as the pinnacle of animation achievement, anime tends to concentrate on a higher level of detail in the artwork rather than fluidity of motion.

4.2.3 Anime on American TV

You might have seen anime on TV and elsewhere! Over the years it has been molded to fit American audiences (or at least what TV producers think American audiences are). If you've lived in the 1960's... you might have seen **Speed Racer, Kimba the White Lion, Gigantor or Astro Boy.**

The 1970's to the early 1980's... you might have seen **Battle of the Planets** and **Star Blazers.**

The mid-1980's... you might have watched **Robotech** and **Captain Harlock and the Queen of a Thousand Years** on TV or played **Cliffhanger** and **Cobra Command** in the arcades.

The 1990's... You might have seen **The Ronin Warriors** or a multitude of anime actually referred to as anime on TV, in stores and in the theaters. Most recently, anime came to Americans in the forms of the theatrical film **AKIRA** or on television in the guise of a children's show **Sailormoon**.

If you take your time and do some research you will see anime has exploded onto TV in the US. The Cartoon Network, Fox, WB, TechTV all have anime being shown there will always be a way to watch it no matter where you go. Also The Anime Network will be your best channel to check out first. (www.tapanime.com)

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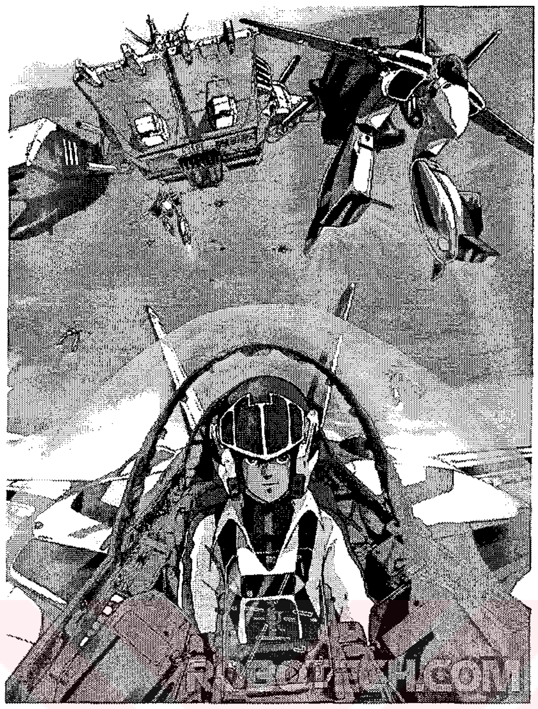

Figure 4.13 Robotech

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Overall manga is becoming more and more prevalent in Western animation, both in children's animation and in animation for adults, which is becoming more of a presence in America and Britain every day.

4.2.4 Characteristics of Anime Drawings

1.) **Hairs** - Anime hairs come in many styles, shades and colors. A good amount of anime characters have pointy hair styles which looks kind of cool. Hair can go from normal to far extreme, either way it's always fun. **Subnote:** You will see some characters where the hair disappears behind the characters eyes or just goes way and reappears under the eye. This is used to make it easier not to redraw the face when the character blinks etc.

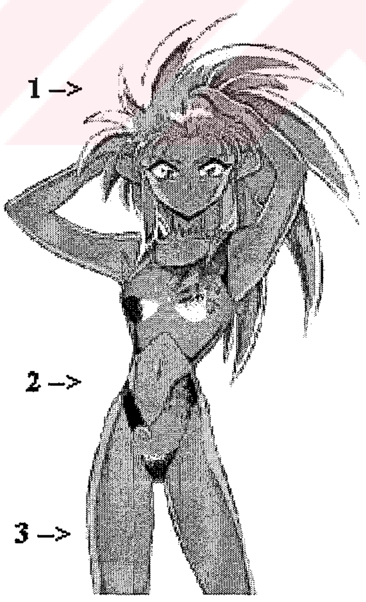


Figure 4.14

2.) **Waist** - The waist is always very slim, small and tiny - For female characters. Male characters will vary but also are in some, slim, small and tiny as well.

3.) **Legs** - Legs as the waist is very hmm nice slim and take up, on some characters, 3/4's of the body.

Eyes - There are two main type of eyes in anime. Anime characters with small eyes are usually serious, pretty or good looking. Large eyes can usually be found on a cute, childish or playful anime character. Big eyes, even large, giant eyes are charactaristic features of anime characters that is very frequent. The general reason for this is that eyes are seen as a window into the soul and the larger eyes are meant to give the viewer greater access to the character. Besides, those big eyes make many characters cuter.

Mouth - Characters' mouth gets bigger when they are expressing something big or just shouting and gets smaller when they are talking softly about something or someone (probably bad things).

Bouncy, Bouncy - It's not too hard to figure out what this is going to be about but for newbies let me some it up for you, the female breast in anime can defy the laws of gravity. Gainax I believe was the first to use this technique. This doesn't mean all female characters display this characterist just that they have this power if they feel it is needed, I guess you could say.

Figure 4.15 Smile of a Japanese Animation Character

Super Deformed - If you either are new or old school fan of anime you will at some point run across a character that either is or changes to a super deformed character. A super deformed character is just a small verison of the original character, sometimes child-like or silly, waky. This normally occurs because of some emotional responds or meant to be funny. A good example would be Ah! my goddess series. You have the original series then you have the Adventures of Mini-goddess, which are meant to be funny.

Lots of Nudity - Anime can contain lots of nudity, the reason being is that to the Japanses Culture nudity is no big deal. As it is over in europe, Nudity is something common and nothing out of the ordinary.

Next would be more expressions than appearences but they work together because sometimes the expressions will change the appearance of the character's physical appearence.

Giant Tear Drops - The tear drops can be small and multiply, as well as being, giant. They appear on the side or back of the heads of the character. Reasons vary why they show up it can be from embarressed, pissed off, fear, nervous, or them being stupid. Sometimes they will grow bigger or smaller and run down the face or back of the head, but when the next shot and/or camera angle hits it will be gone.

Nose Bleeds - Nose bleeds happen to both female and male characters. I will go as far as to say it is more 99% male than female. Characters get nose bleeds when the site of the member of opposite sex shows too much skin and/or are seen naked. This happens to all characters but mostly are either complete perverts or virgins. **Subnote:** Sometimes the character faints due to the shock and/or loss of blood but recovers quickly.

The Blushing - When characters blush could be from many varied reasons such as:

embarressed, happy in love, and being drunk. Blushing sometimes will fill the whole face when embarressed and most of the drunk and happy in love you'll see little light blush marks under the eyes on the cheeks.

Crying Rivers - You will many different varies of crying. It will depend on the situation, some will do the few tear drops which are easily wiped away and thrown, then you'll see some big long streams of tears down the face about an inch thick - the path sometimes is straight or can do a zigzag pattern. Then you will see characters cry so big where is like a hose is put under the eye then turned on and the water flies out of the eyes and disappears before it hits the ground in most cases.

Pulsating, Bulging, Blood Vessels - This is common when the character is stressed out, angry, frustrated, or over exertion. You will see blood vessels appear either big or small depending on the character's mood and can grow in size if the cause continues. They do not always appear on the head, you sometimes will see it happen on the hand or other body parts but either hand or head is the most common.

Mouth Expansion - Characters mouths can easily grow bigger or wider than the face itself. Most of the time this happens when shouting and/or mischievous smiles.

Nose Bubbles - The nose bubbles will indicate that the character is sleeping and will always pop when they become awake.

Peace Sign - The peace sign, doesn't really mean peace in the anime world it is for "I did it" or "I made it" every once in a while it will mean peace.

Sneezing - When a character sneezes it means someone is talking about them behind their back.

Cute - If it's cute, Its Deadly! Many creatures and people in Japanese Animation that are cute are almost among the most powerful in the story. Take for example Ryo-ohki, a creature that looks like a rabbit and meows like a cat. She may look harmlessly cute, but don't let that fool you. Ryo-ohki has the capability to transform into a spaceship with enough firepower to level mountains. I shudder to think what a Care Bear would do in a Japanese Animation world.

Skirt - Skirt peeks a plenty. If there is a girl wearing a skirt, we will see her panties, and if she is in battle, her shirt will rip off, wearing a bra only if show is aimed at those under the age of 20. If the girl transforms her outfit, such as when they go into battle, what she was wearing rips off leaving her temporally nude and is then clothed into a new outfit.

Face fall - Face fault is a term used when a character is so shocked by a comment or action they fall down, usually face first. Face faults are normally reserved for the humorous Anime shows like Ranma 1/2.

Dimensional Objects - In many comedies, especially romantic ones, when a female gets upset at a guy, normally ones they are in love with, she pulls a large hammer or mallet out of nowhere and hits him with it.

4.3 Mixed Media

Because animated filmmakers are completely in command of their material, they are at liberty to select and use images from any source.

The mixing of methods is almost as old as cinema itself. George Mêlées in the 1900s employed all kinds of ways of making images, with live-shot actors - shot either stop-frame or running camera-joined in the same frame with models and drawings. He regarded this as a natural way of exploiting the film camera. In time, however, animated cartoon drawings came to dominate the commercial cinema, and were consequently the form most familiar to the public. Any reversion to combining cartoon drawing with other visual tricks was regarded as mixing an alien strand into the standard form of the medium.

Figure 4.16 Mixed Media, Jerry Seinfeld and Superman

Among the most familiar examples of these mixed-media tricks are Mickey Mouse shaking hands with Stowowski in *Fantasia* and Gene Kelly dancing with Tom and Jerry in *Anchors Aweigh.* Together with other sequences in Disney films *(The Reluctant Dragon, Make Mine Music, Song of the South)* they were interpolations of mixed-image sequences into films that were otherwise all animation or all live-shot.

Figure 4.17 Who Framed Roger Rabbit

It was not until *Who Framed Roger Rabbit* in 1991 that a complete feature film was conceived in which live actors and drawn characters fully interacted throughout. This film was based on a script written in the 1950s, and probably had to wait until the recent developments in digital effects could overcome the problems of giving real unity to the cartoon and live elements. The subtleties of natural lighting are usually at odds with the uniform tone of flat drawn animation, but in *Roger Rabbit* great care was taken to give the correct light and shade modelling on the cartoon figures. Then the blending of them with the live-shot actors and scenery was governed digitally so that the fine variations of lighting were the same for both sets of images.

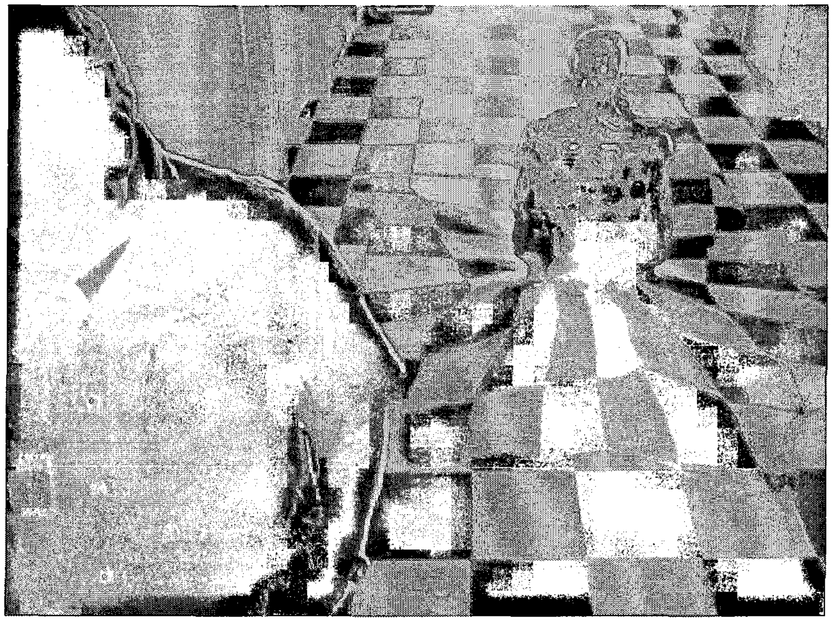


Figure 4.18 "Terminator 2 The Judgment Day" CG composting of a real person and CG character

Futuristic films such as *Terminator* and *Robocop* could also be called mixed media in the sense that the principal characters are combined with so many special effects that you can never be sure whether it is an actor, a model, or a computer-generated image that represents a character. Computer equipment capable of manipulating and combining images from many sources are becoming ever-cheaper, and complicated effects of which were once only possible social comment and tends to be associated with jazzy quick cutting. It is hard to imagine it being sustainable beyond two or three minutes, which makes it also suitable for music videos.

4.3.1 Combining Animation And Live Action

By the traditional method, combining the two in the same frame of film involves several stages and optical printing in a laboratory. It is also possible to circumvent that process by using what is called an "aerial image" rostrum which replaces some of the laboratory stages.

With the current use of videotape the combining is even easier. Full color animation is shot (either on video or on film transferred to video) on a primary colour background, usually blue. This can easily be combined with any other video image by video editing. The process is generally known as "blue screen". Matching, positioning and synchronization are, to some extent, also capable of adjustment at this editing stage.

5 COMPUTER GENERATED IMAGES (CGI)

5.1 Pixel

Each of an image's sample locations, together sampled values, is called an **image pixel** (short for *picture element*). For color images, three samples are usually used for each image pixel, one for red, one for green and one for blue; this choice of samples gives RGB color images their name. Computer images based on pixels are thus sometimes reffered to as **sample-based graphichs.** Image pixel information is stored in a rectangular array and translated into screen in aseries of horizontal rows called rasters, hece the name *raster graphics.*(Spalter, 1999, p.45)

Each pixel will have certain amount of information associated with it, and although it is still common to present a pixel having a specific color, in reality there may be a great deal of additional information that is associated with each pixel in an image.

Digital images are rectangular array of pixels. And each pixel does, of course, have a characteristic color associated with it. But the color of a pixel is actually a function of three specific **components** of that pixel: the red, green and blue. By using a combination of these three primary colors at different intensities, we can represent the full range of the visible spectrum for each pixel.

If we look at a single component (red, let's say) of every pixel in an image and view *that* as a whole image, we have what is known as a specific **channel** of the complete color image. Thus, instead of referring to an image as a collection of colored pixels, we can think of it as a three-layer combination of primary-colored channels.

Consider an image such as that shown in Figure5.1. The next three images, Figure 5.2, 5.3, and 5.4, show the red channel, the green channel, and the blue channel of this sample image. In this case, we've tinted the individual channels to reflect the color they are associated with, and it is convenient to think of the channels as being transparent slides that can be layered (or projected) together to result in a full-color image.

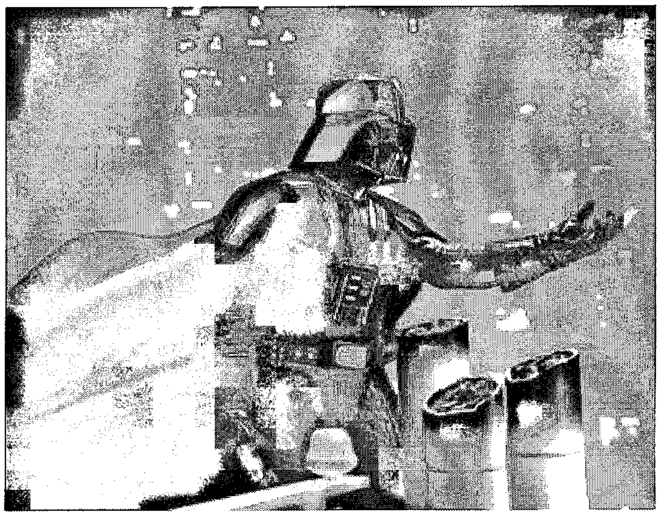


Figure 5.1 Composed colors of the image

Figure 5.2 Red channel

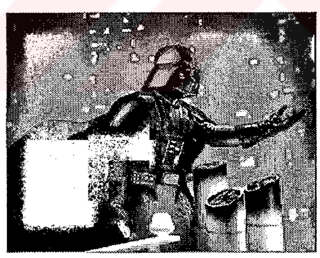


Figure 5.3 Green channel

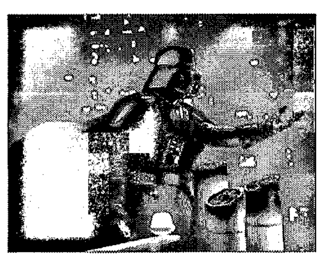


Figure 5.4 Blue Channel

Single pixels are simply too small a unit to deal with individually; in general, composting artists spend about as much time worrying about individual pixels as a painter might spend worrying about an individual bristle on her paintbrush. But more important, dealing with complete channels gives a great deal of additional control and allows for the use of techniques that were pioneered in the days when optical composting was being developed. Color film actually consists of three different emulsion layers, each sensitive to either red, green, or blue light, and it became useful to photographically separate these three layers, or **records,** in order to manipulate them individually or in combination. A digital image (also known as a **bit-mapped image)** of this type will generally consist of these three color channels integrated into a single image, but it should be clear that these three channels can be thought of as separate entities that can be manipulated separately as well.

5.2 Spatial Resolution

A number of measurements are used to gauge the amount of information that is present in a digital image. The most obvious measurement is the number of pixels used to create the image. The larger the number of pixels that are used the greater the **resolution** of the image. When we use the term "resolution" in this fashion, we are actually referring to the **spatial resolution** of the image. There are other types of resolutions, such as color or temporal, but the general convention is that the pixel count for an image is the primary measurement of the image's resolution. (Brinkman, 1999)

A square image that is, for example, 500 pixels wide and 500 pixels tall has 250,000 pixels of resolution. Most images are not square, and thus it's generally more useful to speak of an image's resolution by giving the width and height in pixels. Greater spatial resolution will allow one to reproduce finer detail in the image, but it will also increase the resources needed to deal with the image.

5.3 Bit Depth

Each component of a pixel can be represented by an arbitrary number of bits. A **bit** is the most basic representation of data within a digital system, and is capable of recording only two states. If we only have a single bit to represent a color, it would probably be used to specify either black or white. More bits will allow us a greater number of color variations, and the use of multiple bits for each component of an image is what allows us to store captured imagery with realistic color information.

The number of bits per component is known as the component's (and the channel's) **bit depth.** (Although you will often see bit depth defined in terms of the number of bits per channel, this definition is technically inaccurate, since the channel of an image refers to the full array of pixels that makes up the image. Theoretically, the number of bits per channel for a given image would be the number of bits per component multiplied by the spatial resolution of the image. However, since "bits per channel" is the more common term, we will consider it to be synonymous with "bits per component" and will use the two interchangeably.) (Brinkman, 1999)

Bit depth is the number of bits used to store information about each pixel. The higher the depth, the more colors are stored in an image. For example, the lowest bit-depth, 1 bit graphics are only capable of showing two colors, black & white. This is because there are only two combinations of numbers in one bit, 0 and 1. Four bit color is capable of displaying 16 colors because there are 16 different combinations of four bits:

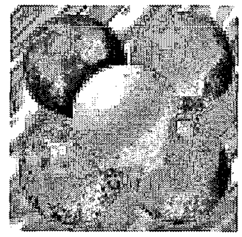
0000 0001 0010 0011 0100 0101 0110 0111 1000 1001 1010 1011 1100 1101 1110 1111

With 8-bit color, there are a total of 256 colors available. With 16-bit color, a total of 65536 is available. When you have 24 bit color, a total of 16777216 colors is available.

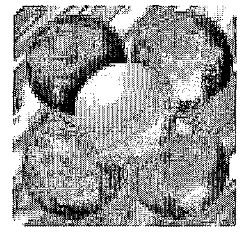
Bit depth might refer to the bit depth of an image, or the bit depth of a monitor. When it refers to the bit depth of a monitor, it means that your monitor is able to show a certain number of colors at one time. If it is meant as the bit depth of an image, it means that the image may contain the specified number of colors.

The following are examples of the same image of different bit-depths. You might not be able to appreciate all the quality of 16 bit images if your monitors do not support those bit-depths. (Brinkman, 1999)

1-Bit image
(781 bytes)



8-Bit image
(5,362 bytes)



16-Bit image
(11,982 bytes)

The higher the bit depth, the more bits per pixel used in an image, and the more pixels used in an image, the larger the actual file is going to be. Sometimes, very high image quality is needed, so you won't use a high bit depth to preserve space.

The bit depth is actually a way of measuring the **color resolution** of a given image. (For the purposes of our discussion, we'll consider "color" to include shades of gray as well. Thus, the number of bits dedicated to reproducing the gray tones in a monochrome image can still be considered a measure of its color resolution.)

Just as a larger number of pixels in an image allows for finer image detail, so a larger number of bits allows for finer variations in color. As you will see, many of the issues we mentioned when discussing spatial resolution have counterpart issues when discussing color resolution. Another term for color resolution is **dynamic resolution,** referring to the greater dynamic range available when using a greater number of bits per component, and you will occasionally hear the term **chromatic resolution** as well.

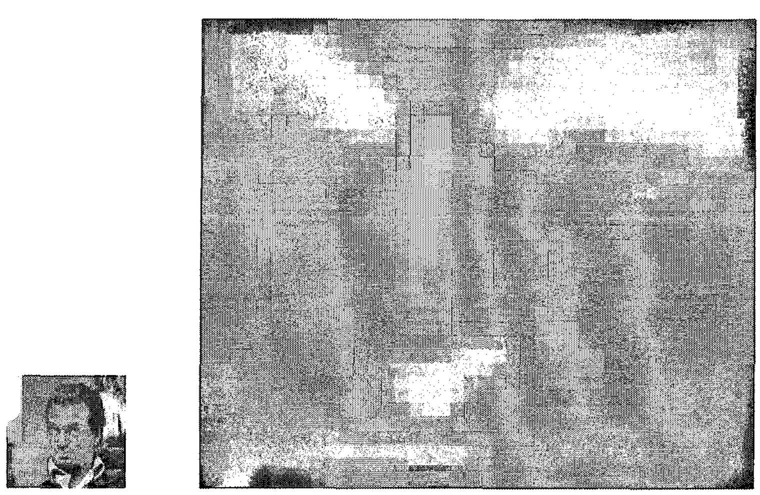


Figure 5.5 Magnified Pixels

Probably the most common bit depth for image storage is 8 bits per channel, which is also referred to as a "24-bit image" (8 bits each for the red, green and bits per channel means that each component of a pixel can t possible intensities and the three components together can million (16,777,216) colors. Although this sounds lost images will not even have that many pixels), it is often produce all of the subtle tonal variations that are captured lagging formats. Feature film work, for instance, often represents digital images with as many as 16 bits per channel, which gives us a palette of 281 potential colors.

5.4 Additional Channels

In addition to the three color channels, there is often a fourth channel, the **alpha channel,** that can be stored with an image. It is used to determine the transparency of various pixels in the image. This channel is also known as the **matte channel;** nearly all compositing is based on the concept of the matte. (Brinkman, 1999)

5.5 Bitmap Images And Vectors

Bitmaps are concentually similar to the raster images. Its structure lends itself directly to rapid output to a computer display. The alternative is to use a vector description that describes the image of a series of primitives like curves, lines, rectangles and circles. In order to convert a vector image into the raster format and display it on screen it has to be rasterized or scan-converted.

Bitmap images can be created from a range of sources: by rendering 3D images from a modelling and animation pakage, by scanning artwork, by digitizing video stills, by shooting on a digital camera, by drawing a pint diagram or by rasterizing a vector file.

5.5.1 Vector images

Vector images record instructions that can be used to reconstruct the image later. Vector images can be created by drawing them in a drawing package or by the conversion of a bitmap image. They contain objects like spline curves, which are defined by a relatively small number of control points. To save the file only the position and parameters of each control point need to be stored. When viewed on a monitor, vector images are rasterized by the software. This process effectively converts the vector image to a bitmap image at viewing time. Vector images have a number of benefits over bitmap images. For many types of image they are much smaller than the equivalent bitmap. This makes vector images an attractive alternative for use on the Internet.

Secondly, vector images are resolution independent. This means that they can be viewed at different sizes without suffering any quality loss. Bitmap images are created at a fixed resolution.

Vector images cannot be used to represent all types of image. They are typically used for storing computer-drawn artwork including curves and text. Scanned photographs and other images with large amounts of color and image detail are difficult to convert usefully to vectors. Packages like Adobe Streamline and Macromedia Flash attempt this conversion but it is often necessary to compromise significantly on image quality in order to achieve a small sized vector image from a bitmap original. Images with photographic realism are not suitable for this process, but more simplified cartoon style images are. This accounts for the cartoon-like look of many images within Flash animations.

6 PRODUCTION OF 3D ANIMAION

Three-Dimensional Animation (3-D for short) is probably the most prevalent form of animation seen in media today. As its popularity has skyrocketed, 3-D has forever changed the look of TV, movies, video games, the Internet, and other forms of entertainment.

The ability to create convincing 3-D animation was once limited to high-powered, expensive workstations, but with computer technology on the move always improving and always becoming more accessible the cost of 3-D software and the platforms to run it on has dropped dramatically. While higher-end systems remain the ones that are used to make the most professional-looking imagery, it is now possible to create quality animation on a home computer.

All of the basic principles of animation still apply, and the best 3-D animators have usually started as eel or stop-motion animators. Traditional animators' knowledge of movement, weight, and expression of character allows their work to be far superior to the overused "flying logos" and traveling-camera moves so typical of poor 3-D animation. A working knowledge of film production is also a key tool in creating high-quality 3-D work. Just as a live-action director sets up cameras, positions actors, and lights scenes, so too must a 3-D animator. (Laybourne,1989, p 236)

Because the computer aids in the process, a common myth is that 3-D animation is easier, faster, and even "better" than other forms of animation. While the machine does, in fact, draw every frame of the animation, the entire process is complex and takes some getting used to. As with any form of animation, 3-D requires liberal amounts of patience and diligence, but with a home computer and software costing less than $500, you can create amazing imagery that realistically duplicates our own world or explores new visions limited only by the imagination.

6.1 The Third Dimension

Before getting into the details of 3-D animation, a basic grasp of "space" is required. Other forms of animation, such as eel and line animation, generally work in two dimensions. Such "flat" surfaces comprise the Cartesian plane, which is defined by an x-axis and a y-axis. Any line or geometrical shape can be defined as a series of coordinates within this grid.

Obviously, 3-D animation introduces a third dimension. This adds a new coordinate, the z-axis, and you now have three-dimensional space within which to work. Instead of simply drawing a square and moving it horizontally across a frame, as you might do with cutout animation, the computer allows you to take your square, transform it into a cube, and move it *around* the camera. In traditional two-dimensional animation, the dot on a piece of paper could always be located by a field guide showing north, south, east, and west from the center of the frame. The third dimension adds the possibility of forward and back. The z access slices through the center of the frame at 90 degrees from the xy plane.

It probably won't surprise you to learn that the third dimension of space has a big impact upon the process of animation itself. Whereas in other techniques one has some freedom in how to attack a new project, in 3-D animation there are five basic steps that must be followed in this order: *modeling, applying textures, building the scene, animating,* and *rendering.* Although there is some overlap, this sequence is fairly rigid in that it is necessary to complete one process before moving on to the next. (Laybourne,1989, p235)

Each step is very time-consuming and it is all too easy to lose track of one's overall idea in the detail of the new creative tools. Hence it is crucial to have a good storyboard in place before you begin, so that you don't end up going backward and losing track of what is important.

In fact, each of the five steps within the creative process can be so elaborate that professional 3-D animators often specialize in only one. As you explore 3-D, you may find that you are drawn to one of these areas more than the others. Consequently, you can learn to tailor your 3-D animations to highlight your strengths and minimize those areas where you feel less interest and/or have less skill.

6.2 Modeling

Regardless of what kind of animation you are planning, the first thing you must do is creating the objects you plan to use in your animation. In keeping with the live-action metaphor, objects can be thought of as anything that is in front of the camera. This includes actors, props, and scenery. *Modeling* is the process through which you build all of the objects that appear in your scene. (Avgerakis, 2004, p233)

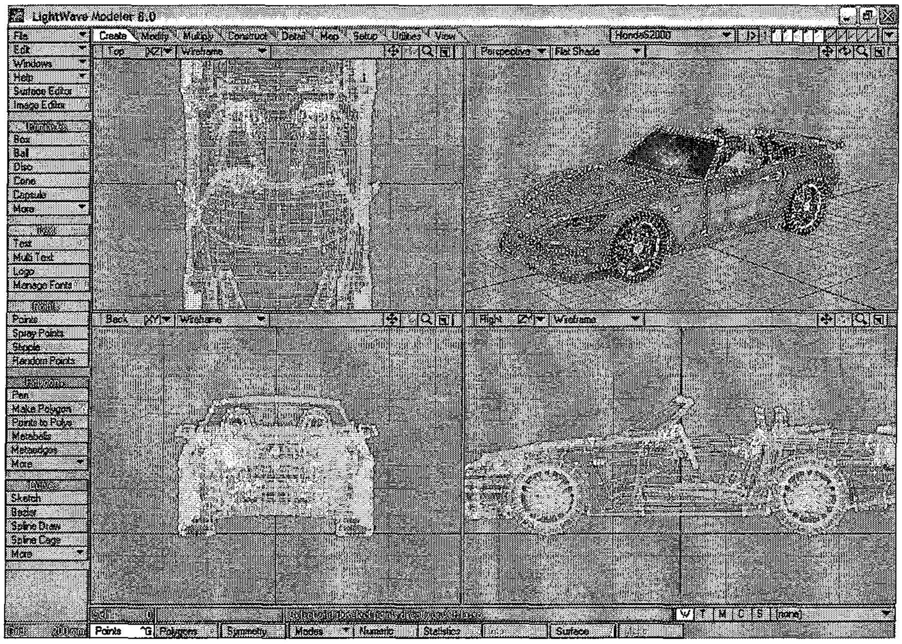


Figure 6.1 LightWave's Modeller

The easiest way to get started modeling is by using *primitives,* which are simple 3-D shapes that come with most software packages. These cubes, spheres, cylinders, cones, pyramids, and planes can be combined to create more complex objects. This process is very much like building with blocks or Legos. You don't actually build the pieces you use; you just put them together. Once you've built an object by combining some primitives, it is likely you will want to link these together so that whenever you move one piece, the rest will follow.

A second way to create a model is by starting in two dimensions. Almost every 3-D package gives you the ability to draw a curve or shape, manipulate it, and use it as a basis for creating a model. The types of curves you can create vary from program to program, and each type has its own set of characteristics. In addition, most software will allow you to import 2-D curves from some other program, such as Adobe Illustrator. (Laybourne,1989)

After creating a curve, there are a number of ways to bring it into the third dimension, the simplest being *revolving* and *extruding.* Revolving is the process of taking a 2-D curve and rotating it around an axis so that it acquires some volume.

6.3 What is a 3D Model?

A **model** is a version of an object, concept, or phenomenon that represents some of its important features. For instance, an architectural model shows the shape of a building and its parts, as well as its overall visual appearance. It is not the same size as the real building, probably doesn't depict the wiring and plumbing or have the characteristics of real building material, and quite often is completely empty inside. The builder of a model must decide which features of the real object or other entity to incorporate in it. The use of models is crucial in fields as varied as particle physics and Hollywood stage set design.(Splater, 1999)

All artwork involves modeling, that is, representing some part of a scene, a feeling, or an experience, while leaving other parts out. For example, "when Matisse painted a woman's face with a few deft brush strokes, he was extracting the "salient features," the important information that he felt modeled the face. At the same time he was ignoring thousands of details that would not have contributed to his painting.

A good model captures information and relationships vital for a specific purpose, whether that purpose is functional or aesthetic. A good model lets its creator conceive ideas that would be difficult, if not impossible, to come up with when faced with a real phenomenon in all its complexity. For example, in war movies, the general may conceive a battle strategy by using salt and peppershakers on a tablecloth; scientists were able to think about atoms in new ways after physicist Niels Bohr created his geometric model of the atom. (Spalter, 1999, p 215)

Geometric models need not be based on physical geometric forms. Information about a company's reporting hierarchy can be represented in an organization chart, and data from the stock market or a scientific experiment or opinion poll can be plotted as bar graphs or pie charts in two or three (or more) dimensions. (Spalter,1999)

Most 3D modeling tools offer a comprehensive range of 3D primitive objects that can be selected from a menu and created with mouse clicks or keyboard entry. These range from simple boxes and spheres to special purpose objects like terrains and trees. The term parametric refers to the set of parameters that can be varied to adjust a primitive object during and after creation. For a sphere the parameters might include the radius and number of segments. This latter setting defines how many polygons are used to form the surface of the object, which only approximates a true sphere. This might be adjusted retrospectively to increase surface detail for object: close to the camera, or to reduce detail for objects far away. (Kuperberg,1999)

6.4 Modeling Techniques

In the earlier days of animation, the only way of creating complex objects was by manipulating and combining groups of flat polygons. This method came to be known as **polygon modeling.** The drawback of this method was that it tended to create objects with prominent angles that looked boxy and artificial. To avoid the boxiness, the component polygons were subdivided into smaller elements until the edges tended to smooth out and disappear.

Later, more advanced methods, based on modeling with curves, were invented, such as **splines.** Although mathematically more complicated than polygon modeling, splines allowed for attractive, rounded surfaces, composed of nonflat polygons so that they could be modeled easily. Splines and other methods that were invented later attracted a certain number of animators, creating groups that would prefer one method over another. Even later, refinements to polygon modeling and spline modeling were introduced, reviving the interest in earlier techniques and further complicating the factions. (Avgerakis,2004, p 231)

6.4.1 Polygon Modeling

Each of the three animation programs in this book has different ways of offering users the various methods of modeling. Some programs, such as LightWave, handle the various modeling methods differently. (Kuperberg,2002)

6.4.2 Points and Polygons

At the most basic level, defining points and polygons creates an object. The process is very simple: Define at least three points somewhere in the scene and connect them with lines to form polygons. In animation, the most common polygon is the triangle, because it will always serve as the basic element of the most complex surface. When divided small enough, large arrays of triangles can be used to model the most intricate details. In addition, the triangles also have a unique property. Imagine a triangular piece of plastic laying on a table. If you lift one corner, the other corners stay flat on the table. You cannot do this with any other polygon. This unique attribute allows triangles to compose any surface and allows that surface to flex in any way imaginable (if the triangles are small enough).

Animation programs have various tools for changing squares and irregular polygons into subdivided arrays of triangles, and you will no doubt use them frequently. These arrays are often called **meshes.** Keep in mind, however, that the more polygons an object has, the more memory it will take to describe and the longer it will take to render. Again, it is important to anticipate the end use of your object and design it appropriately. If you are making a simple cube that will inflate with air and become rounded, you will need to subdivide the surfaces with enough triangles (perhaps hundreds) to create the illusion of roundness. If the cube will remain a cube, however, you can get away with six points and six planes, or even fewer if the cube does not rotate.

Obviously, a polygon can have any number of points. When designing a logo, for instance, you might find that a complex shape, such as the letter P, can have dozens of points (sometimes referred to as **n-gons).** If all the points lay on one plane, you will have no problem defining the surface within those points, and the computer will render that surface predictably. If, however, you should cause a polygon with more than three points to bend, you could easily move one or more points off the common plane. This would define a surface, which is difficult, if not impossible for the computer to render. (Spalter,1999)

Although you may think otherwise, computer animation allows the existence of one- and two-point polygons. A single-point polygon with appropriate attributes can serve a number of useful purposes. It can be invisible (called a **null object)** and serve as a reference or **parent** object to which other objects are subordinated. It can also be visible and serve as an infinitesimal source of light, such as a star.

Two-point polygons define a line, such as a string or hair strand. Under most conditions, two-point polygons always remain thin, however, no matter how close the camera zooms into them. Many programs use two-point polygons to define complex arrays of strands, such as a field of grass, a head of hair, or rain.

6.4.3 Primitives

Animation programs offer a default assortment of primitive 2-D polygons and 3-D objects that can be created with a few clicks of the mouse. Polygons such as triangles, squares, and regular polyhedrons (pentagons, hexagons, and so on) can be quickly brought to the scene by selecting the appropriate tool and defining the boundary of the polygon in one of the orthogonal views. In addition to the click-and-drag option, each program offers the capability to enter numerical values and, after clicking the Create or Apply button, the computer creates the polygon precisely as defined.

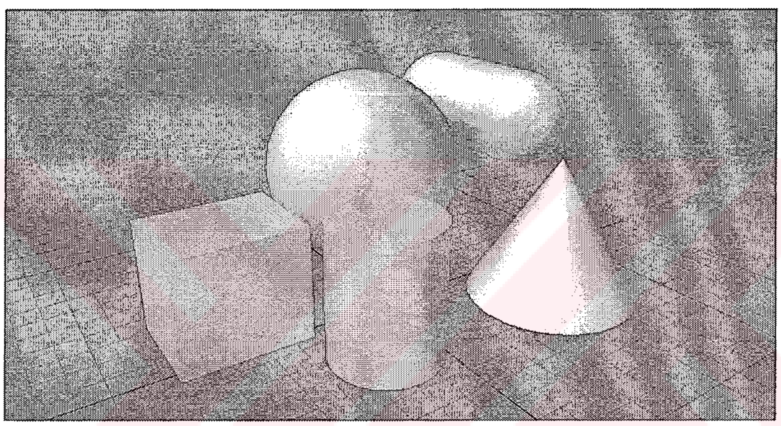


Figure 6.2 Primitives

Choosing from an assortment of buttons can easily create primitive 3-D objects such as cubes, spheres, pyramids, cones, and so on. Once the type of object is selected, the operator chooses a view, places the cursor, and drags out a boundary. Letting go of the cursor initiates creation of the object.

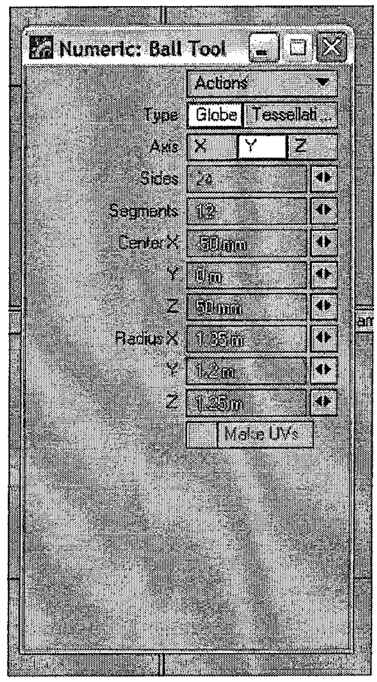


Figure 6.3 Lightwave's Numeric Panel

6.4.4 Numerical Entry

Numerical entry is a process of specifying values by typing numbers on your keypad, as opposed to dragging object components on the UI. Numerical entry is available at all levels of animation production and is useful in maintaining consistency that cannot be achieved with click-and-drag input. Although your program will create any primitive tapering of the 2D shape, along the length of the guideline, which is impatred.

6.4.5 Rotation or Revolving

You can easily create interesting objects by rotating a closed polygon or curve around a defined point or axis. For instance, if you begin with a half-circle curve and rotate it around the center of the curve, you will create a sphere. If you take a 2-D circle and revolve it around a point or axis outside the circle, you will get a donut. Like extrusions, rotations and revolutions are useful tools to automate the process of creating shapes. Always consider these options when beginning each element in the labors of modeling.

Boolean Tools

Boolean algebra uses a limited vocabulary of terms, such as AND, OR, Nor, and NOR to define interactions of groups. For instance, a Boolean command of AND (boys AND girls) would result in the joining of two groups, whereas the command NOT would result in a subtraction of groups (Americans, NOT New Yorkers). Animation programs enable Boolean operations on objects by allowing operations built on Boolean terminology.

For instance, you may want to join two spheres with a cylinder to form a barbell object. To do so, you would place the two spheres at an appropriate distance and add the cylinder between them. You would then initiate a Boolean AND (also called an ADD) function, and the three objects would be merged. This seems rather simple, right? But how about the command, NOT (or SUBTRACT)? This function is much more fascinating.

Let's suppose you wanted to take a sphere and drill a nice, neat hole through it. Start with the sphere and superimpose the cylinder so that it passes through the sphere at any angle. Then use the Boolean command NOT (or SUBTRACT) and assign the cylinder as the subtractor. Bingo. The cylinder disappears and a hole in the sphere, where the cylinder was, is created. Using Boolean functions can provide a wide range of complex objects.

For instance, you might spend hours digitally sculpting the outline of a perfect ear, but an ear has thickness and you need to create the inside of the ear. You could start with a solid shape, duplicate it, shrink the duplicate a bit, and then execute a Boolean subtraction of the smaller ear from the larger ear to produce a perfect interior sculpting of the larger object.

6.4.6 Splines

After several years of working with polygons (during which a billion or so "flying logos" and other animations were made, based on boxes), the designers of animation programs began to look for other ways to define surfaces and model objects. Realizing the shortcomings of polygonal modeling, the designers searched for a way of defining surfaces with mathematically defined curves.

In this process, the designers realized that the computer used polygons to define specific sets of points in 3-D space. If these points could be expressed instead by formulas, the resulting shape would be smoother, easier to calculate, and more flexible.

6.4.7 Deforming

Simple objects, such as spheres and cones, are made more complex when the operator selects groups of points or polygons and moves or extrudes them. For instance, a single point on a sphere can be selected and pulled away from the center to form a pointed extension of the sphere, such as the tip of a nose. Selecting a wider range of polygons, pulling them away from the center, and then rotating them slightly downward might make a more elegant nose. In LightWave, tools like **Drag, Magnet,** and **Dragnet** provide this capability. In 3ds max, you might use **Editable Poly.** In Maya, you use **Manipulator Handles.** (Avgerakis, 2004)

The standard primitives available are useful up to a point, but for more complex work modeling can involve the creation of a 2D shape using spline curves or 2D primitives like rectangles and circles. The 2D shape is then converted to 3D in one of several ways.

The simplest approach is extrusion. A closed 2D polygon is swept along a line at right angles to its surface to create a block with a fixed cross-sectional shape.

Lathing is a technique that takes a 2D polygon and revolves it to sweep out a surface of revolution. This approach is useful for objects with axial symmetry like bottles and glasses.

Lofting is an extension of extrusion that takes an arbitrary 2D shape as a path (rather than the straight line at right angles to the surface) and places cross-sectional shapes along the path. The cross-sectional shapes which act, as ribs along the spine created by the path can be different shapes and sizes. Lofting is useful for complex shapes like pipes and aircraft fuselages. (Kuperberg,2002)

6.4.8 3D Digitizing

Just as 2D images can be acquired by scanning 2D artwork, 3D mesh objects can be created by digitizing physical objects. 3D scanners come in various types, some based on physical contact with the object and some based on laser scanning. The resulting mesh objects can be animated using the skin and bones approach described below. Characters for games and animated motion pictures are often digitized from physical models. Ready digitized or modeled 3D geometry can also be purchased allowing you to concentrate on the animation.

6.4.9 Modifiers

Modifiers are adjustments that can be added to a 3D object. Modifiers include geometric distortions like twists and bends, which change the shape of the object to which they are applied. The individual nature of each modifier is retained so their parameters can be adjusted or the modifier removed retrospectively.

6.4.10 Polygonal models and meshes

For more flexible sculpting of 3D objects it is sometimes useful to convert objects created with primitives and modifiers into polygonal meshes. Consider a 3D sculpture made out of chicken wire and imagine that it was made out of elastic wire that could be stretched. Polygonal mesh-based objects can be sculpted by selecting vertices or groups of vertices and manipulating them by moving, scaling and adding modifiers. The disadvantage of the mesh-based approach is that the designer doesn't have access to any of the original creation parameters of the shape. Polygonal mesh-based modeling is an art form that is particularly important for 3D game design where low polygon counts have to be used to achieve good performance.

6.4.11 NURBS

NURBS (Non-Uniform Rational B-Spline) curves can be used to create complex 3D surfaces that are stored as mathematical definitions rather than as polygons. They are the 3D equivalent of spline curves and are defined by a small number of control points. Not only do they make it possible to store objects with complex surfaces efficiently (with very small file size) but they also allow the renderer to draw the surface smoothly at any distance. The renderer tessellates (subdivides it into a polygonal mesh) the surface dynamically so that the number of polygons used to render it at any distance is sufficient for the curve to look good and run efficiently. NURBS are good for modeling complex 3D objects with blending curved surfaces such as car bodies. Think of NURBS' surfaces as a kind of 3D vector format that is resolution independent. Contrast this to the polygonal mesh which is more like a bitmap form of storage in that it is stored at a fixed resolution. If you zoom into a NURBS' surface it still looks smooth. If you zoom into a polygonal mesh you see that it is made up of flat polygons.

6.4.12 Metaballs

Metaballs are spheres that are considered to have a 'force' function that tails off with distance. A collection of metaballs is arranged in 3D and converted to a polygonal mesh by the calculation of the surface where the sum total effect of the 'force function' of each metaball gives a constant value. They are useful for modeling organic shapes. The effect is similar to modeling a physical object by sticking lumps of clay together.

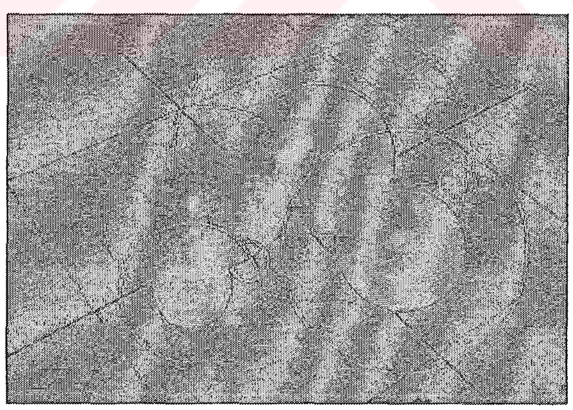
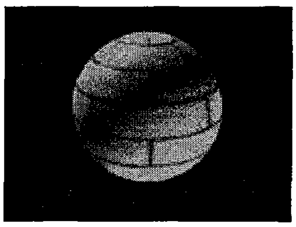


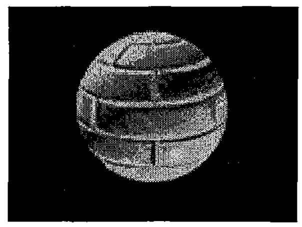
Figure 6.4 Metaballs

6.5 Texturing and Surfacing

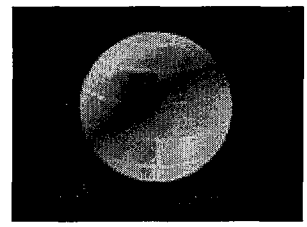
Very often, when objects are to be rendered, in order to achieve a more realistic look, a surface map is applied to an object or a part of an object. A surface map is really just a picture, which is wrapped around an object in one or more fashion. A surface map can be a decal placed onto a bumper of a car or a brick texture put on a wall in order to make it look more realistic. Surface maps are sometimes referred to as textures.



Surface



Bump



Reflection

Sometimes simple projection of a surface map will not do a trick. If actual texture needs to be seen, a bump map can be used. When rendering a bump map, the computer looks at the different black and white calues of the image and makes the surface of the rendered object look as if it had such a texture. There are also other ways of applying surface maps. Some make parts of an object transparent and are referred to as opacity maps. Others can make an object shiny or dull. Depending on the software package, there may be a few other effects which can be created using surface maps.

If objects are the actors, then textures are their costumes. While modeling defines the shape of your objects, textures define what their surfaces look like. There are two basic types of textures: *materials* and *image maps.* You will find that most projects require both types of textures.

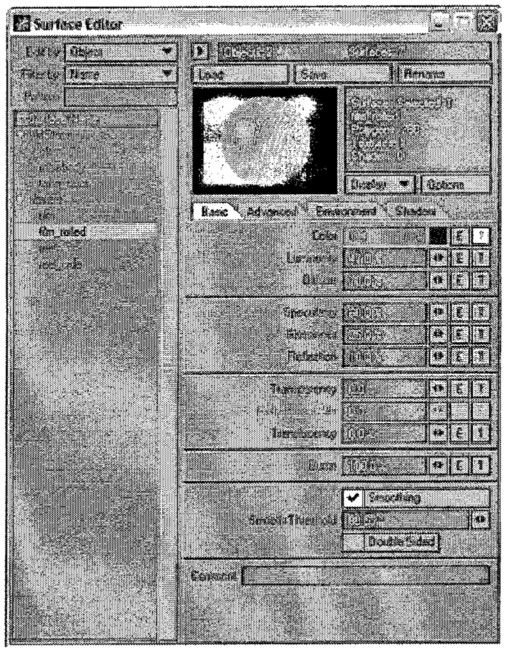


Figure 6.5 LightWave's Surface Editor

Most programs come with a set of materials that you can simply select from a menu and apply to your objects. There is a wide variety of metal, stone, wood, skin, glass, and liquid to choose from. As in the real world, materials differ from one another in the way that they reflect light. The different ways in which objects appear to the eye, say glass versus metal, is the result of a combination of several different properties. These include color, diffuse shading (how much light it reflects), ambient shading (how dark the shadows on its surface are), reflectivity (how much of its environment shows on its surface), luminance (how much light it emits), and transparency (how much you can see through it). All of the premade materials that come with software packages have these properties already defined. Glass is defined as transparent, partially reflective, and a little diffuse. Stainless steel is completely opaque, very reflective, and barely diffuse. These properties can be combined in an infinite number of ways to produce any desired result.

Image maps are 2-D images that are "placed" on the surface of an object. Think of a wine bottle to go with your wine glass. To make the bottle appear to be made of green glass, you could probably just select a premade material from a menu. But to put a label on the front, you need to first create a label in a paint program, such as Photoshop (or scan one in). You would then import this file into your 3-D software and place it on the front of the bottle. As with other textures, you can define the surface attributes of your image map in order to make it reflect light as an actual paper label would. Image maps (and their cousins, bump maps) can also be *tiled* to cover an entire object. Some software packages also allow you to apply moving images as textures, allowing you to map, for example, a piece of video onto the front of a television model.

6.6 Virtual Camera

A virtual viewpoint in 3D space that possesses both position and direction in a 3D scene, the camera represents the viewer's eye. When the scene is rendered at final quality, it is the camera view that is used, reather than the one seen in the software's workspace. This enables the artist to move around the workspace without disturbing the camera view.

6.7 Building A Scene

Now that your objects are fully textured, you are ready to build your scene. There are actually three stages to this: *Composition, camera setup,* and *lighting.* It is at this point that any live-action filmmaking and TV production experience you may have had will come in handy. Just as you would place human actors, props, and scenery in front of a camera and light them, you now take your objects, position them in front of the camera, and arrange a variety of lights to illuminate your scene.

The virtual camera that you will employ in 3-D animation is very much like a real camera but is not limited by the laws of physics. It can zoom in and out, dolly forward and back, and vary its focal length, just like an actual movie camera. It can also change size, fly through the air, or automatically track an object moving through the scene. In the end, though, it remains a camera: your eye on the world. Viewers will see only what you show them, so it is essential to compose your frame carefully.

For novice 3-D animators, lighting a scene can be one of the most challenging parts of the whole process. The balance between fully illuminating your scene while still maintaining the proper mood comes only with practice and repeated test renderings. Most software packages come with at least three types of lights: spotlights, which direct a beam in a single direction from a single point; radial lights, which emit light equally in all directions, like a bare bulb; and parallel lights, which, like the sun, emit light equally in a single direction. Each of these types of lights has its proper usage and own set of characteristics (see Figure 16.10). As a 3-D designer, you can control the focus, intensity, and color of each light in order to create the right look. If you find yourself drawn to 3-D production, it is probably worth it to pick up a book on film, television, or theatrical lighting. (Digital Animation Bible)

6.8 Animating

By modeling, applying textures to your objects, and building a scene, you can create a very photo realistic still life. However, in order to create an animation, you've got to introduce the element of time. It's useful to remind yourself regularly that *anything* in your scene can be animated. Objects, cameras, lights, and in some cases textures can all be changed over time in a number of ways, including size, position, and rotation.

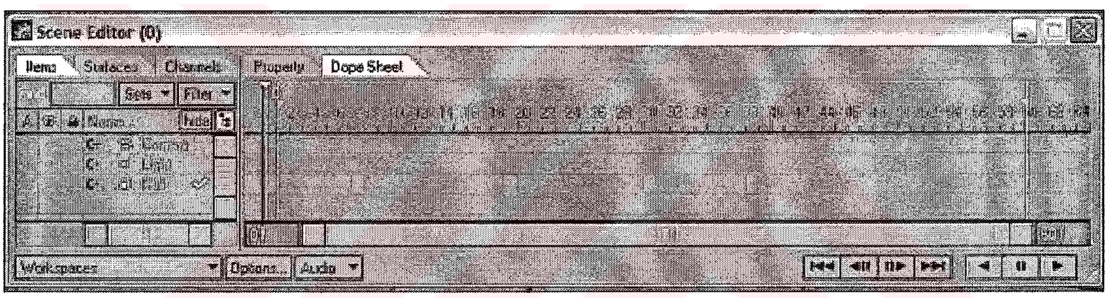


Figure 6.6 Ligtwave's Scene Editor and Timeline

Many of the techniques utilized in nondigital animation carry over onto the computer. As with feel animation, a 3-D animator builds *key frames* that define an object's motion. Unlike eel animation, though, no in-betweening is required, as the computer computes all of the intermediate frames necessary for a smooth animation. Objects can be animated along straight lines or curves, and many software packages are equipped to automate basic animation timing methods such as ease-in and ease-out. The more knowledge you have of classic animation techniques, the more polished your 3-D animation will look. The concepts of stretch and squash, anticipation, and exaggeration are as relevant to 3-D as to any other form of animation. *Inverse kinematics* is one type of 3-D animation worth noting. IK, as it is called, is the process by which the computer is able to animate a human figure while maintaining proper anatomical structural relationships. If you had a human figure you wanted to make run, it would be a nightmare to first move a thigh, then a shin, and then a foot, all the while making sure these body parts were still aligned properly. IK allows you to simply move a single body part, and have all the adjoining body parts move accordingly within a defined range of motion. It is this type of technology that allowed for the high-quality character animation of *Toy Story.*

6.9 Rendering

Rendering is the process a computer uses to create an image from a data file. Most 3D graphics programs are not capable of drawing the whole scene on the run with all the colors, textures, lights, and shading. Instead, the user handles a mesh which is a rough representation of an objects. When the user is satisfied with the mesh, he then renders the image.

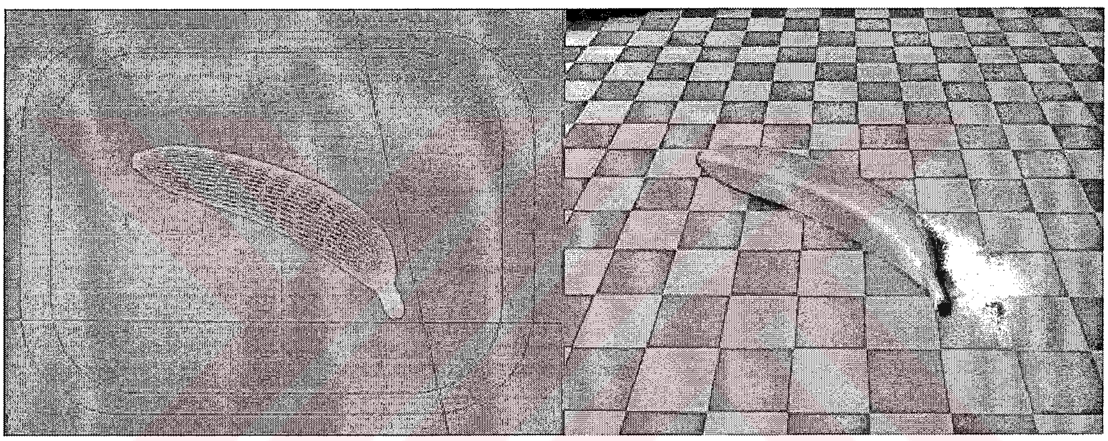


Figure 6.7 An undered and rendered object

This isn't really a rendering method, by definition. Most 3D graphics programs represent objects as meshes. What happens in wire frame rendering is, every section of the mesh gets colored in with the average color of the texture. This comes in usefull for special effects, and for quick previews. To take wire frame rendering one step further, some programs do a process called hidden line removal. It is just like normal wire frame rendering, except the parts of the mesh that would not be visible if the mesh was a solid are not rendered. (Kuperberg, 2002)

Even though today's computers are capable of doing thousands, and sometimes millions, of computations every second, most are still not fast enough to keep up with the demanding mathematics required by 3-D production. *Rendering* is the process through which the computer takes all of the data that define a 3-D scene, including models, textures, lights, and camera, and creates a 2-D image of that scene.

Depending on how realistic the image that the computer must create, rendering a single frame can take anywhere from a fraction of a second to several hours, or even days. (Laybourne,1998, p 241)

Rendering usually takes a long time. The time it takes to render an image depends on the quality of rendering. There are a couple of different qualities of rendering.

6.10 Keyframes and Movement

The earliest computer animation systems were derivative of conventional hand-drawn animation systems in which positions of objects and the observer were specified at certain key frames. The positions and orientations were then interpolated to produce the frames between these keys. For now, we will only consider interpolation of positions; interpolating orientations involves issues particular to that application and are discussed as a separate topic in Section 1.3. Marcelli Wein and Hunger interpolated between 2-1/2D key frames.

Key frame animation is based on traditional animation techniques. Master animators would define and draw key frames that would essentially provide foundation pillars for the motion. Apprentice animators would then draw in the intermediate frames based on the key frames on either side of the intermediate sequence. This same idea was one of the earliest techniques implemented for two-dimensional computer animation. The 'master' animator would draw key images and provide point-to-point correspondence information for interpolation programs which would then produce the intermediate images. The computer was an automated version of the apprentice animators. Although the computer could do the interpolation faster and more accurately than apprentices, it had to be provided with extensive information concerning what corresponded with what in the different key frames. These computer programs process two-dimensional information and therefore could not readily handle the three-dimensionality implied by animated figures the way the apprentices could. (Siggraph)

7 DIGITAL COMPOSITING

The digitally manipulated combination of at least two source images to produce an integrated result.

The most difficult part of this compositing is producing the integrated result, an image that looks naturel and real for all the source elements. One must be able to belive that everything in the scene was photographed at the same time by the same camera.

The combination of multiple sources to produce a new image is certainly noting new, and being done long before computers entered the picture.

7.1 Historical Perspective

The Swedish born photographer *Oscar G. Rejlander* created the most technically complicated photograph that had ever been produced in 1857. Working at his studio in England, Rejlander selectively combined the imagery from 32 different glass negatives to produce a single, massive print which was titled "Two Ways Of Life"

Had the artist wished to capture this image on a single negative, he would have required a huge studio and many models. Even than, it is doubtful he could have lit the scene with as much presion or have positioned all the people in exactly the fasion he desired. Certainly it could have been proven to be an expensive, time consuming process. Instead, he painstakingly shot small groups of people and sets, adjusting each for the position and size that he would need them to be. In some cases, the only way to make them small enough in frame was to photograph them reflected in a miror. Once the various negatives were created, the combination process involved selectively uncovering only aportion of the printing paper and exposing the desired negative to that area.

The scene was resulted from this complex undertaking was designed to depict the two paths that one may chose in life. The right side of the image represents the righteous path, with individual figures who illustrate Religion, Knowledge, Mercy, Married life, and so on. The left side of the image depicts somewhat less lofly goals, with figures representing everything from Idleness to Gambling to Licentiousness to Murder.

Photography was only just becoming accepted as a true art form, but Rejlander's work was immediately recognized as an attempt at something more than typical documenatry or narrative photographs of the time. This is important to understand, since it points out that Rejlander used this combination technique in persuit of a specific vision, not as a gimmick. There was a great deal of science involved, but more important, a great deal of art.(Brinkman, 1999)

Motion picture photography came about in the late 1800s, and the desire to be able to continue this sort of image combination drove the development of specialized hardware to expedite the process. **Optical printers** were built that could selectively combine multiple pieces of film, and **optical composting** was born. Optical composting is still a valid and often-used process. Many of the techniques and skills developed by optical compositors are directly applicable to the digital realm, and in many cases, certain digital tools can trace not only their conceptual origin but also their basic algorithms directly to optical methodologies. Consequently, the digital composting artist would be well served by researching the optical composting process in addition to seeking out information on digital methods.

A number of early examples of optical composting can be found in the 1933 film *King Kong.* The image shown in Figure 7.1 is actually a composite image that was created in the following fashion: The giant ape was photographed first a 16-inch tall miniature that was animated using **stop-motion** techniques. (Brinkman, 1999)

Figure 7.1 An early motion picture composite, from the film King Kong (1933)

This process involves photographing the model one frame at a time, changing the pose or position of the character between each frame. The result, when played back at normal speed, is a continuously animating object. After this footage was developed and processed, it was projected onto a large **rear projection** screen that was positioned on a full-sized stage. The foreground action (the actress in the tree) was then photographed while the background footage was being projected behind it, producing a composite image. This particular type of composting is known as an in-camera effect, since there was no additional post-production work needed to complete the shot. Other scenes in the film were accomplished using an early form of **bluescreen** photography, where the foreground and background were photographed separately and then later combined in an optical printing step. (Brinkman,1999)

Figure 7.2 Superman Flying

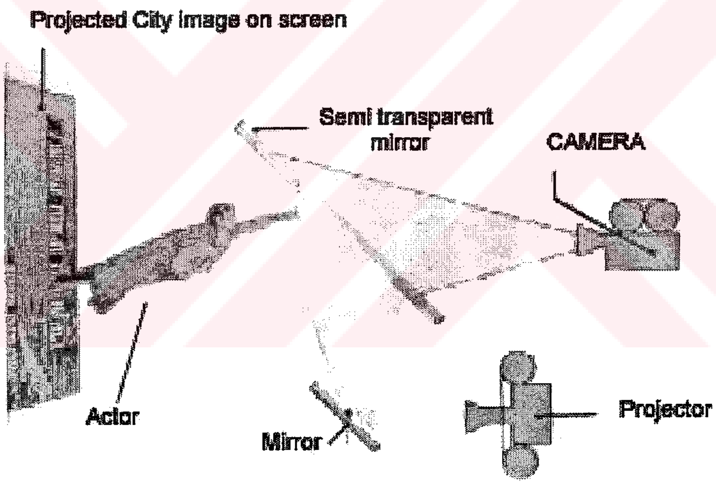


Figure 7.3 Scene Setup

Nowadays, optical composting equipment has been largely (but not completely) replaced with general-purpose computer systems and some highly specialized software, but the concepts have not really changed. Before we start our discussion of these software tools.

7.2 Basic Image Composting

The process of combining two or more image sequences is the true heart of digital composting. It requires the use of special operators that are capable of dealing with more than a single input sequence, and so we will refer to these operators as "multisource operators." As was the case with our discussion of basic image manipulation tools, we will only take an in-depth look at a few of the most important image-combination tools.

It is obvious that a single-input Add operator that added a constant value to each pixel in an image. Although we'll be using the same name for the multisource operation we're about to discuss, the difference should be obvious. By using the same names, we're following typical nomenclature used in the industry; because of the obvious difference in the situations in which the two operators will be used, there should be little room for confusion. A number of the basic mathematical single-source operators, such as Subtract or Multiply, have dual-input equivalents.

Adding two images together involves, not surprisingly, the addition of each pixel in the first image to its corresponding pixel in the second image. Figure 30 and Figure 31 show the two source images we will be using to illustrate some of our multi-input operators. Combining these two images using an Add produces the image shown in Figure 32. As you can see, the result is similar to a photographic double exposure. (Brinkman,1999)

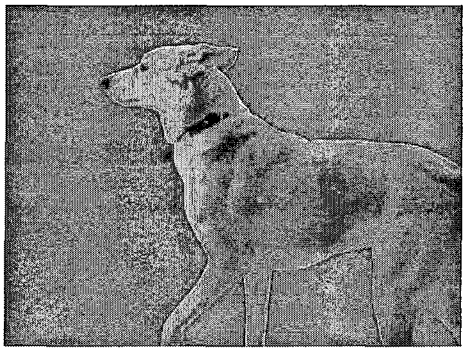


Figure 7.4 Source Image

Figure 7.5 Background Image

Figure 7.6 The result of adding images

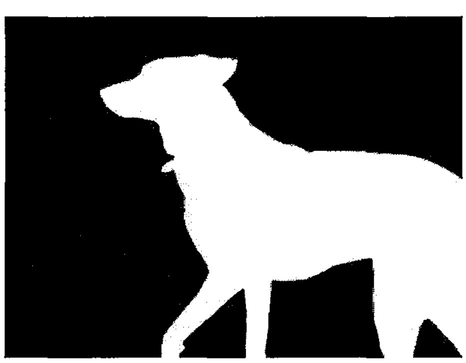


Figure 7.7 The matte image

Figure 7.8 Final Composited Image

While this effect is certainly useful in a variety of situations, it does not give us the impression that any sort of layering has occurred. There is no sense that certain portions of one image are actually occluding the second image. To accomplish this, we need to introduce the concept of a matte.

7.3 The Matte Image

Combining different image sequences needs to be a process with as much control as possible. We need to be able to limit which portions of the various images will be used, and which will not. We need to be able to control the transparency of the various layers so that they don't completely obscure everything that they are covering. And we need to have a method for defining and controlling these attributes that is intuitive and consistent with the rest of the image processing we will be performing. This is what the matte image gives us.

First of all, understand that a matte image is no different from any other image, in terms of the data used to represent it. It can generally be treated and manipulated in exactly the same fashion as other images, but it is considered to have a different *purpose* than those images. Instead of providing a visual representation of a scene, it is more like a utility image, used to control individual composting operations. (Brinkman,1999)

Mattes are used during composting when we only wish a portion of a certain image to be included in the result. You may also hear the term "mask" used when referring to mattes, and it is not uncommon to find the two terms used interchangeably. For sanity's sake, we will try to limit the use of the word "mask" to refer to a general image that is used to control or limit certain parameters in an operation, such as a color correction.

To complicate things even further, both "mask" and "matte" may also be used as either nouns or verbs. The terms can refer to the image used in the process of protecting or excluding a section of an image, or they may refer to the process itself. Consequently, we may "matte out" a section of the foreground so that the background is revealed, or we may "mask off" the bottom third of an image when we color correct it so that the correction doesn't affect that area.

Mattes are generally considered to be single-channel, grayscale images. There is no need for three separate channels, as there is when specifying color, since the transparency for any given pixel can be described by a single numerical value in the range of 0 to 1. Many systems and file formats support single-channel images, whereas others will simply place a copy of the same information into all three channels of an RGB image. While this method is redundant (and wastes disk space), it does sometimes provide a simpler model for both the user and the programmer.[1] Ideally, the composting system will store a single-channel matte image as efficiently as possible, yet still allow the compositor to treat it as if it were a normal RGB image when necessary.

Depending on the software package you are using and the file format you have chosen, a matte can also be bundled along with a three-channel color image as a discrete fourth channel. When the matte image is part of a four-channel image, it is known as the **matte channel** or the **alpha channel.** In the next section we will discuss four-channel images in greater detail, but for the time being we will consider the case in which our matte is a separately stored image.

Let's look at a very simple example of how a matte image is used, given our original two images (Figure 30 and 31) and a third matte image shown in figure 33. We will use this matte channel to isolate or extract a foreground piece of Plate 18a and will then place it over the background of Figure 31. The resulting image is shown in figure34

This example is simply to give you an intuitive idea of how a matte channel might typically be used. As you can see, areas that are white (have a pixel value of 1.0) in the matte channel are used to specify that the corresponding area of the foreground image is kept at full opacity. This is said to be the "solid" area of the matte. Conversely, the black areas of the matte are used to specify that the corresponding pixels in the foreground image will be transparent, or effectively removed, when it is placed over the background. Intermediate gray levels of the matte channel provide a continuum of transparency, with brighter (higher-valued) pixels specifying more opaque areas and darker pixels specifying more transparent areas.

In the preceding examples, we have only shown matte images as being distinct entities, completely separate from normal color (RGB) images. Any operation that is used to combine two images would need to reference the matte image as a third image in order to control varying levels of transparency. This need not always be the case if we are working with a system that supports four-channel images.

7.4 The Integrated Matte Channel

As stated earlier, very often an image will be stored with not only the three basic color channels, but also a fourth channel, the matte channel. But there is more to the process than simply attaching that matte channel to an image. Usually, when a fourth channel is added to an image, the color channels are modified as well, to include some of the information that comes from the matte channel. In fact, the standard definition of a four-channel image assumes that the red, green, and blue channels have already been multiplied by the integrated matte channel. Such an image is referred to as a **premultiplied image,** and it is most commonly produced as the output of a 3D rendering and animation package. (Occasionally there are situations in which you may have a three-channel image that has already been multiplied by an external matte. This too could be referred to as a premultiplied image, but this scenario is much less common.)

As you can see, everywhere that the matte was black (having a digital value of 0), the color channels have become black, or 0. Wherever the matte was a solid white, the color channels are unmodified. Less obviously, in areas where the matte had some intermediate gray value, the corresponding pixels in the RGB image have been darkened by a proportional amount.

Premultiplied images can be a great source of confusion, primarily because in certain situations this multiplication step is done automatically but in other situations (or using different software packages) the process must be dealt with explicitly by the user.

Whether or not an image is premultiplied can significantly affect the composting process and the resulting imagery. Using premultiplied images with tools that aren't expecting them can be disastrous, as can the reverse. This is particularly true when dealing with certain layering operators such as the Over tool, which we will discuss in a moment.

Before we take a look at some additional multisource operators, it will be useful to stop and describe a few notations that we will be using in conjunction with our definitions.

7.5 Multisource Operators

Many of the multisource operators that we will be discussing will support images that carry an auxiliary alpha channel. Unless otherwise specified, assume that the operation discussed is independent of whether the images contain integrated matte channels. For those operators where it is applicable, we will first discuss the process as it relates to images without any integrated matte channel and then will look at the same operator's behavior with four-channel images. When we do need to make a distinction about separate image channels, we will use the following notation. For any image A,

A_{rgb} = The RGB channels only.

A_a = The alpha, or matte channel, only.

A = All the channels (be there three or more) of the image.

Finally, just so that we can put some of these descriptions into equation form, we'll define "O" to represent our output image. We will also occasionally use "M" whenever we need to denote an image that is used exclusively as a matte channel. Such an image should generally be thought of as a single-channel (grayscale) image.

Using these notations, the Add multisource operator that we originally discussed could be simply represented as

$$O = A + B$$

A and B are our two source images and O is the resulting image. Since the Add operator behaves the same with either three- or four-channel images, there is no need to mention any specific channels in this particular equation, and it should be obvious that in actuality,

$$O_{rgb} = A_{rgb} + B_{rgb} \quad \text{and} \quad O_a = A., + B_a$$

Now that we have a common language that we can use to discuss some of these concepts, we can finally begin to talk about some of the more powerful compositing operators. Most of these are not just two-source operators such as the Add we just saw, but instead can accept several inputs, including matte inputs that may be used to control which portion of one image is combined with another image. By far the most common operator for selectively combining two images is the Over tool.

7.5.1 Over

Since the Over operator is such a crucial, often-used tool, we will examine it in great (some may say excruciating) detail. Even if you feel you are very familiar with using Over for compositing, it is worth understanding the exact algorithm that is used, since a number of problems can be diagnosed when you are armed with this knowledge.

The Over operator takes two images and, using a third image as a controlling matte, lays a portion of the first image on top of the second. Intuitively, people understand compositing with the Over tool as if the matte were a cookie cutter that removes all excess information from the foreground image. Once this cutout is created, the result is then pasted on top of the background.

Here's what really happens, mathematically, when we place image A (the foreground) over image B (the background), using image M as the matte for image A.

$$O = (A \times M) + [(1 - M) \times B]$$

Let's break this down into the specific steps as they occur. First, the foreground image is multiplied by the matte image (A X M). In our example, this was already shown to produce the intermediate image. Again, everything outside of the matte has become black, and the portion of the image that is located within the solid, or white, area of the matte remains unchanged.

The second step is to take the inverted matte image and multiply that with the background image. This multiplication produces a new intermediate image with a black hole where the foreground will go. To complete the process, these two intermediate images are then added together, creating the final output, which we already saw in figure 36.

This example underscores an important point about most image-combination tools. They are often just a group of even more simple operations applied sequentially. If you find yourself trapped on a desert island with a composting system that has only a limited number of tools, you will usually be able to recreate a large number of more complex tools as necessary.

For those of you who are accustomed to working with images that already have an integrated matte channel (such as those rendered by a 3D animation package), the equation describing the Over operation may seem to contain an additional step. In fact, the first stage of our Over equation (described by (A X M)) is designed to produce a normal premultiplied image that would behave identically to an image produced by 3D rendering software.

If we look again at the Over operation, this time simplifying for the case of an image with an integrated matte channel, the equation becomes

$O_{rgb} = A_{rgb} + [(1 - A_a) X B_{rgb}]$

Note that the color channels of the output image are independent of the background image's matte. However, the output image's matte channel is composed as follows:

$$O_a = A_a + (1 - A_a)x B_a$$

We could also write the simplified equation for all four channels as

$$O_{rgba} = A_{rgba} + [(1 - A_a) X B_{rgba}]$$

7.5.2 Mix

A mix is the weighted, normalized addition of two images. In other words, the two images are averaged together, often with one of the images contributing a larger percentage to the output. Figure31 shows the result of mixing 75% of image A with 25% of image B.

The equation for such a mix, where "MV" refers to the mix value (the percentage of the first image that we will be using), is as follows:

$$O = (MV X A) + [(1 - MV) X B]$$

This operation is usually known as an "additive mix," since the weighted averages are added together.

To "dissolve" from one image to another over a given period of time, one merely animates the mix value so that it initially displays 100% of image A and then eventually displays 100% of image B.

7.5.3 Subtract

The Subtract operator causes every pixel in image A to be subtracted from its corresponding pixel in image B. Quite simply,

$$O = A - B$$

Note that Subtract is not a symmetrical operator. The order in which the two images are specified is important to the result. Be aware of which multisource operators are symmetrical and which are not, since it will determine whether or not you need to be concerned about the order in which you combine images. Thus, (B + A) equals (A + B), but (A - B) does *not* equal (B - A).

Most implementations of the Subtract operator will allow you to choose whether to clip all values that go below zero, or to take the absolute value of the result, in which negative numbers are converted to positive. The absolute value method is particularly useful for difference matting.

7.5.4 In

There are certain multisource operations that require only a matte image for the second input. (The matte image can either be a single-channel image or the alpha channel of a four-channel image.) The In operation is one of these. As you can see from the equation, it pays no attention to the color channels in the second image, even if it is a four-channel image:

$$O = AXB_a$$

When we describe the use of the In operator, we usually say we are placing image A *in* image B; the result is an image that consists of only the areas in image A that overlapped with the matte of image B. Both images are assumed to have an integrated solid matte channel that corrresponds to the shape you see. "A in B" is shown on the right.

7.5.5 Out

The Out operation is the inverse of the In operation—it results in a new image that consists only of pixels from image A that did not overlap the matte of image B. We say that A was "held out" by B.

$O = A \times (1 - B_a)$

7.5.6 A-top

As mentioned, many image-combination tools can be used in tandem to produce new tools. Most of these combinations are given different names by different software vendors, so we will not attempt to list them. But to give an example, we show a fairly common one, usually referred to as an Atop operator. It places image A over image B, but only in the area where image B has a matte. We say we are placing A "atop" B.

O = (A in B) over B

Although most of these image-combination operators are really just very simple mathematical calculations that work with images and mattes, more complex operators certainly exist. **Morphing,** for instance, combines the animated warping of two images over time with a controlled dissolve between the two sequences.

7.6 Masks

There are times when we wish to limit the extent of a certain operator's effect. A particularly useful method for doing this involves the use of a separate matte as a control image. Whenever a matte is used in this fashion, it is usually referred to as a **mask.** In essence, the use of masking with a single-event operator implies a multisource scenario, with the original sequence as the first source and the mask as the second. Just about any operator should be something that can be controlled by an external mask, and so we'll look at a fairly simple example.

If your system does not support masking to control operations, you can still accomplish the same effect manually, using some of the image-combination tools that we have already discussed. You would first apply the effect to the entire frame and then use the mask to isolate the proper area and combine it with the original, unaffected image.

7.7 Color-Correcting and Combining Premultiplied Images

Whenever we premultiply an image by a matte, there is a very specific brightness relationship between the pixels in the color channels and the pixels in the matte. Systems that assume you are working with premultiplied images will rely on this image/matte relationship; consequently, the brightness of any color channel can no longer be modified without taking the alpha channel into account (and vice versa). Thus, any time you apply a color correction to a premultiplied image, you run the risk of producing a new image whose matte/image relationship is no longer "legal." If you look at the math that is used when we premultiply an image by a matte, it should be obvious that the brightness of any given red, green, or blue channel in such an image can never exceed the value of the alpha channel. This can sometimes be used as an indicator that there has been some kind of operation performed on the image after the premultiply occurred. The result of compositing with this image will vary, depending on the extent of the change made to the different channels, but generally it will manifest itself as a slight brightening or darkening of the composite in areas where the foreground matte was semitransparent. More extreme changes to the color or matte channels will obviously result in more extreme artifacts.

A particularly common problem will occur when some color correction has been applied to a foreground premultiplied image that causes the blacks in the scene to be elevated above a value of 0. Now, even though the matte channel may still specify that the surrounding field is black, the RGB channels may have some small, often visually undetectable, value. The problem will show up when one attempts to layer this element over a background. The resultant image will show a noticeable brightening of the background in the area outside the foreground's matte. As one becomes a more experienced compositing artist, artifacts like this become the clues that let one track down exactly which layer in a composite is causing a problem. In this case, the clue is the fact that the background gets brighter. As you can imagine, it may be very difficult to determine if this problem exists, since at first glance an improperly modified image may appear perfectly correct.

Because inevitably you will find yourself with a need to color correct a premultiplied image, there is usually a tool on most systems to temporarily undo the premultiplication, at least in the critical areas of the image. We will refer to this tool by the rather unwieldy name of "Unpremultiply." Essentially, the tool redivides the image by its own matte channel, which has the effect (except in areas where the matte is solid black, or 0) of boosting the areas that were attenuated by a partially transparent matte back to approximately their original values. (Areas where the matte was equal to 0 have been set to be pure white.) Although this is obviously not a completely perfect recreation of the original image, it restores enough information in the edges so that appropriate color corrections can be applied.

If your system does not have an explicit tool to perform this operation, you can try using some other tool to simulate it. For example, if there is a simple expression language available, you can modify the image so that

Red = Red/Matte Green = Green/Matte Blue = Blue/Matte

Once the image has been unpremultiplied, any necessary color corrections can be applied without fear of corrupting any semitransparent areas. The result should then be remultiplied by the original matte channel, which will restore the element to one whose image-to-matte relationship is correct.

For slight color corrections, or when using images that have very hard-edged mattes, you may get perfectly acceptable results without going through this process. As usual, use your best judgement, and if it *looks* correct, then by definition it is correct. But if there is any doubt in your mind, or if you are having problematic edges, you may want to take a moment and compare the results of performing your color correction before and after the image is multiplied by the matte.

By default, all the major 3D packages will render elements that have been premultiplied by their matte channel. As we've seen, this is not always the ideal scenario and in many situations may actually be counterproductive. Assuming that the 3D element is perfectly ready for integration into the scene, having it delivered already premultiplied by its matte channel will be fine. But as often as not, this conceit is not really the case. You may want to determine if there is some way of overriding this premultiplication behavior in the 3D package, so that you can have unpremultiplied images available for your compositing work. This ability will be particularly important if you are in a situation in which you will be performing a good deal of color correction on the 3D element.

7.8 Luminosity

When working with four-channel premultiplied images and using the Over operator, there is an additional effect that can sometimes be useful. It involves selectively manipulating the alpha channel of the image to intentionally modify the image-to-matte relationship. This operator is often referred to as a "Luminosity" tool. By decreasing the value of the alpha channel before placing an object over a background, the object will appear to become brighter in the result. In addition, the background will become more visible through the foreground element.

In this case, the matte channel for the foreground image was multiplied by 0.6 before being placed over the background. In fact, as the matte channel is decreased toward 0, the result becomes more and more like an Add operation instead of an Over. This can be proven by examining the equation for Over again. If the matte of the foreground object in a premultiplied image is set to 0, the Over operator will produce the same results as an Add.

8 ANIMATION INDUSTRY

Possibilities and experimentation have evolved into commonly used and widely accepted tools to create effects, images, and characters for films. The education needed to succeed in the digital entertainment industry has also changed. The early emphasis on technical skills, especially computer science, has broadened to include a strong focus on art and animation skills. The reasons for this necessitate looking at the industry and education over the last twenty or so years. While this article primarily addresses the entertainment film industry, that industry offered few digital production jobs before 1992. We must therefore consider the role that television commercials (and those ubiquitous "flying logos") played in the development and adoption of digital technology in the film industry. In addition to theatrical motion pictures, the fast-growing digital film industry now produces a wide variety of filmbased entertainment, from ride simulators to large-format special-venue theaters such as OmniMax and Imax. (Morie, 1998)

8.1 History of The Industry

The quality of animation from the major Hollywood studios began to decline in the 1950s, though this decline was gradual. Both the Warner Bros and MGM cartoon studios were at the peak of their creativity at the beginning of the decade. The Hollywood cartoon studios gradually moved away from the lush, realistic detail of the 1940s to a more simplistic, less realistic style of animation. The influence of UPA had caused a number of studio heads to literally order their cartoon studios to "make cartoons like UPA!," and the effect was seen on the screens(http://www.fact-index.com)

Hollywood special effects continued to develop in a manner that largely avoided cel animation, though several memorable animated sequences were included in live-action feature films of the era. The most famous of these was a scene during the movie *Anchors Aweigh,* in which actor Gene Kelly danced with an animated Jerry Mouse (of *Tom and Jerry* fame). But except for occasional sequences of this sort, the only real integration of cel animation into live-action films came in the development of animated credit and title sequences. Saul Bass' opening sequences for Alfred Hitchcock's films (including *Vertigo, North by Northwest,* and *Psycho* are legendary, and he had several imitators. Likewise, the opening title sequence of the *Pink Panther* film series were popular enough to give rise to a series of cartoons based upon the character of the same name. (http://www.fact-index.com)

Yet another wild card was added to this crowded, competitive atmosphere with the rise of a new wave of computer animation. The decade of the 1990s saw exponential improvement in the use of computer technology to enhance both animated sequences and live-action special effects, allowing lavish computer-animated sequences to dominate both. This new form of animation soon dominated the world of Hollywood special effects (the movies *Terminator 2: Judgment Day* and *Jurassic Park* included stunning computer-animated sequences), and it was only a matter of time before a full-length feature film would be produced entirely with computers. (http://www.fact-index.com)

In 1975, computer graphics had been around little more than a decade. Because the field was so new, it did take a rocket scientist to do the work required for computer graphics. Few basic tools existed, and computer graphics specialists invented the tools they needed from the technical and mathematical ground up. Only those who could write the code could tell the machine what to do artistically.

Hollywood knew little about this fledgling area. The biggest advances involved 2D graphics, and in the 1970s the few movies that employed CGI used either on-screen graphics (simulating what would be seen on a computer terminal or screen readout in a spaceship, for example) or 2D computer imagery. By 1975 CGI had been used in only two major films. In 1973, *Westworld* featured scenes that showed audiences the world viewed by the eye circuitry of a synthetic human (played by a very real Yul Brenner) in a future Western theme park. This effect was achieved with 2D computer graphics tools mostly derived from image processing techniques. The 1974 sequel to *Westworld*, *Futureworld*, used 3D CGI. (Morie, 1998)

Using 3D CGI extensively in films remained a dream. Few in the movie industry believed in CGI, but academic researchers around the country sought to create viable tools. Because no one knew what could be done with CGI, it was considered extremely risky, and also very expensive. Making a film was already an expensive endeavor; using budding CGI technology could significantly increase the overall cost, even if it did manage to get done on time and not delay the film's release date. In the meantime, television embraced the fledgling computer graphics industry. CGI examples tended to be quite short because the technology was highly technical and tedious, with long rendering times needed to get good-looking images. Short formats, however, worked well for TV with its 30-second commercials and program openers. Also, rendering for broadcast required considerably less resolution than film about one-tenth the number of pixels per frame and therefore less time as well. Then as now, commercials had to grab the audience's attention before they launched the sales pitch. Computer graphics offered a new, glitzy way to do just that, and the advertising industry had the money to spend on it. The digital film industry owes a great deal to advertising's need for something new to captivate audiences. Companies doing primarily TV commercial work proliferated in the late 1970s and early 1980s. These companies had relatively few artists on staff, however. They needed technically versed workers to write new code and manipulate technology into doing things it hadn't done before. The commercials' artistic design generally came from the CGI company's contracting agency usually a prestigious ad agency that could afford CGI's high price. Most companies thus had one or, more likely, no artists on staff. Among the few exceptions, Triple-I (Information International, Inc.) had three: Richard Taylor, Art Durinski, and John Whitney, Jr. (Morie,1998)

During the 1980s, the Reagan administration repealed a number of regulations on television; among other things, it greatly loosened the standards a TV show had to meet to be considered "educational" (and thus worthy for viewing by children). Toy manufacturers and marketers took advantage of these new standards, and the first half of the decade saw the introduction of a wave of toy-based cartoons that were widely criticized for being little more than half-hour TV commercialss for toys and video games. These cartoons, including *G.I. Joe, Transformers, Care Bears, Pac Man, Saturday Supercade,* and many others were often cited as examples of poor writing and animation; nevertheless, they were a big hit with young viewing audiences. They were also the first cartoons to seriously threaten the dominance of Hanna-Barbera for the kids' viewing market. Despite their low quality, the Marvel Productions cartoons (especially *G.I. Joe* and *Transformers*) offered a change of pace from the formula writing offered by Hanna-Barbera's continuing series. (www.fact-index.com)

By 1986, thanks to all the work done for commercials, digital technology had made inroads in the film industry but the work force hadn't changed much. The chances were still high that whatever was needed for a particular shot had never been done and required new code. This called for programmers, not artists. If a company did hire an artist, it was typically as an art director, working alongside the programmers to help them understand and translate an artistic vision into code. Few people could claim to be both scientists and artists at this time (although some schools were starting to train well-rounded people who would play pivotal roles in the digital film industry's future). During this decade, the quality of images generated by CGI rose substantially. In addition, people who worked on traditional effects (optical and physical) began working in the digital realm. As CGI infiltrated the film community, commercial CGI creators also learned more about the way films were made. Looking back, 1981 was a milestone year for digital film, with 3D computer graphics in two major films. In Michael Crichton's film *Looker*, Susan

Figure 8.1 Tron

Dey's character needed to obtain physical perfection as embodied by a computer program's ideal 3D representation of her. Based on their work for *Futureworld*, Triple-I won the task of creating this 3D figure. Though not a box office success, *Looker* showed the new medium's potential. Also released in 1981 (and also not a box office success), *Tron* used 3D computer graphics extensively in both concept and actuality. Although traditional optical effects created the characters' look, the film used the most CGI to date—it took four major CGI companies to achieve it all. The light cycles were done by Magi, the solar sailor ship by Triple-I, the *Tron* title logo and wireframe world by Robert Abel and Associates, and the bit character and *Tron* opener by Digital Effects. The next landmark was *The Last Starfighter* (1985). Digital Productions created an astounding 27 minutes of CGI for this film. Unfortunately, the film's success did not translate into success for the company; Digital Productions closed in 1986. Besides generating original imagery, CGI began to make inroads into another traditional effects mainstay, optical compositing, or the layering of foreground and background elements within a single scene using analog film equipment called optical printers. (Morie, 1998)

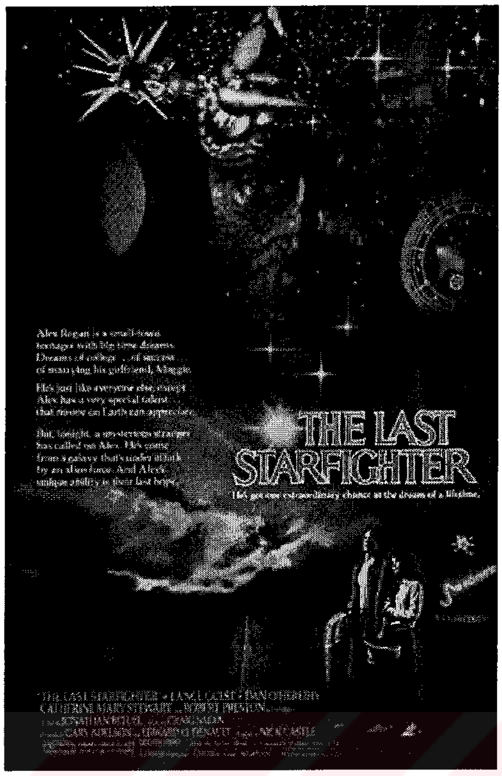


Figure 8.2 The Last Starfighter

Digital compositing had its start in the early 1980s. It had been tried early on in the movie *Flash Gordon* at an optical printing house run by Frank Vander Veers. Both the early Digital Scene Simulation system and the Pixar Image Processing Computer (developed in 1982 by the Lucasfilm Computer Division) further developed the technology for digital compositing, and slowly the idea took hold in Hollywood. Digital compositing offered many benefits, chief among them a simplified production pipeline that did not involve shooting, processing, nd aligning many layers of filmstock. In the late 1980s, illusion once the domain of highly skilled artists creating matte paintings or constructing miniatures, and skilled film industry specialists putting the elements together with optical printers became the domain of physicists, mathematicians, computer scientists, and electrical engineers. About two-thirds of the key people in the digital effects industry in the 1980s came from these disciplines. Unfortunately, the decade that saw the meteoric rise of so many CGI companies also witnessed their demise. Within a fairly short period of time, four of the largest CGI houses Abel, Cranston/Csuri Productions, Omnibus, and Digital Productions closed their doors. Their high overhead and the rapid pace of innovation made it impossible for them to survive. (Digital Productions' Cray computer reportedly cost $250,000 per month in upkeep.) The entertainment industry was not willing to pay exorbitant capitalization expenses or research and development costs. Work moved to smaller companies that could operate on more traditional budgets. Despite its successes, producers and directors still did not trust CGI. A Siggraph 88 panel, "The Reality of Computer Graphics in the Motion Picture Industry," considered various directions CGI might take. Several participants urged exploring it more for its storyboarding capabilities than its potential for generating original images. In preparation for this panel, Richard Hollander, owner of a company that produced on-screen visuals and video displays for the movie industry, informally surveyed movie people in person and by phone on the state of the industry. The good news was that everyone knew what CGI was. The bad news was they repeatedly commented on the great expense and that CGI had a unique look appropriate for a limited range of film styles. The industry decision-makers did not see beyond CGI's existing uses, and many remembered the high cost and box office failures of movies that relied too heavily on CGI. Alex Singer, a veteran Hollywood director and currently a director on *Star Trek Voyager*, has followed technology's progress and potential for some time. In a phone conversation, he remarked about this period in Hollywood: Everybody was learning. The artists and programmers were learning how to create things that had never been seen before. The producers and directors were learning that this new thing was out there, even if they didn't trust it at all. Even the audiences were learning much like *Citizen Kane* was not a commercial success when it came out (for 10 years) because the audience was not sophisticated enough to know what it was looking at. *Tron* was a failure, not only because of a bad story, but in a contributory way because the audience was not tuned into the subject matter. We could call the 1980s the startup decade for CGI in film. It enhanced such commercial successes as *Star Wars: Return of the Jedi* (the death star hologram), *Star Trek: Wrath of Khan* (the Genesis effect), and *Young Sherlock Holmes* (the stained-glass man). *The Abyss* typified the decade's end, offering a prime example of a major director (James Cameron) taking a chance, but not too big a chance. Had the CGI effects for the pseudopod water face scene not worked out, it would not have affected the movie's schedule or success. The fact that it did work convinced Cameron that this tool, if used well, could deliver. (Jacquelyn Ford Morie)

The early 1990s saw major growth for CGI in films. *The Abyss*' success convinced Cameron that he could successfully undertake a new film that relied heavily on digital effects and, in fact, could not be made without them. The 1992 film *Terminator 2* proved to be not only a box office smash but also the turning point that convinced the film industry that CGI was indeed a reliable tool. In his keynote address to the 1991 Society of Motion Picture and Television Engineers tutorial "Issues in Advanced Motion Imaging," James Cameron talked about CGI achieving respectability after many years of "hard work." He also discussed his experiences with *The Abyss* and *Terminator 2*. What surprised him about *The Abyss* was that each company vying for the job proposed very different techniques to create the effect. Happy with the work Industrial Light and Magic did, Cameron described himself as "intoxicated" with the technology's possibilities, prompting him to take the big step with *Terminator 2*. But he also said this about the practitioners of the digital arts: You (digital) effects guys know too much. You're getting like doctors—too much knowledge and not enough bedside manner.4 CGI made significant inroads in film as awareness and demand grew. Many films in the early 1990s used large amounts of CGI technology, including *Batman Returns*, *Alien 3*, *Jurassic Park*, *The Lawnmower Man*, *Death Becomes Her*, *Toys*, *In the Line of Fire*, *The Mask*, and *Forrest Gump*. Companies specializing in CGI were finally in demand and had to find more talent to keep up with the new and hectic pace. And, just maybe, they were starting to develop some bedside manners.

By 1996 CGI, by most accounts, had come of age. Moving beyond just usefulness, CGI had become an essential film industry tool for simulating dangerous or costly effects and for the final digital compositing of all separate elements. Besides effects and compositing, CGI's role in entertainment also grew with the resurgence of the animated feature film. While some companies tried early on to make animation cheaper to produce with CGI, innovations by Disney's Feature Animation Division in the 1980s and 1990s enabled CGI to enrich the look of animation in ways not necessarily cheaper, but better. One involved achieving an unlimited number of layers in the digital multiplaning technique (prohibitively expensive in its traditional form and limited by the buildup of density of the numerous cel layers when stacked). Another involved replicating single character elements, essentially animatedonce, into flocks, herds, and crowds. Animated features' new popularity may stem in part from the new richness computer graphics techniques bring to animation. In 1995, an entirely computer-animated feature film, *Toy Story*, marked a major digital milestone. Created jointly by Pixar and Walt Disney Feature Animation, this film's success took many by surprise. For many years the Pixar group had been creating cutting-edge short computer films such as *Tin Toy* and *Luxo, Jr*. Later they delved into commercial work, focusing on character animation. The Pixar team, widely acknowledged as the world's best CGI character animators, seemed well suited to step up to a feature-length film. *Toy Story*'s success motivated more than one Hollywood company to start developing in-house CGI animated features. This growth, and the entertainment industry's confidence in mature CGI, spurred intense demand for talent to fill the growing ranks of CGI companies between 1994 and 1996. Top students were often pulled from schools before they completed their education; others were hired immediately upon graduation. Companies searched the world to find the talent they needed. In fact, the only area that grew as fast during these years was the human resource departments tasked with all the recruiting and hiring. But it has been quite difficult to find the talent the industry needs, even though in sheer numbers more students are looking for work than there are jobs. While hundreds of schools now offer CGI programs or courses, a disparity exists between a graduating student's knowledge and what employers desire. We can further explore some of the many reasons for this disparity by examining what was going on in the academic world in the same years we examined for industry. (Morie, 1998)

8.2 CG Education in the Field of Computer Garphics

In the 1970s, few schools offered formal study in computer graphics for the entertainment industry. Those that did typically offered a course or two in their computer science or electrical engineering departments, usually at a graduate level. Few art departments had funding or equipment for computer graphics classes.

Graduate students lucky enough to find funding for computer graphics research often worked on Department of Defense computer simulation projects, the primary application for this new field.

By the mid-1980s, several schools had started fusion programs aimed at teaching basic artistic and technical concepts. Sheridan College in Ontario, Canada, had developed a successful computer animation program. The University of Illinois at Chicago's Electronic Visualization MFA program, started in 1980, balanced technical and artistic training in a joint effort between engineering, computer science, and art and design departments.

Many educators agreed on the need for interdisciplinary studies in computer graphics. At Siggraph 84, more than 200 people attended a two-day course, "Interdisciplinary Issues in Art and Design." Vibeke Sorensen, a long-time computer graphics teacher and one of the course organizers, listed 31 schools "leading the way" in CGI in 1984, making no distinction between CS and art schools. This made sense in light of the session's goal to find ways to merge the art and science of computer graphics into one harmonious course of study. This course resurfaced at Siggraph 87 as a one-day Educators' Workshop on "Teaching Computer Graphics: An Interdisciplinary Approach." For teachers trying to establish or improve their computer graphics programs, this course represented the best of CG education. It featured detailed descriptions of programs and courses, syllabi and sample curricula, and lists of resources such as books, magazines, and journals. It included articles like "Why Artists Should Learn to Program" by University of Oregon art professor Craig Hickman and information on where graduates were getting work many at Hollywood's main entertainment companies. The Siggraph Education Committee emerged in the 1980s as well. Siggraph's mission has always been to educate, but many practitioners found themselves going into teaching with few resources.

By the 1990s, hundreds of schools had some sort of computer graphics program, many targeting entertainment as their students' professional destination. Students especially were drawn to this glamorous new area, having seen exciting CGI effects in popular films. Studios began to provide limited, highly competitive internships almost certain to lead to permanent jobs for students with the appropriate talent and personality. While most film industry jobs still advertised for people with three to five years of experience, any student determined and talented enough could hope to end up with a job somewhere in the industry eventually. Most entry-level jobs, however, were at small boutique production companies around the country where students could gain the experience needed for Hollywood. In the early 1990s, many technical and vocational schools focused on bringing students up to speed quickly. Spurred by students' demands to get into this industry fast, and their willingness to pay, these schools provided programs ranging from six months to two years. High tuition permitted these places to offer newer equipment and industry-level software that many colleges could not. However, they also emphasized training on specific commercial software. Studios buried in work sought students who had logged many hours on an up-to-date system. Some companies advertised for jobs such as "Wavefront Operator"—many postings listed specific hardware or software—and students took classes to become just that. If studios couldn't get what they really wanted, they could at least hire someone who knew the software. In this atmosphere, university teachers had difficulty convincing students to spend additional years learning subjects that did not seem pertinent. Often, students settled for a university over a trade school only because of the cost difference. Fueling students' impatience was what I call the "software vendor trap"; as a panelist at the Siggraph 97 Education Panel put it, "If you get an outfit, you can be a cowboy too" (after a humorous Smothers Brothers song). Some students felt that knowing one software package made them ready for work, without understanding that they possessed only a small part of the knowledge and skills required. A student at Ringling School of Art and Design was convinced by a software salesman (from a company no longer in business) to take his next year's tuition and buy their system it was all he needed to start his own business. The student did so but was back at the school's door within the year, having learned the hard way that he did not have the training he needed. (Morie, 1998)

8.3 Animation Studios And Companies

8.3.1 The Crew

Audio Technician: Audio Technicians include Mix Technicians, Transfer Operations Technicians, Recordists, Central Operators and Projectionists. Responsibilities vary depending on the specific job title. However, duties may include setting up and operating technical equipment for a mix, aligning the recording, playback and projection equipment; assisting with the locating, setting up and breakdown of outboard equipment; completing billing forms such as mix logs and master inventory tracking sheets, and assisting clients with various technical needs. (http://www.ilm.com)

Character Animator: Character Animators comprehend and execute direction from the Animation Supervisor or Animation Director to create the motion and personality of computer graphics characters. The Character Animator will use various high-end animation software packages such as SoftImage, Maya and proprietary software. As a member of the production team they participate by providing feedback to other members of the production and by attending dailies on a regular basis. Character Animators are generally from a traditional background in cel or stop motion animation who now take a computer modeled character or object and bring it to life via the computer.

Computer Graphics Technical Assistant: Provide general but crucial support to all current productions. Computer Graphics Technical Assistants (TAs) retrieve files from tapes, process conversions, transfers, and the backing up of data to tape. They have the opportunity to develop simple scripts and tools to streamline operations and also provide assistance in monitoring shots.

Compositor: Compositors seamlessly integrate all the layers or elements of a shot, including live-action and computer graphic elements. At ILM, in-house proprietary compositing software runs on Linux and UNIXbased systems. There is also a department of high-speed Discreet-based compositing workstations. Both groups work closely with the Visual Effects Supervisor and CG Supervisor compositing the numerous elements that complete a visual effects shot. The Compositor performs many 2D tasks including blue/green screen extractions, tracking, stabilization, painting, rotoscoping, and color continuity. The Compositor is usually the last person to work on a shot before it goes out to film. (http://www.ilm.com)

Digital Matte Artist: Digital Matte Artist works with the Visual Effects Supervisor to create digital set extensions and virtual environments. Digital paint and photo manipulation skills are used to create vistas, cityscapes and backdrops of all kinds that fool the eye and look real. The Digital matte artist is often responsible for designing, creating and incorporating animation and 3D elements into the matte "painting." Research is often required to locate and obtain appropriate visual reference materials.

Digital Plate Restoration Technician: After viewing shots using proprietary viewing software, Digital Plate Restoration Technicians use paint software to clean frames and remove dirt, scratches, etc. They transfer the cleaned frames to the Resource Assistants to backup and to load into the shows work area.

Digital Resource Assistant: The Digital Resource Assistants (RA) serve as the primary liaison for resource information between Production, CG Artists and Computer Graphics Technical Assistants. They are responsible for tracking all information through the digital pipeline using various tools. They ensure information is accurate in bringing files online and off-line to meet the needs of the digital artists and production. They also track the status and location of all files used by artists. This is an entry-level position that can provide a strong foundation/experience in postproduction, leading to various career growth opportunities.

Editorial Technical Assistants: The Editorial Technical Assistant (TAs) are responsible for various editorial support tasks including video dubbing on Betacam, Digital Beta 3/4", VHS, Hi8, D1, DAT and DDR, providing support/tape changes for CMX and Avid sessions, video support and tape changes for production dailies.

Creature Developers: Enveloping is an ILM term for creating the skin motion of a CG creature. Creature Developers, are primarily responsible for ensuring that models maintain an anatomically correct and sculpturally detailed form while moving through animated motions. Achieving this goal requires proficiency in the tasks of connecting the rendered surfaces of models to animation controls, creating procedurally animated simulations of hair, cloth, muscles and flesh, and generally making sure that models proceed through the animation and render pipeline of a shot in good form.

Matchmover: Matchmovers create motion files matching the original background plate photography and converting the plates into various formats for use with in-house software. They model the set geometry used to create the matchmove and CG environment for Character Animators and Technical Directors. They light, render and composite the files with the background to judge the move. They also match any live-action characters that interact with both the lighting or CG characters.

Modeler - Organic & Hard Surface: Modelers work closely with Art Directors, Visual Effects Supervisors, Animation Supervisors to turn 2D concept art and traditionally sculpted maquettes into high detail, topologically sound 3D wireframe models. They will continue to assist the Technical Animator and Enveloper as the model has a skeleton put in place and the skin is developed. Following this, the model may be handed back to the Modeler, who will proceed to sculpt facial expressions and any specific muscle tension/jiggle shapes required.

Motion Capture Technical Assistant: Motion Capture is a technique for recording performances from actors and applying those performances to digital characters. ILM uses this technique to animate a wide range of digital characters for feature films and commercials. The Motion Capture Technical Assistant performs technical support tasks for the Motion Capture Group. The primary role of the TA is to processes mocap data to reconstruct and deliver clean data that accurately represents the captured performances. This involves cleaning up noise artifacts, thinning oversampled data, reconstructing missing trajectory segments, and blending multiple motion capture performances.

Production Assistant: Provide administrative support and back-up to the production team including typing memos, documents and schedules; photocopying, filing, preparing, maintaining and distributing storyboards and other reports; organizing dailies, helping with live action stage and location shooting as needed including craft service and errands.

Otoscope Artist: Working very closely with Compositors, Rotos Artists modify and remove isolated elements for digitally composited sequences using both procedural and hand-painting methods. They perform plate clean-up and create digital articulate mattes as well as doing background repairs, wire removals and blue screen extractions.

Systems/Tools Programmer: The Script/Tools Programmers improve, develop, maintain and document the "generic scripts" used by the Render Support Department in tracking the shots rendering for each production. The generic scripts are programs and control files written in C shell, python, or other high-level computer languages. New versions of the scripts are delivered to the render support personnel by the Script/Tools Programmer who then assists with the integration of the tool as well as following up should any problems occur. They will also receive show specific script changes from the Assistant Technical Directors and then assist in integrating changes into the generic scripts. When necessary, the Render Support Department may ask for other programming tasks to be completed also.

Systems Developer: Systems Developers are responsible for design, prototype and construction of complex computer and data storage systems needed to create cutting edge graphical images. They define and build applications, including software and hardware, needed to support the artists in fulfilling their mission of creating visual images for the motion pictures. Systems Developers function as a liaison with the application software groups and artistic groups.

Technical Director: Technical Directors (TD) work with direction from the Visual Effects Supervisors and CG Supervisors to create the look of computer generated objects and scenes. They are responsible for lighting, shading, rendering, some compositing and for creating the motion dynamics and look of simulated effects such as water, smoke, fire and hair. TDs work with other artists such as Character Animator, Rotoscope Artists and Compositors to bring the shot together. They must be familiar with the ILM render pipeline and be technically adept to identify and debug any problems.

Video Engineers: Video Engineers install and maintain complex video systems and equipment that support the production process, ensuring integration with existing systems. They are responsible for trouble shooting equipment and systems problems along with repairing and maintaining video equipment and systems.

8.4 On The West Coast

In the early 1990's Steven Spielberg was working on a film version of the latest Michael Crichton best seller, "Jurassic Park." Since the movie was basically about dinosaurs chasing (and eating) people, the special effects presented quite a challenge. Originally, Spielberg was going to take the traditional route, hiring Stan Winston to create full scale models/robots of the dinosaurs, and hiring Phil Tippett to create stop-motion animation of the dinosaurs running and movements where their legs would leave the ground.

Tippett is perhaps the foremost expert on stop-motion and inventor of go-motion photography. Go-motion is a method of adding motion blur to stop-motion characters by using computer to move the character slightly while it is being filmed.

This new go-motion technique eliminates most of the jerkiness normally associated with stop-motion. As an example, the original King Kong movie simply used stop-motion and was very jerky. ET on the other hand used Tippett's go-motion technique for the flying bicycle scene and the result was very smooth motion. Tippett went to work on Jurassic Park and created a test walk-cycle for a running dinosaur. It came out OK, although not spectacular.

At the same time, however, animators at ILM began experimenting. There was a stampeding herd of Gallimimus dinosaurs in a scene that Spielberg had decided to cut from the movie because it would have been impossible to create an entire herd of go-motion dinosaurs running at the same time. Eric Armstrong, an animator at ILM, however, experimented by creating the skeleton of the dinosaur and then animating a walk cycle. Then after copying that walk cycle and making 10 other dinosaurs running in the same scene, it looked so good that everyone at ILM was stunned. They showed it to Spielberg and he couldn't believe it. So Spielberg put the scene back into the movie.

The animators at ILM worked closely with Stan Winston, using his dinosaur designs so the CGI dinosaurs would match the large full-scale models Winston was creating. Alias Power Animator was used to model the dinosaurs, and the animation was created using Softimage software. The dinosaur skins were created using hand-painted texture maps along with custom Renderman surface shaders. The final scene which is a show-down between the T-Rex and the Velociraptors was added at the last minute by Spielberg since he could see that ILM's graphics would produce a realistic sequence. The results were spectacular and earned ILM another Special Effects Oscar in March of 1994.

9 ANIMAION STUDIOS IN USA

9.1 Pixar

P I X A R

9.1.1 Introduction

Pixar Animation Studios combines creative and technical artistry to create original films in the medium of computer animation. Pixar has created and produced five of the most successful and beloved animated films of all time: Academy Award®-winning *Toy Story* (1995); *A Bug's Life* (1998); Golden Globe-winner *Toy Story 2* (1999); the Academy Award®-winning *Monsters, Inc.* (2001); and the Academy Award®-nominated *Finding Nemo* (2003), the highest-grossing animated film of all time. Pixar's five films have earned more than $2.5 billion at the worldwide box office and sold over 150 million DVDs and videos worldwide. The Northern California studio's next two films are *The Incredibles* (November 5, 2004) and *Cars* (holiday 2005). (http://www.pixar.com)

Toy Story, released November 22, 1995, reflects more than nine years of creative and technical achievements. The film received tremendous critical acclaim and became the highest grossing film of 1995, generating over $360 million in worldwide box office revenues. *Toy Story*'s director and Pixar's executive vice president of creative, John Lasseter, received a Special Achievement Academy Award® for his "inspired leadership of the Pixar *Toy Story* team resulting in the first feature-length computer animated film." Pixar has since released *A Bug's Life*, the highest grossing animated film released in 1998 and *Toy Story 2*, the highest domestic grossing animated film released in 1999. *Toy Story 2*, at the time of release, broke numerous opening weekend records all over the world and won a Golden Globe award for Best Picture, Musical or Comedy in 1999. In 2001, Pixar released the Academy Award®-nominated *Monsters, Inc.*, which reached over $100 million at the domestic box office in just nine days, faster than any animated film in history. At the time of release, *Monsters, Inc.*'s opening-weekend gross of $62.6 million marked the largest three-day opening ever for an animated film, the largest three-day opening ever in the month of November, the largest three-day opening in the history of The Walt Disney Studios, the largest three-day opening in the history of Pixar Animation Studios, and the sixth-largest opening in industry history. *Monsters, Inc.* has become the third-highest grossing animated feature film worldwide.

Most recently Pixar's fifth film *Finding Nemo* smashed box office records all over the world. *Finding Nemo* opened domestically with an astounding $70.2 million over the first three days. It is now the highest grossing animated film worldwide, the highest grossing film of 2003 and the ninth highest grossing film of all time.

9.1.2

Technology

Since its incorporation, Pixar has been responsible for many important breakthroughs in the application of computer graphics for filmmaking. Consequently, the company has attracted some of the world's finest talent in this area. Pixar's technical and creative teams have collaborated since 1986 to develop three core proprietary software systems:

i. Marionette™, an animation software system for modeling, animating and lighting,
ii. Ringmaster™, a production management software system for scheduling, coordinating and tracking a computer animation project and
iii. RenderMan11®, a rendering software system for high-quality, photo-realistic image synthesis that Pixar uses internally and licenses to third parties.

In 2001, the Academy of Motion Picture Arts & Sciences' Board of Governors® honored Ed Catmull, President, Loren Carpenter, Senior Scientist, and Rob Cook, Vice President of Software Engineering, with an Academy Award of Merit (Oscar)® "for significant advancements to the field of motion picture rendering as exemplified in Pixar's RenderMan®."

Pixar believes that its proprietary technology, which enables animators to precisely control the motion of characters and the sets in each frame, represents a breakthrough in the art of animation. The result is a new "look and feel," with images of quality, richness and vibrancy that are unique in the industry. Pixar continues to invest heavily in these software systems and believes that further advancements will lead to additional productivity and quality improvements in the making of its computer animated films and other products. Pixar's technology also facilitates the manipulation, editing and reuse of animated images, which helps to reduce person-hours and therefore film production expenses.

In 2002, the Producer's Guild of America honored Pixar with the Guild's inaugural Vanguard Award, which recognizes outstanding achievement in new media and technology.

Figure 9.1 John Lesseter

9.1.3 Creative Team

Mr. Lasseter is a two-time Academy Award®-winning director and animator. In addition to overseeing all of Pixar's films and projects as executive vice president of creative, he served as director of *Toy Story*, *A Bug's Life* and *Toy Story 2* as well as executive producer of *Monsters, Inc.*, *Finding Nemo* and *The Incredibles* (November 5, 2004). Mr. Lasseter is currently in development on his fourth feature film, *Cars*, scheduled for release holiday 2005. In February 2004, the Art Director's Guild recognized Mr. Lasseter for his contributions to Cinematic Imagery.

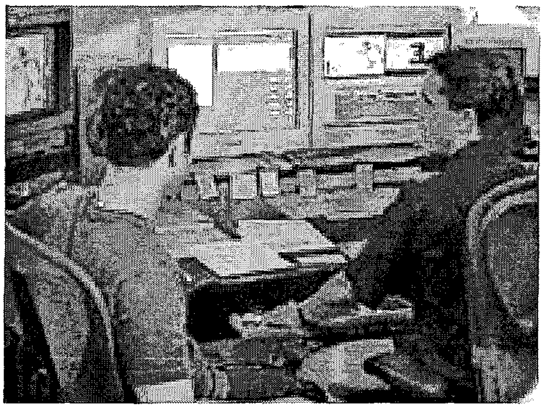


Figure 9.2 Inside of Pixar

Under the guidance of Mr. Lasseter, Pixar has built a creative team of highly skilled animators, writers and artists. This team was responsible for creating, writing and animating all films from original stories. Pixar strives to hire animators who have superior acting ability—those able to bring characters and inanimate objects to life, as though they have their own thought processes. In order to attract and retain quality artists, the company founded Pixar University, which provides educational opportunities for all of Pixar's employees. Pixar University has three goals: raise the level of the best, cross-train, and develop mastery.

Pixar also has a complete production team that gives the company the capability to control all elements of production of its films. Pixar has successfully expanded the production team so several projects may be worked on simultaneously.

Business Model

Successful animated feature films, such as Disney's The Lion King and Aladdin, have become some of Hollywood's top moneymakers. A single animated feature film has the ability to generate billions of dollars worth of consumer spending. Such revenues are derived from marketing campaigns surrounding the theatrical release of the animated film, which, in turn, drive demand for home videos, television, toys, and other film-related merchandise. Under the 1997 Co-Production Agreement with The Walt Disney Studios, Pixar and Disney have agreed to share the production costs of five animated feature films. Six films will actually be produced under the deal, as the sequel *Toy Story 2* does not count as one of the five films under the agreement. All profits will be shared.

9.1.4 Disney Relationship

Since the release of Snow White and the Seven Dwarfs by Disney in 1937, animated films have become one of the most universally enjoyed forms of entertainment. Disney has a long history of developing, producing, and distributing films such as Beauty and the Beast, Aladdin and The Lion King. The stories and characters of these popular animated feature films have become part of our modern mythology, enjoyed generation after generation. Traditionally, these popular animated feature films have been created using the time-consuming and labor-intensive process of two-dimensional, hand-drawn cell animation. (http://www.pixar.com)

In May 1991, Pixar entered into the Feature Film Agreement with Walt Disney Pictures for the development and production of up to three computer animated feature films to be marketed and distributed by Disney. It was pursuant to the Feature Film Agreement that *Toy Story* was developed, produced, and distributed. In February 1997, Pixar entered into the Co-Production Agreement (which superseded the Feature Film Agreement) with Disney pursuant to which we, on an exclusive basis, agreed to produce five original computer-animated feature-length theatrical motion pictures for distribution by Disney.

Figure 9.3 Bug's Life

Pixar and Disney agreed to co-finance the production costs of the Picture, co-own the Picture, co-brand the Pictures, and share equally in the profits of each Picture and any related merchandise as well as other ancillary products, after recovery of all marketing and distribution costs, a distribution fee paid to Disney, and other fees and costs, such as participations to talent and the like. The first three original Pictures under the Co-Production Agreement were *A Bug's Life*, *Monsters, Inc.* and *Finding Nemo* which were released in November 1998, November 2001 and May 2003, respectively. *Toy Story 2*, the theatrical sequel to *Toy Story*, was released in November 1999, and is also governed by the Co-Production Agreement, although it does not count towards the five original Pictures. We are currently in various stages of production on the remaining two Pictures under the Co-Production Agreement, *The Incredibles* (November 5, 2004) and *Cars* (holiday 2005).

9.1.5

Awards

Finding Nemo was honored with an Oscar® for Best Animated Feature Film and received Oscars® nominations for Best Sound Editing, Original Screenplay and Original Score.

Monsters, Inc. composer Randy Newman took home the Oscar® for Best Song ("If I Didn't Have You"). *Monsters, Inc.* also received three Academy Award® nominations: Best Animated Feature Film, Best Sound Editing, and Best Score.

Toy Story 2 was honored by the Hollywood Foreign Press Association with a Golden Globe for Best Picture, Musical or Comedy. The film was also chosen as Best Animated Feature by the Broadcast Film Critics Association. And composer Randy Newman has garnered a Golden Globe nomination as well as an Academy Award® nomination for the *Toy Story 2* score.

A Bug's Life was chosen as Favorite Family Film by the Blockbuster Entertainment Awards in 1999. Also in 1999, composer Randy Newman won a Grammy for his score on *A Bug's Life* (Best Instrumental Composition Written For A Motion Picture, Television or Other Visual Media) and was nominated for Best Original Musical or Comedy Score for *A Bug's Life.*

John Lasseter, Pixar's executive vice president of creative and director of *Toy Story*, won the Academy Award® for Special Achievement for his "inspired leadership of the Pixar *Toy Story* team resulting in the first feature-length computer-animated film." Toy Story is also the first and only animated film to receive an Academy Award® nomination for Best Screenplay Written Directly For the Screen. The film also garnered a Golden Globe nomination for Best Picture.

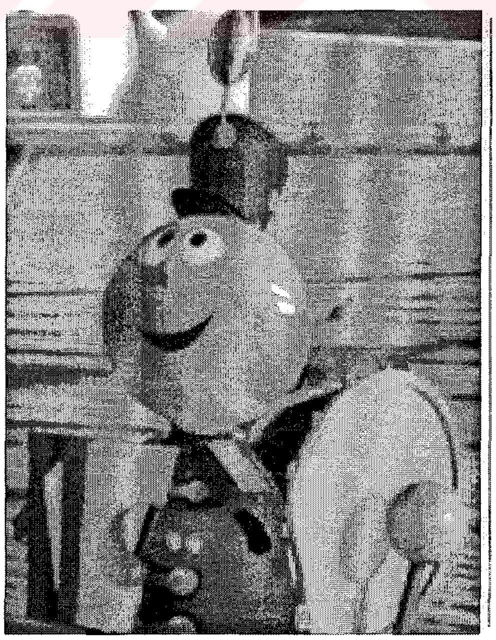


Figure 9.4 Tin Toy

At the animation industry's Annie Awards in 1996, *Toy Story* ran away with all eight top motion-picture honors, winning every Annie Award category in which it was nominated. In addition to winning an award for Best Animated Feature, Pixar also received recognition for: Directing, which went to *Toy Story* director John Lasseter; Producing, awarded to Ralph Guggenheim and Bonnie Arnold; Writing, received by Andrew Stanton, Joss Whedon, Joel Cohen and Alec Sololow; Production Design, awarded to Ralph Eggleston; Animation, which went to Pete Docter; and Music, awarded to Randy Newman. Pixar Animation Studios also received a special technical achievement award for the extraordinary advances in three-dimensional, computer-generated animation showcased in *Toy Story*. The Annie Awards are sponsored by ASIFA-Hollywood.

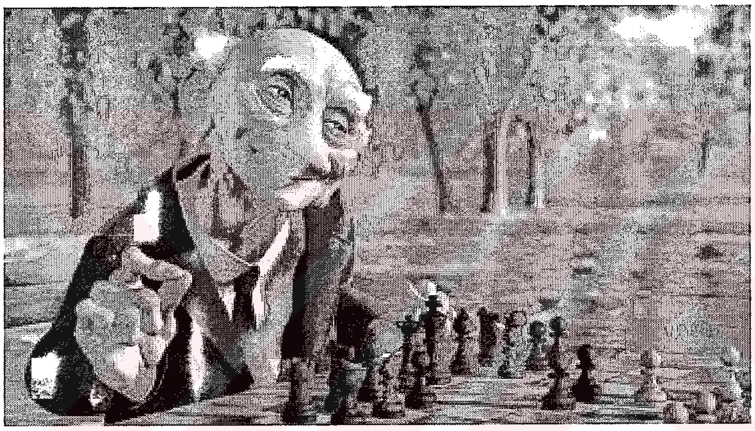


Figure 9.5 Gery's Game

For more than eleven years, Pixar's creative and technical teams have worked closely to produce short films and television commercials using three-dimensional computer animation while continually developing their creative expertise and proprietary technology. In 1986, Pixar's first short film, *Luxo Jr.*, received an Academy Award® nomination for Best Animated Short Film. In 1988, Pixar's short film *Tin Toy* received an Academy Award® for Best Animated Short Film. And in 1997, *Geri's Game*, also received the Academy Award® for Best Animated Short Film. Geri's Game was the first film to incorporate the studio's technology for creating more realistic-looking skin and cloth. In 2002, Pixar's *For the Birds* received the Academy Award® for Best Animated Short Film. In 2003, *Mike's New Car* received an Academy Award® nomination for Best Animated Short Film. Most recently, *Boundin'* was Oscar® nominated for Best Animated Short Film.

In total, Pixar employees have been awarded sixteen Academy Awards®. Pixar has also won two Gold Clios in the category of Computer Animation for its commercials, one in 1993 for the Gummi Savers commercial titled "Conga," and one in 1994 for the Listerine commercial titled "Arrows."

9.1.6 Management

Pixar is located in Emeryville, California, and has over 730 employees. Pixar's Office of the President consists of Steve Jobs, chairman and chief executive officer, Edwin E. Catmull, president, Simon Bax, executive vice president and chief financial officer, John Lasseter, executive vice president of creative, and Sarah McArthur, executive vice president, production, and Lois Scali, executive vice president and general counsel.

9.2 Industrial Light + Magic (ILM)

In 1971 George Lucas formed his own independent production company, Lucasfilm Ltd., in Marin County, just north of the Golden Gate Bridge.

In July of 1975, with the Star Wars saga already written and design work begun the previous year, Industrial Light + Magic (ILM) was established to produce the visual effects for *Star Wars*.

That same year Sprocket Systems was established to edit and mix *Star Wars*. It was later to become known as Skywalker Sound.

In 1977 *Star Wars* opened and became the largest grossing film of all time to that date. It received six Academy Awards for original score, film editing, sound, art and set decoration, costume design and visual effects, as well as a Special Achievement Academy Award for sound effects creations.

With the release of *The Empire Strikes Back* in 1980 and a new home in San Rafael, ILM began to establish itself as the leader in visual effects production. The same year, ILM received a Special Achievement Academy Award for visual effects for *The Empire Strikes Back* and began to work on its first non-Lucasfilm picture, *Dragonslayer*.

Throughout the 1980's, ILM continued to receive recognition for its visual effects work, earning 9 Visual Effects Academy Awards during that decade. Included among the films honored are: *The Empire Strikes Back, Raiders of the*

Lost Ark, E.T.: The Extra-Terrestrial, Return of the Jedi, Who Framed Roger Rabbit? and *The Abyss*.

Skywalker Sound was also honored with 5 Academy Awards during this period for Best Sound and Best Sound Effects Editing on films including *The Empire Strikes Back, Raiders of the Lost Ark* and *E.T.*

Figure 9.6 ILM Model Supervisor Geoff Campbell and Animation Director Rob Coleman working on the character animation of Yoda for a scene in Star Wars

In 1987, construction was completed on the Technical Building at Skywalker Ranch, Lucas's film production facilities

in central Marin, allowing Skywalker Sound to move into the 145,000 square-foot facility.

Terminator 2: Judgment Day in 1991 was another milestone in the history of LDL . Additional advancements and achievements in the field of computer graphics were realized. Both ILM and Skywalker Sound were rewarded with Academy Awards for their work on the film. (http://www.ilm.com)

In 1992 George Lucas was honored by the Academy of Motion Picture Arts and Sciences with the Irving Thalberg Award. This award was voted by the Academy Board of Governors to a "creative producer whose body of work reflects a consistently high quality of motion picture production" and is given only in years when the Board feels there is a deserving recipient. Steven Spielberg presented the Thalberg award to Lucas at the Academy Awards Ceremony on March 30th.

The following year, in 1993, a new corporate structure was set up among Lucas' various companies to allow for management flexibility and accountability. Three separate companies were the result of the restructure:

• Lucasfilm Ltd. - Film and Television Production, THX and Lucas Licensing.

• LucasArts Entertainment Company - Games and Learning

• Lucasfilm Entertainment Company, Ltd..- Industrial Light & Magic and Skywalker Sound

Inspired by its successful work in the feature film arena, ILM expanded into the world of advertising in 1989. Today,

Industrial Light + Magic Commercial Productions (ILMCP) is a full service production company, specializing in the production of live-action commercials as well as commercials with visual effects. ILMCP accounts for nearly a quarter of ILM's revenue.

Additionally, the George Lucas Educational Foundation (GLEF) was founded in 1991 as a non-profit organization focused on creating media materials (films, books, newsletters and a Web site) which promote a vision of learning where students are challenged and engaged, learn by doing, having access to interactive technologies and are supported by inspired teachers and involved parents and communities.

9.2.1 Technology Timeline Highlights

1977, Industrial Light + Magic revolutionized special effects with *Star Wars.* The film marked the first use of a motion control camera.

1979, George Lucas set up the Computer Division to explore new uses of computers for digital imaging, electronic editing, and interactivity.

1982,Industrial Light + Magic, working with the Computer Division, created the "Genesis sequence" for *Star Trek II: The Wrath Of Khan*, which marked the first completely computer-generated sequence.

George Lucas formed the Games division to explore interactive entertainment.

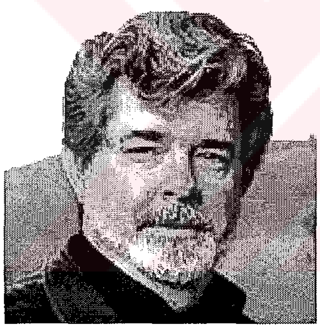


Figure 9.7 George Lucas

1984, Lucasfilm pioneered film-oriented computerized electronic nonlinear editing for picture and sound and premiered EditDroid and SoundDroid at the National Association of Broadcasters conference.

1985, Industrial Light + Magic made further breakthroughs in computer graphics with the first completely computer-generated character with the "stained glass man" in *Young Sherlock Holmes.*

1987, The Games division leads the move from parser-driven interfaces to the "point-and-click" interface popular today with its new story engine SCUMM (Script Creation Utility for Maniac Mansion).

1988, Industrial Light + Magic created the first morfing sequence for motion pictures in the film *Willow*. ILM subsequently won a Technical Achievement Award for its development of Morf, a computer-graphics program allowing the fluid, onscreen transformation of one object to another.

1989, Industrial Light + Magic created the first computer generated three-dimensional character with the "pseudopod" in *The Abyss*.

1991, Industrial Light + Magic created the first computer graphics main character with the T-1000 in *Terminator 2: Judgment Day*.

Skywalker Sound introduced the first utilization of T-1 tie-lines for real-time digital audio transmission to distant locations. The projection of film at Skywalker Sound is synchronized, through patented technology, with the screening room projector at a filmmaker's office or home. With the combination of synchronized projection and real time digital audio transmission, it is no longer necessary for the filmmaker to leave his home or office.

LucasArts introduced its patented interactive sound system *iMUSE* (Interactive Music and Sound Effects) with MONKEY ISLAND 2: LE CHUCK'S REVENGE. *iMUSE* allows a game's soundtrack to be as interactive as the gameplay, responding seamlessly and spontaneously to unpredictable player choices. *iMUSE* composes sound and music on the fly, making the soundtrack of a game work like that of a film--creating mood, building suspense, and moving the experience forward. *iMUSE* now manages digital soundtracks for all LucasArts titles.

1992, Lucasfilm broke new ground in digital production by utilizing D1 digital video technology to complete post-production and visual effects on "The Young Indiana Jones Chronicles." The series won 10 Emmy Awards including one for visual effects which included digital replication of actors, digitally created matte paintings, and digital compositing.

1993, Industrial Light + Magic won its 12th Academy Award for its computer graphics work on *Death Becomes Her* and its fifth Academy Technical Achievement Award. This marked the first time human skin texture was computer generated.

Avid Technology acquired the EditDroid and SoundDroid technologies and joined forces with Lucasfilm to develop and produce the next generation of digital picture and sound editing systems.

Lucasfilm Entertainment Company, Ltd. and Silicon Graphics formed an exclusive alliance to create JEDI, a unique networked environment for digital production. JEDI is a beta test sight for Silicon Graphics equipment and allows the artists and technicians at ILM to advise SGI on future developments.

LucasArts created a new proprietary video streaming engine, INSANE (Interactive Streaming Animation Engine), for its first exclusive CD-ROM game, REBEL ASSAULT. REBEL ASSAULT is one of the few elite PC titles to sell more than one million units.

1994, Industrial Light + Magic won its 13th Academy Award for its work on the computer-generated dinosaurs for Steven Spielberg's *Jurassic Park* and its sixth Academy Technical Achievement Award fo pioneering work on film digitization. For the first time, digital technology was used to create a living, breathing character with skin, muscles, texture, and attitude. This breakthrough expanded the filmmaker's canvas and changed the cinematic art of storytelling.

1995, LucasArts developed the proprietary Jedi Engine for DARK FORCES. The new engine supports full 3D objects, a realistic lighting model, atmospheric effects such as haze and fog, and animating textures.

Industrial Light + Magic won its 14th Academy Award for its breakthrough work on *Forrest Gump*. Although the most obvious accomplishment is the manipulation of archival footage allowing seamless interaction with historical figures, a variety of "invisible" effects, such as the character who becomes a double amputee, computer-generated jets, helicopters, birds, crowds, and ping-pong balls, subtly help the filmmaker tell the story.

Industrial Light + Magic's computer animation work on *The Mask* garnered an Academy Award nomination. For the first time, the ILM team created a photo-real cartoon character. The artists and technicians turned a human being into a cartoon character.

Industrial Light + Magic created the first fully synthetic speaking characters with distinct personalities and emotions for *Casper*.

Whereas *Jurassic Park* had six minutes of digitally animated dinosaurs on the screen, the ghosts in *Casper* are on the screen for more than 40 minutes.

Industrial Light + Magic created the first computer-generated photo-realistic hair and fur for the digital lion and monkeys in *Jumanji*.

This movie also featured a stampede scene with dozens of elephants, rhinos, zebras and pelicans, all computer-generated.

1996, Industrial Light + Magic is awarded a Technical Achievement Award from the Academy for its pioneering work in digital film compositing.

With *Mission: Impossible*, ILM created a fully virtual set for the climactic action sequence, requiring a computer-generated train speeding through a computer-generated tunnel followed by a computer-generated helicopter; actors were digitally composited into the virtual set to complete the scene.

Twister's digital tornadoes were the stars of the box-office sensation of the summer movie season. These stunning images of one of nature's fiercest weather events were wholly computer-generated via particle systems animation software.

Industrial Light + Magic's proprietary facial animation software brought the 3D digital character of Draco, the star of *Dragonheart*, to life. With the voice and facial physique of Sean Connery as their guide, ILM's team of animators redefined what can be successfully shown on screen.

1997, Industrial Light + Magic's software team was awarded two Technical Achievement Awards by the Academy of Motion Picture Arts and Sciences, for the creation and development of the Direct Input Device, which allows stop-motion animators to bring their skill and artistry to computer animation; and for the development of a system to create and control computer-generated hair and fur in motion pictures. The Academy also awarded the ILM software team a Scientific and Engineering Award for the development of the Viewpaint 3D Paint System, which allows artists to color and texture details to computer-generated effects. ILM and its team of innovators and pioneers have won a total of twelve "sci-tech" awards from the Academy.

Skywalker Sound installed the largest digital audio console at any audio post-production facility worldwide. The Capricorn, manufactured by AMS Neve, can technologically match the artistry of the sound designers and mixers. Two of the first projects to be mixed on the Capricorn, *Contact* and *Titanic*, earned Academy Award nominations for best sound.

Utilizing more sound elements, including dialogue loops and sound effects, than any feature film in history, *Titanic* won best sound awards from the Academy, Motion Picture Sound Editors and Cinema Audio Society.

1998, ILM's research & development team is awarded two patents for proprietary techniques. One is for "hair, fur and feathers," as illustrated by the groundbreaking images of the computer-generated gorilla in *Mighty Joe Young*. The other patent, for facial animation software initially developed for the 1995 release *Casper*, was further enhanced and refined over the next several years on projects such as *Dragonheart* and *Men in Black.*

1999, "Caricature," the facial animation system awarded a patent, also earns a Technical Achievement Award by the Academy of

Motion Picture Arts & Sciences for ILM's software developers. The award states: By integrating existing tools into a powerful interactive system, and adding an expressive multi-target shape interpolation-based freefrom animation system, the "Caricature" system provided a degree of subtlety and refinement not possible with other systems.

ILM's camera department receives a Technical Achievement Award from the Academy of Motion Picture Arts & Sciences for their pioneering work in motion-controlled, silent dollies.

The Mummy stars the most realistic digital human character ever seen in film. Featuring totally computer-generated layers of muscles, sinew and tissue, the ILM team again elevates its artistic and technical skill level in bringing a digital character to life.

With over 90% of George Lucas's *Star Wars: Episode I "The Phantom Menace"* featuring digital effects shots, a new method of filmmaking is achieved. Scenes which are fully computer-generated, featuring synthetic environments and digital terrain generation, computer graphic lead characters and thousands of digital extras are but some of the accomplishments, which were rewarded with an Academy Award nomination for best achievement in visual effects.

2000, The digital waves and weather created at ILM are the stars of *The Perfect Storm*, one of the summer's most anticipated film events.

2001, Industrial Light + Magic is nominated for best visual effects by the Academy of Motion Arts and Sciences for *Pearl Harbor* and *A.I. Artificial Intelligence*.

2002, Industrial Light + Magic's software team was awarded two Technical Achievement Awards by the Academy of Motion Picture Arts and Sciences, for the creation and development of its proprietary Motion and Structure Recovery System and Creature Dynamics System.

10 ANIMAION STUDIOS IN TURKEY

10.1 Anima

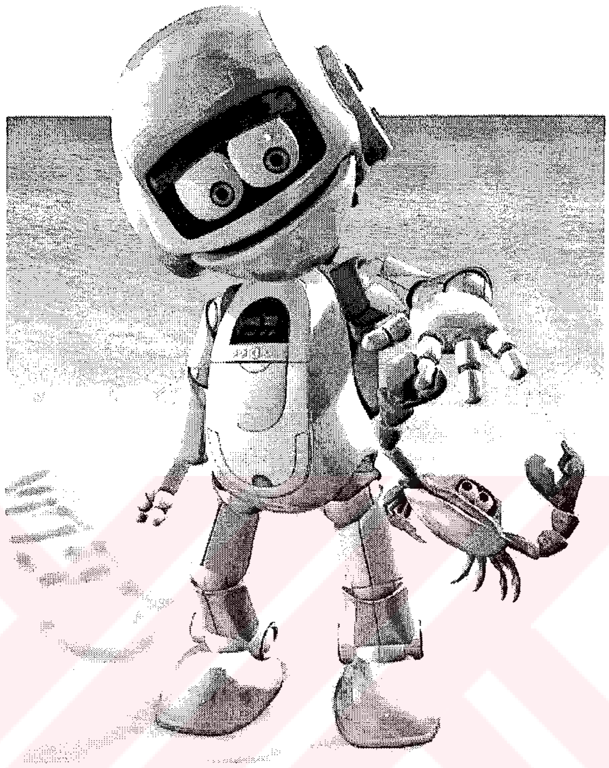


Figure 10.1 Anima's most famus character "Çelik"

Anima is an animation studio and production company, which has been in operation since 1994 in Istanbul. While volume animation is their main product, Anima also produces animated cartoon, cut-out, 2D and 3D computer animation. They have experience for both designing and realizing special/visual effects.

Since its foundation Anima produced, about 60 promotional films, video clips, TV serials, and cooperated with other companies in the form of contributions relating to design and production of animation, special effects, stage setting, model etc.

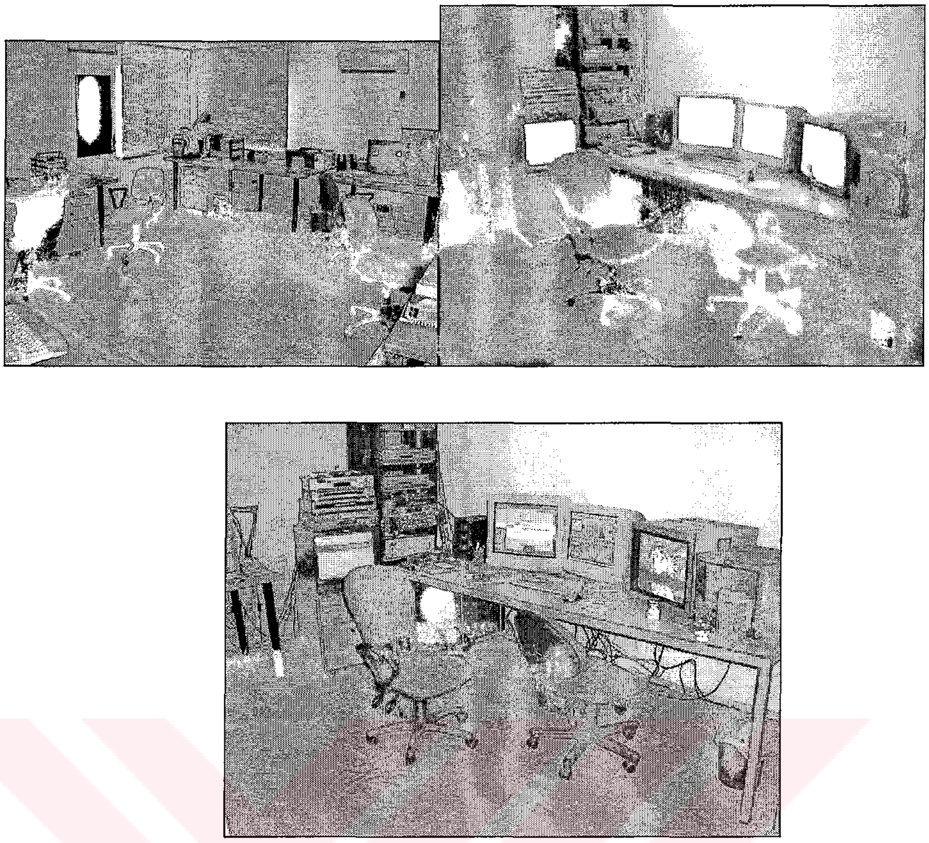


Figure 10.2 Inside of Anima

Housed in its modern 600-sqm building are a cartoon animation unit, a computer animation unit and an editing unit, two studios for stop-motion animation along with the necessary workshops and equipment. Alongside the complete infrastructure for puppet animation there is a joiner's workshop, a plaster and latex cast workshop, and a metal and construction workshop. **Anima** also possesses a 35 mm camera, designed specifically for stop-motion animation, together with its objective lenses, camera stand and a video recording set. A new building will be operational next year. The post production divivision will be moving there.

Crew

The Anima staff is made up of of eighteen dedicated people each experienced and expert in her/his respective field. Should the occasion arise, there is a large pool of available freelancers which Anima can draw on to fulfill more demanding projects, i.e. Anima disposes of a flexible structure which enables it to realize the projects in its own building and with its own team and equipment.

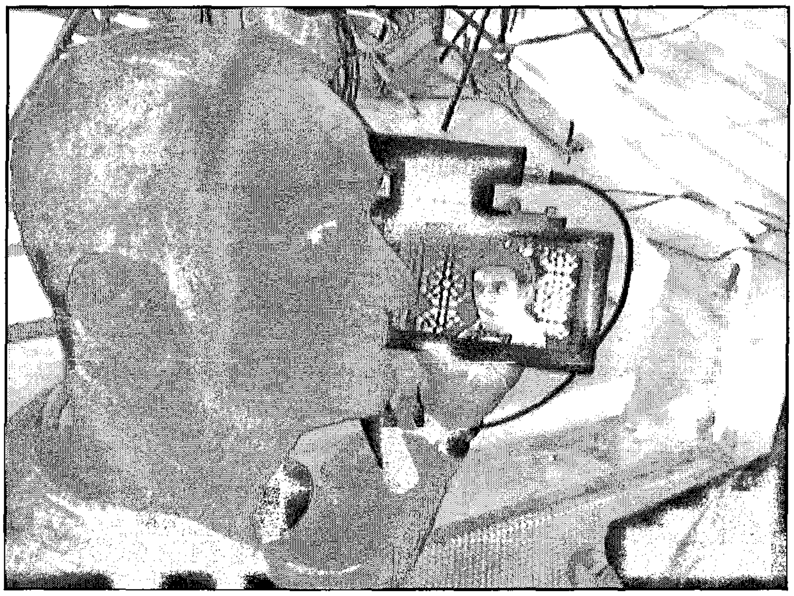


Figure 10.3 Anima's Mehmet Kurtuluş

The most important thing in anima among the workers is no one does the other ones work. Every worker and animator is specialized on his or her job.

Anima has its own restaurant where everybody can have meals at nay time they want during the long working hours.

Anima also has a render farm made up of 50 computers. This farm is very important for rushing jobs that has very limited time or a close deadline.

Mehmet Kurtuluş, the director of Anima says, "we invested for the people not for the hardware" meaning the workers and animators are the most important assets of the company. Many other companies have invested on hardware instead of people; most of them have not survived.

The most important problem is a foreign language problem. Mehmet Kurtuluş thinks that the people who are working in this area should at least be able to read English. Because all the resources and tutorials are in English on the subject of composting, 3D animation and hardware diagnostics.

10.2 Yoğurt Teknolojileri

Figure 10.4 Başar Muluk (partner of Yogurt Teknolileri)

The company was founded in 1997 by a group of people who left the company called "Telesine". They have been producing cell animation in Telecine when they decided to form a new company named "Yoğurt Tkenolojileri". The name was chosen because, yoğurt is something that everybody knows that its origin is in Turkey. Making yoğurt is very long work that needs care and patience like making animation.

Yoğurt Teknolojileri is producing 2D (traditional cell and computer generated Flash animations) and 3D animations using a great variety of software including New Tek's Lightwave 3D and Macromeadia's Flash.

The company had been suffering from the economical crisis in 1999 and 2000. It is still trying to get over the depts. This situation is preventing the company to hire more workers. The company is trying to survive while working with freelancers. This causes problems like it is not known which person works for what purpose. Job titles are not obvious. So it is not possible to say how many workers are working or who is in charge of doing so. Their salaries are not definite. The workers and animators who work in Yoğut Teknolojileri looks like they are at school and they have no definite responsibilities.

Figure 10.5 inside Yoğurt Teknolojileri

They are mainly working with PC's linked together with a network connection, sharing scanners and printers.

There are tree large rooms, full of desks and computers with the staff working on animation programmes. The Staff is spending most of their time in front of the desk.

"Having meals is a big problem" says Başar Muluk (one of the partners in the company). They don't have a place or a table for eating lunch. There is a kitchen where they can make coffee or tea. The workers order meals from the restaurants outside or going out for lunch using sodexo for payment, which is given them by the company.

Mostly they are producing web animations as well as TV commercials. They have been making commercials for The Coca Cola Company Turkey and Turkcell Hazır Kart and their web sites.

11 AN IDEAL ANIMATION STUDIO DESIGN

This studio is specialized on 3D animation and composting. The final products are used in commercials and feature films. The studio has five production departments working to produce the final work. These departments are:

- Writing, Consenting and drawing Department
- Modelling and surfacing and Animating Department
- Directors and Producers Department
- Studio Department
- Composting and Editing Department

11.1 Departments

11.1.1 Writing, Consenting and Drawing Department

This department has five people. Three of them are writers, which write a story and compose it into a script. These tree people form the writers' team. The other two people are the drawing artists who are drawing the conceptual storyboards, which will help the production in the next steps. They are the storyboard artists who are also designing the look of the scenes by the help of the director.

If the job is coming from an advertisement agency these writers and storyboard artists will setup a meeting with the representers of the product company and the agency, with the directors and the technical advisors. By this meeting, which will take place in the meeting room, final concepts are decided.

11.1.2 Modelling and Surfacing and Animating Department

There are two modellers who will build the objects that will be animated later. These two modellers examine the drawings that are produced by the storyboard artists then they build the 3D objects using the 3D modelling software. If the project need character development, the modellers build the objects and them rig them by forming a bone structure and defineing the IK system. If the objects or character needs a show expressions the modellers also prepare the morph targets for each object and save them into the pool that all the computer on the network share.

When the objects are ready it is time for the surface editing people to load the objects from the shared folders in the pool. The surfacers define the poligons of the objects with names and parts. According to the conceptual drawings, they edit the parameters of the surfaces and make them look like what the storyboard artists have drawn. They also apply image maps and procedural surfaces. The diffusenes, reflectivity and bump array is decided and formed by these two people. If the Object is a non-geometrical object it may require some UV mapping.

As soon as the objects are mapped and surfaced, two people of five animators proceed with scene setup. They apply atmospherical effects like sky, lighting and camera angles. Their most important job is to put every needed element in the scene and save the scene files into the pool. When the scene setup is complete with objects, surfaces, lighting and camera angles. It is the time for the directors and producers to critisize the project and decide if the project is ready for further proceeding or needs some redoing.

After the approval of the directors, it is the job for animators to make the scene move. The scene can be moved by directly moving the objects on the timeline, using the morph targets, changing the values of the IK targets or using the dynamics. The animators are four people, each of them specialize on different animating techique. Animating the characters, backgrouds or environments is their job. When they have a full animated scene it is time to send the project files to the render farms que.

11.1.3 Studio Department

The studio department is made up of one cinematographer, two camera assistant, two lighting assistant, one lighting chief, one studio rig chief and two rigs. Nine people work for shooting the needed live scenes. These live scenes may be used for whole live performances or they may be used for compositing while they are shot in front of a blue/green screen.

The cinematographer is the one who decides the visual matters in the shots. He is the most responsible before the director. He is also called the director of photograpy. The camera movements and the angles are his decision.

Camera assistants are the helpers of the cinematographer. While one of them pulls the focus the other one is resposible for recording or filming.

The lighting chief is reponsible for making the lighting conditions just as the cinematographer wants. Directing the lighting assistants is also his job. Before shooting a scene, the director, the cinematographer, lighting chief and digital compositor need to have a meeting to decide how to proceed with the shooting.

The rig chief and the assistants are the muscle of the studio. They have painting and carpenting skills. Moving anything in the studio is their job.

11.1.4 Compositing and Editing Department

When the exposed film returns from the laboratory, processed and telecined, the tape is what we have to compose or edit. There are two editors and two compositors who will deal with the scenes shot or rendered. The editors digitize the tapes to the HD's on the pool. When it is digitized it is ready for editing and compositing. Sometimes editing can be made befor the compositing. In that condition when editing is finished the edited shots must be send back to the pool for compositing. The compositors, composite different shots from live action shots to rendered sequences to eachother.

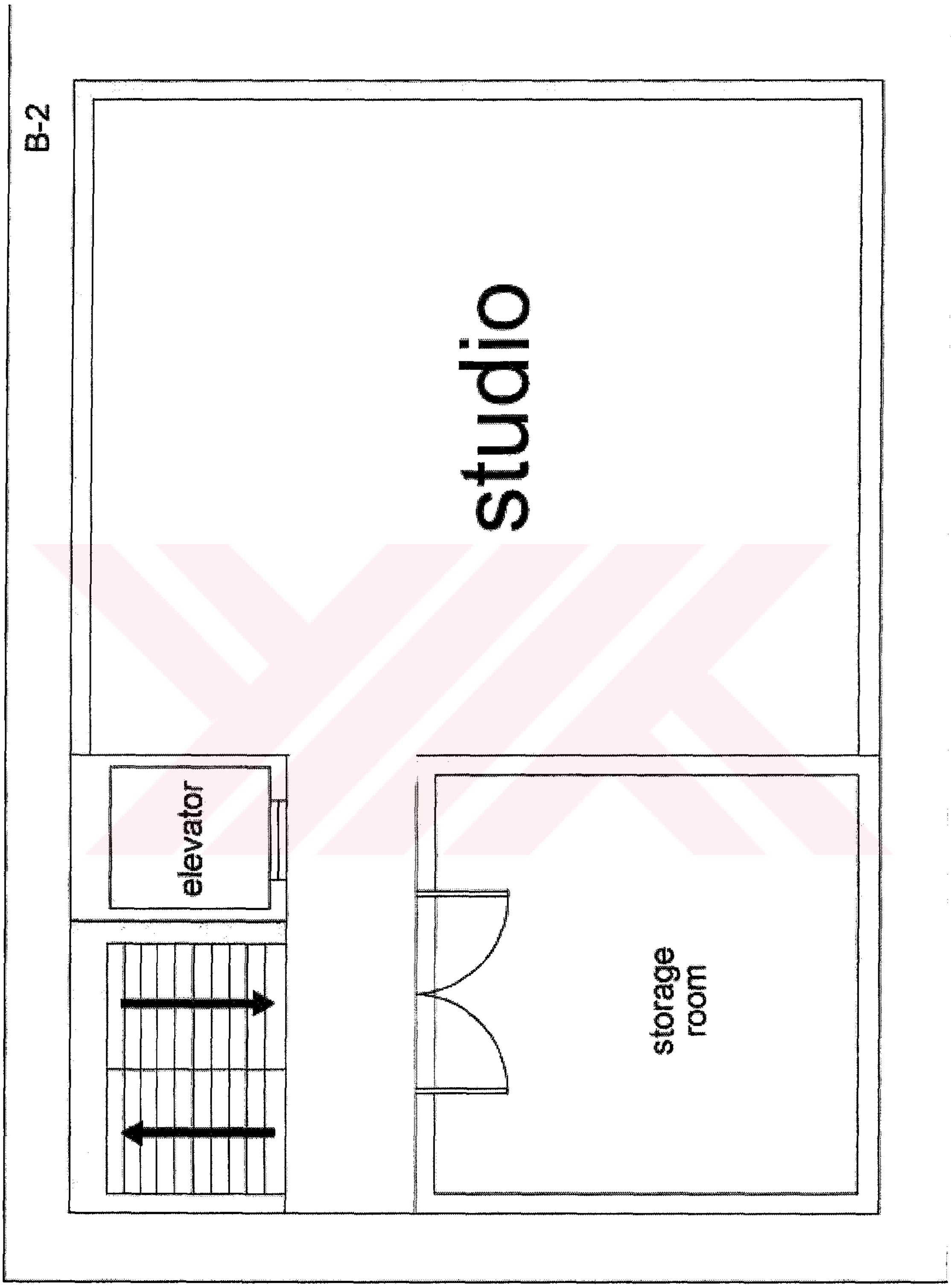
The compositors and editors work with the directors. The director directs them. Editing is a time taking process and it is the process that the film becomes a whole.

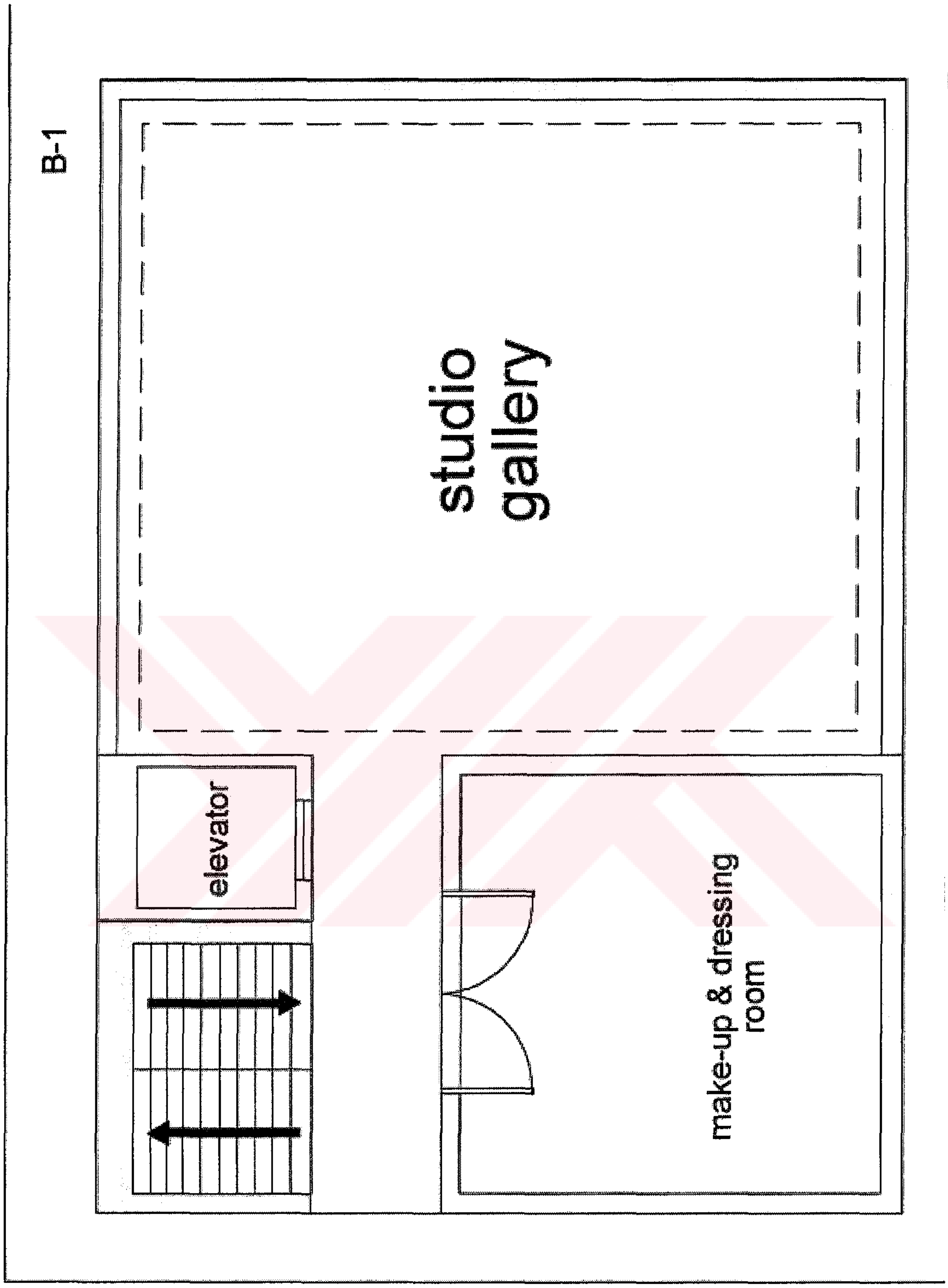
11.1.5 Directors and Producers Department

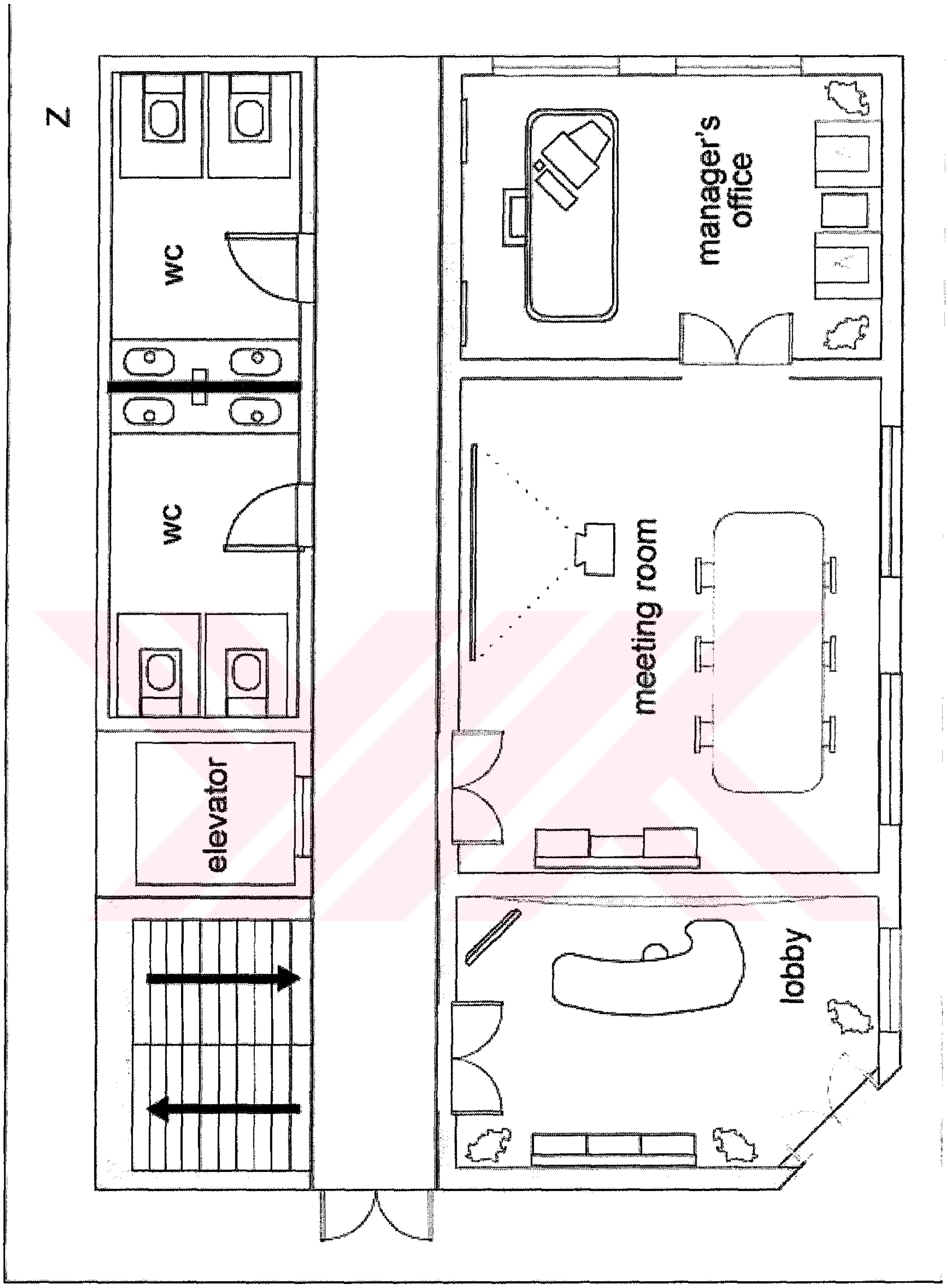
The director is the creator of the film. From the concepting to editing, he is resposible for making decisions and building the film. He is the artist of the film.

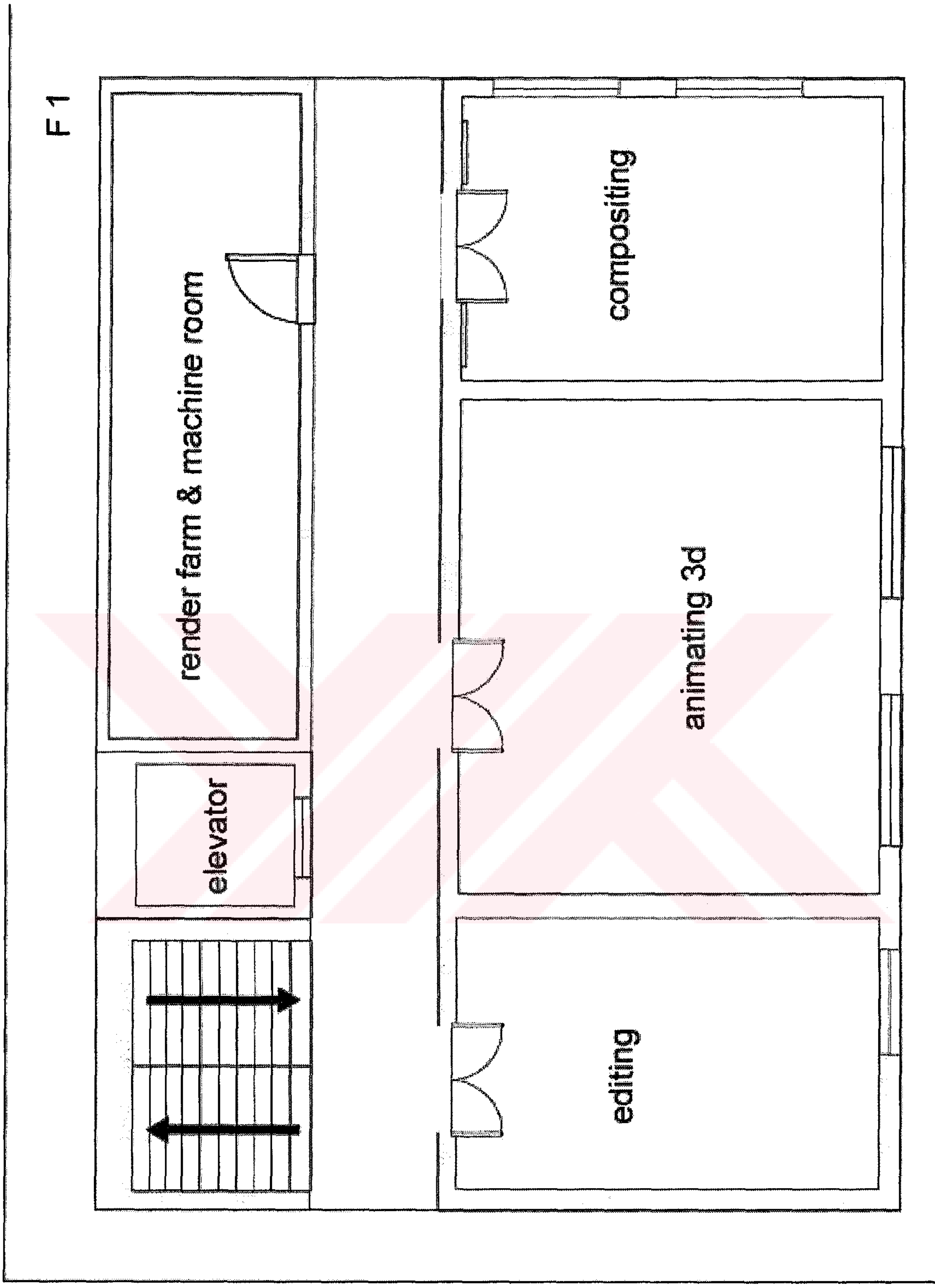
The producer is the owner of the film since it is his duty to finace everything in the process of the production. One of the main concers of a producer is to provide the team what is needed to conclude the project. He is also responsible to the customer who ordered the film. Basicly he owns the company, and he is the managerial director of the company. He puts people in charge of the work.

12 APPENDIX A : The Plans of The Studio Designed

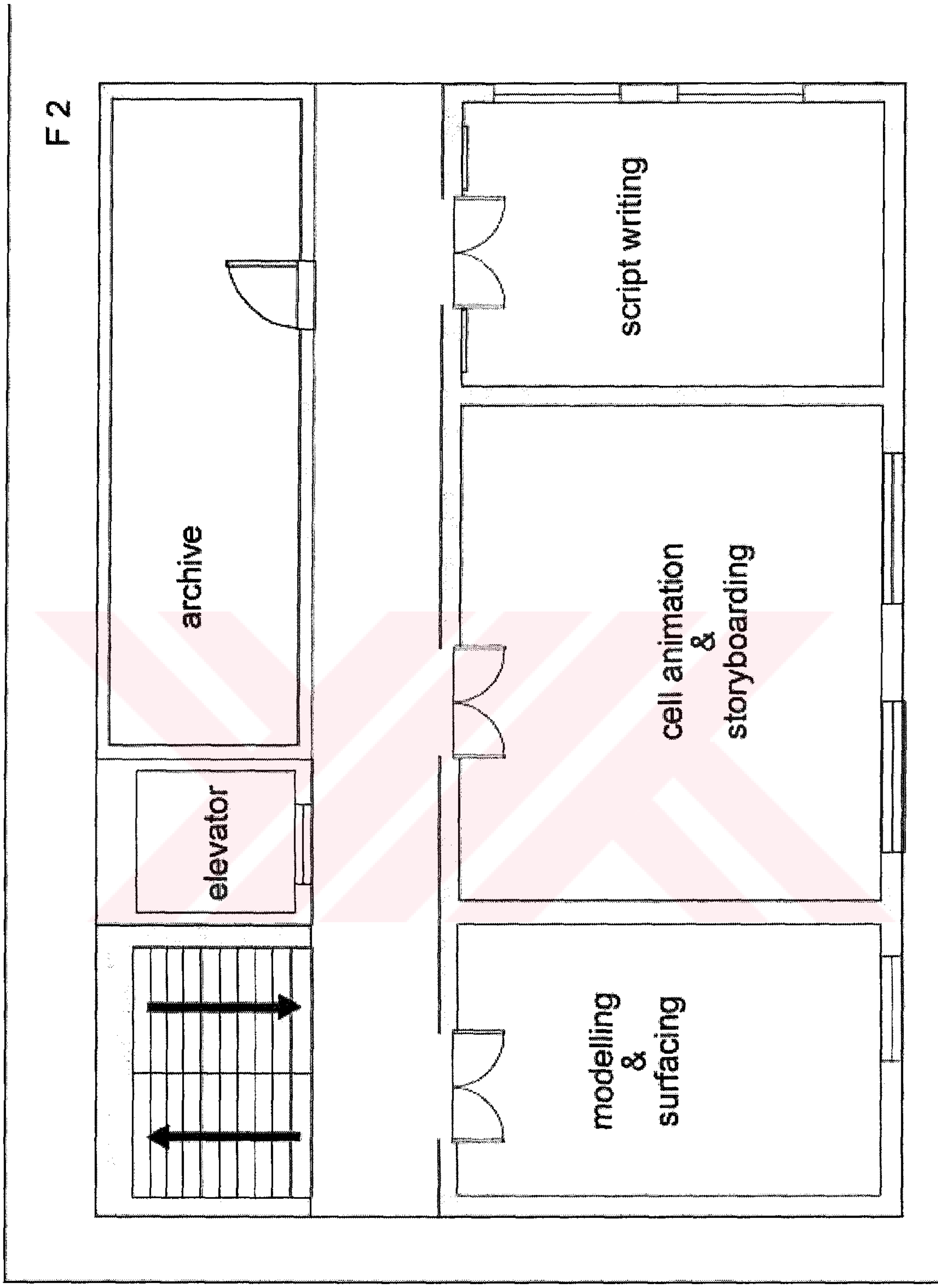


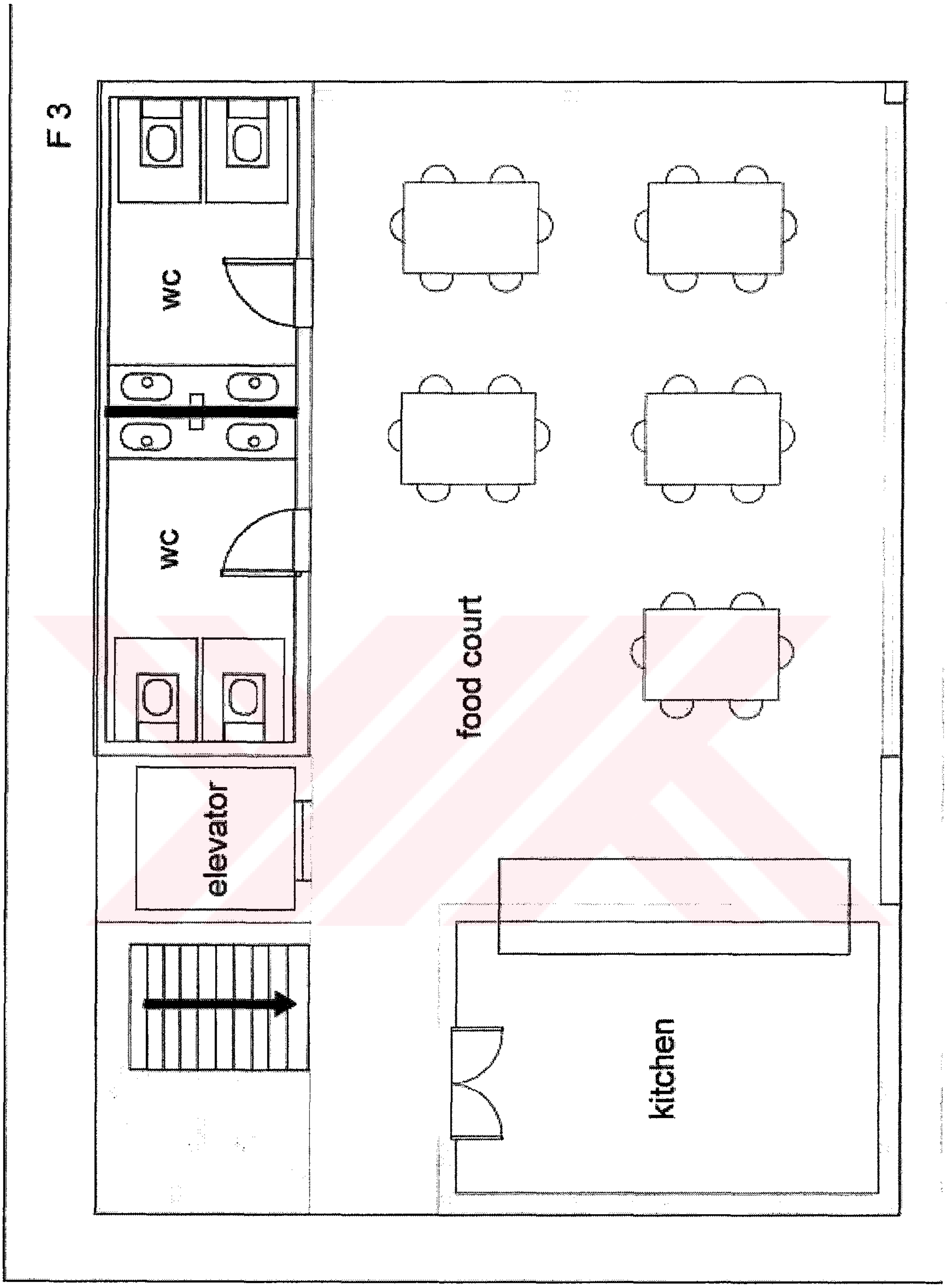

B-1
studio gallery
elevator
make-up & dressing room

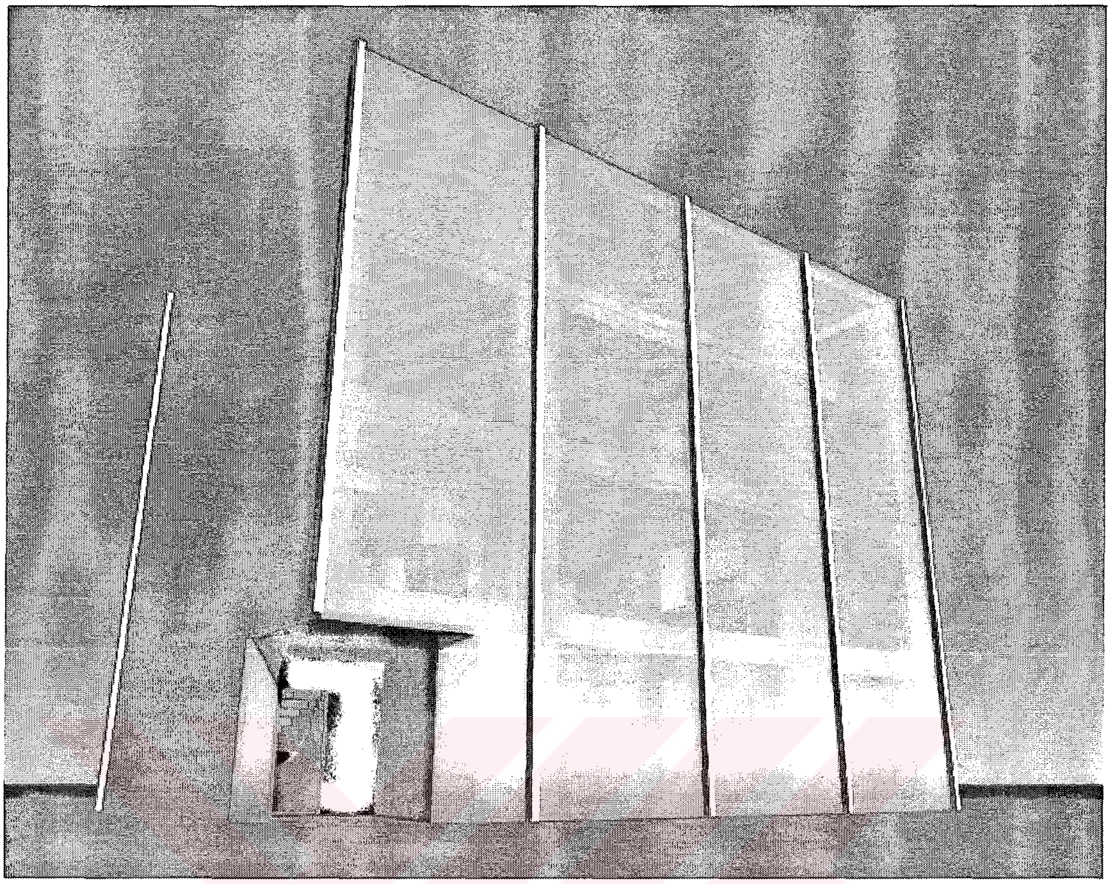

N
wc
wc
elevator
meeting room
manager's
office
lobby

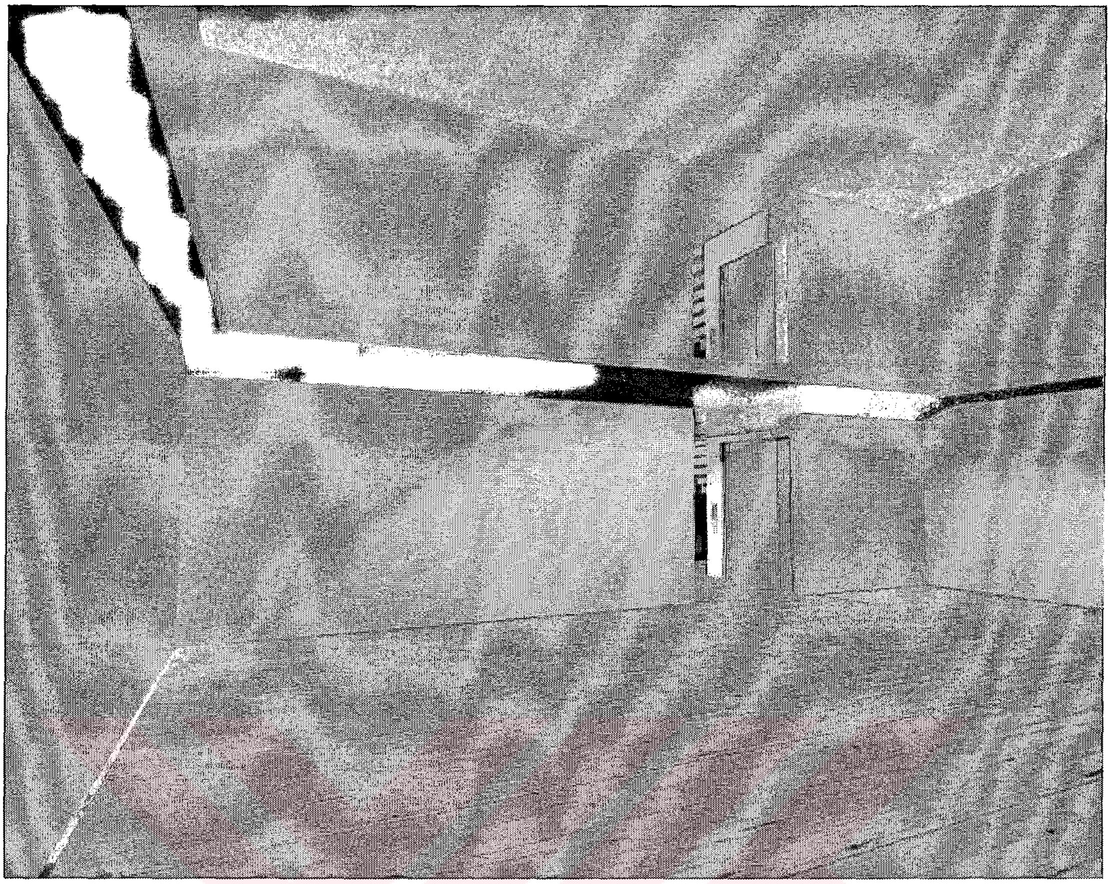


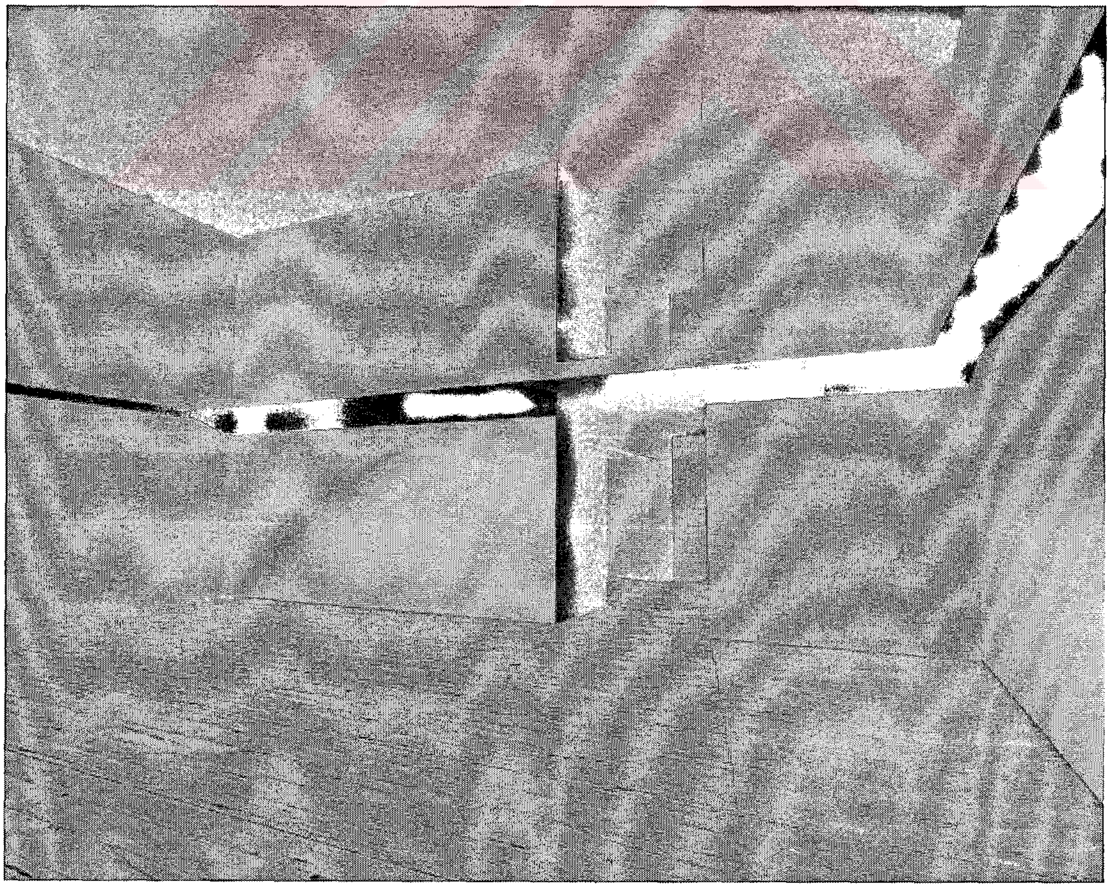
F 1
render farm & machine room
elevator
compositing
animating 3d
editing

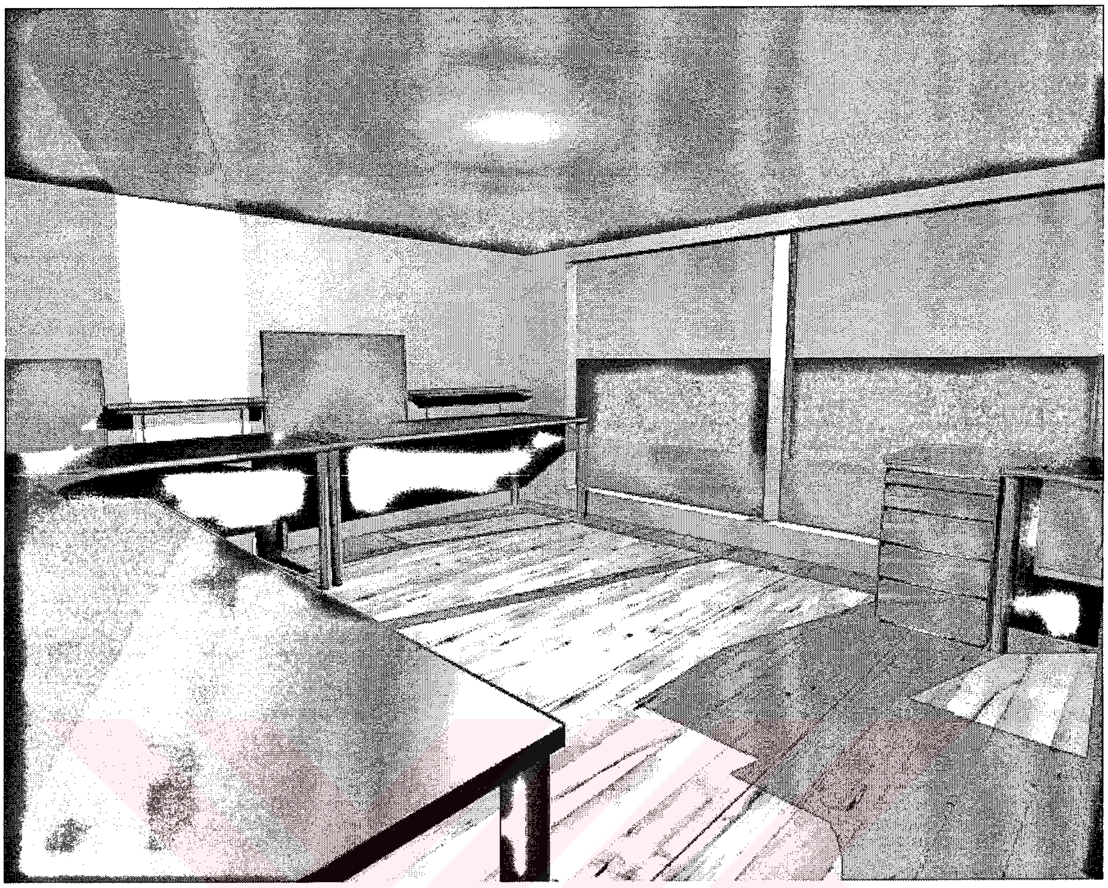

F 2
archive
elevator
script writing
cell animation
&
storyboarding
modelling
&
surfacing

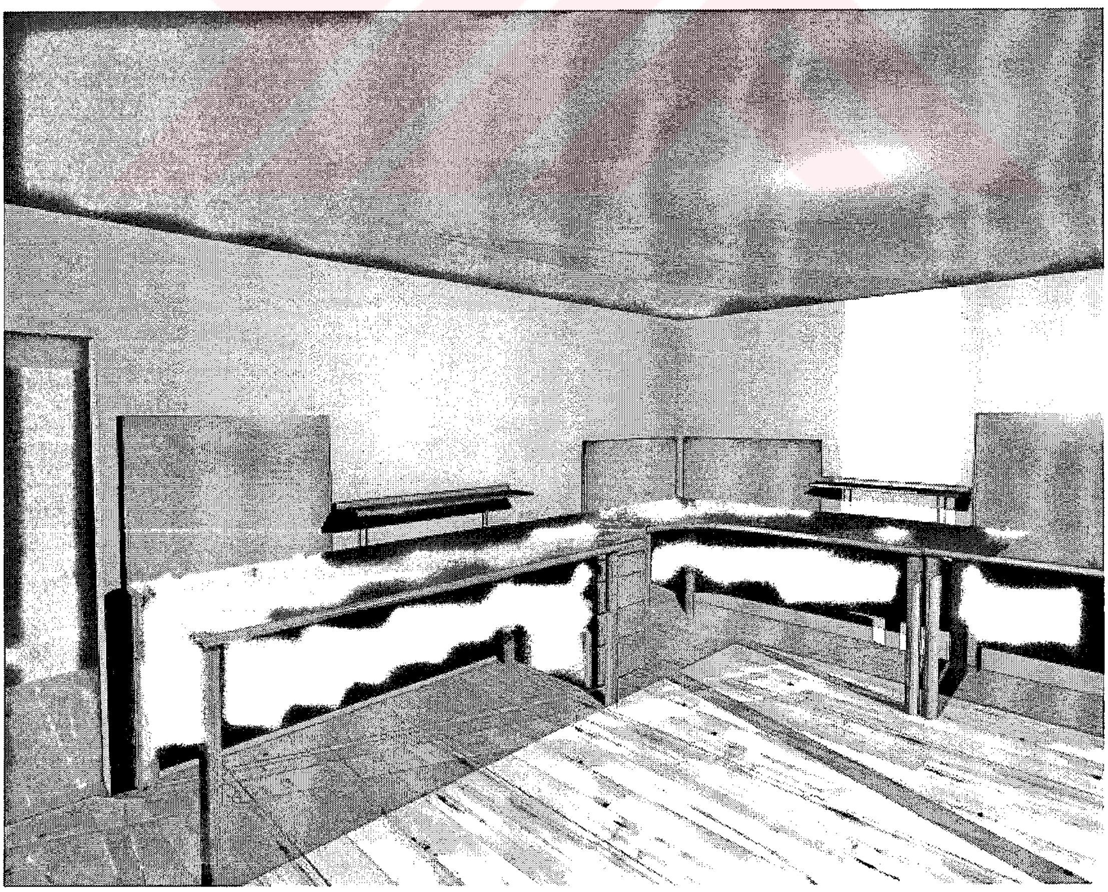

F 3
wc
wc
elevator
food court
kitchen











13 APPENDIX B: Film Credits For ILM

2004 **THE BOURNE SUPREMACY** Universal
2004 **THE CHRONICLES OF RIDDICK** Universal
2004 **HARRY POTTER AND THE PRISONER OF AZKABAN** Warner Bros.
2004 **THE DAY AFTER TOMORROW** 20th Century Fox
2004 **VAN HELSING** Universal
2004 **HIDALGO** Disney
2004 **ALONG CAME POLLY** Universal
2003 **PETER PAN** Universal/ Columbia/ Revolution
2003 **STUCK ON YOU** 20th Century Fox
2003 **TIMELINE** Paramount
2003 **MASTER AND COMMANDER: THE FAR SIDE OF THE WORLD** 20th Century Fox
2003 **ONCE UPON A TIME IN MEXICO** Miramax
2003 **11'9"01 – SEPTEMBER 11 (SEGMENT USA)** Empire Pictures
2003 **THE LEAGUE OF EXTRAORDINARY GENTLEMEN** 20th Century Fox
2003 **PIRATES OF THE CARIBBEAN** Disney
2003 **TERMINATOR 3: THE RISE OF THE MACHINES** Warner Bros.
2003 **THE HULK** Universal
2003 **DREAMCATCHER** Warner Bros.
2003 **TEARS OF THE SUN** Revolution Studios
2003 **THE HUNTED** Paramount
2002 **GANGS OF NEW YORK** Miramax
2002 **HARRY POTTER AND THE CHAMBER OF SECRETS** Warner Bros.
2002 **STAR WARS BOUNTY HUNTER** LucasArts Entertaiment
2002 **PUNCH-DRUNK LOVE** Revolution
2002 **BLOOD WORK** Warner Bros.
2002 **SIGNS** Disney
2002 **K-19: THE WIDOWMAKER** Paramount
2002 **MEN IN BLACK 2** Sony Pictures 2002
2002 **MINORITY REPORT** Fox
2002 **THE BOURNE IDENTITY** Universal
2002 **STAR WARS: EPISODE II "Attack of the Clones"** Lucasfilm
2002 **BIG TROUBLE** Disney
2002 **E.T.: THE EXTRA-TERRESTRIAL (Re-release)** Universal
2002 **THE TIME MACHINE** Warner Bros./DreamWorks SKG
2002 **IMPOSTER** Miramax/Dimension
2001 **THE MAJESTIC** Warner Bros.
2001 **HARRY POTTER AND THE SORCERER'S STONE** Warner Bros.
2001 **PLANET OF THE APES** 20th Century Fox
2001 **JURASSIC PARK III** Universal
2001 **A.I.: ARTIFICIAL INTELLIGENCE** Warner Bros./DreamWorks SKG
Academy Award Nomination – Best Visual Effects
2001 **THE MUMMY RETURNS** Universal
2001 **PEARL HARBOR** Disney
Academy Award Nomination – Best Visual Effects
2000 **IMPOSTOR** Miramax/Dimension
2000 **SPACE COWBOYS** Warner Brothers
2000 **POLLOCK** Pollock Film, Inc.
2000 **THE PERFECT STORM** Warner Bros.
2000 **THE ADVENTURES OF ROCKY AND BULLWINKLE** Universal
2000 **MISSION TO MARS** Disney
1999 **SWEET AND LOWDOWN** Sony Pictures Classics
1999 **MAGNOLIA** New Line Cinema
1999 **SNOW FALLING ON CEDARS** Universal
1999 **GALAXY QUEST** DreamWorks SKG
1999 **THE GREEN MILE** Warner Bros.
1999 **SLEEPY HOLLOW** Paramount
British Academy Nomination - Best Visual Effects

1999 **BRINGING OUT THE DEAD** Paramount/Disney
1999 **DEEP BLUE SEA** Warner Brothers
1999 **THE HAUNTING** DreamWorks SKG
1999 **WILD WILD WEST** Warner Brothers
1999 **STAR WARS: EPISODE I "The Phantom Menace"** 20th Century Fox/Lucasfilm Ltd.
Academy Award Nomination – Best Visual Effects
British Academy Nomination - Best Visual Effects
1999 **THE MUMMY** Universal
British Academy Nomination - Best Visual Effects
1999 **OCTOBER SKY** Universal
1998 **THE LAST DAYS** October Films
1998 **MIGHTY JOE YOUNG** Disney
Academy Award Nomination - Best Visual Effects
1998 **JACK FROST** Warner Brothers
1998 **CELEBRITY** Miramax
1998 **MEET JOE BLACK** Universal
1998 **REACH THE ROCK** Gramercy Pictures
1998 **SNAKE EYES** Paramount/Disney
1998 **SAVING PRIVATE RYAN** DreamWorks SKG/Paramount
British Academy Award - Best Visual Effects
1998 **SMALL SOLDIERS** DreamWorks SKG/Universal
1998 **DEEP IMPACT** DreamWorks SKG/Paramount
1998 **MERCURY RISING** Universal/Imagine Films
1998 **DEEP RISING** Disney
1997 **DECONSTRUCTING HARRY** Fine Line Features
1997 **AMISTAD** DreamWorks SKG
1997 **TITANIC** 20th Century Fox/Paramount
1997 **FLUBBER** Disney
1997 **MIDNIGHT IN THE GARDEN OF GOOD & EVIL** Warner Brothers
1997 **STARSHIP TROOPERS** TriStar/Touchstone
1997 **SPAWN** New Line Cinema
1997 **CONTACT** Warner Brothers
1997 **MEN IN BLACK** Columbia
British Academy Award - Best Visual Effects
1997 **SPEED 2: CRUISE CONTROL** 20th Century Fox
1997 **THE LOST WORLD: JURASSIC PARK** Amblin/Universal
Academy Award Nomination - Best Visual Effects
1997 **STAR WARS TRILOGY SPECIAL EDITION** 20th Century Fox/Lucasfilm Ltd.
1996 **MARS ATTACKS!** Warner Brothers
1996 **STAR TREK: FIRST CONTACT** Paramount
1996 **101 DALMATIANS** Disney
1996 **DAYLIGHT** Universal
1996 **SLEEPERS** Warner Brothers
1996 **TRIGGER EFFECT** Universal
1996 **ERASER** Warner Bros.
1996 **DRAGONHEART** Universal
Academy Award Nomination - Best Visual Effects
1996 **TWISTER** Warner Bros./Universal
Academy Award Nomination - Best Visual Effects
British Academy Award - Best Visual Effects
1996 **MISSION: IMPOSSIBLE** Paramount
1996 **SPECIAL EFFECTS (AN IMAX FILM)** WGBH
1995 **JUMANJI** TriStar Pictures
1995 **THE AMERICAN PRESIDENT** Castle Rock/Columbia
1995 **SABRINA** Paramount
1995 **THE INDIAN IN THE CUPBOARD** Paramount
1995 **CONGO** Paramount
1995 **CASPER** Amblin/Universal
1995 **VILLAGE OF THE DAMNED** Universal
1995 **IN THE MOUTH OF MADNESS** Katja/New Line Cinema
1994 **DISCLOSURE** Warner Brothers
1994 **STAR TREK: GENERATIONS** Paramount
1994 **RADIOLAND MURDERS** Lucasfilm Ltd./Universal
1994 **THE MASK** New Line Cinema

Academy Award Nomination - Best Visual Effects
British Academy Award Nomination - Best Visual Effects
1994 **FORREST GUMP** Paramount
Academy Award - Best Visual Effects
British Academy Award - Best Visual Effects
1994 **BABY'S DAY OUT** 20th Century Fox
1994 **WOLF** Columbia
1994 **MAVERICK** Warner Brothers
1994 **THE FLINTSTONES** Amblin/Universal
1994 **THE HUDSUCKER PROXY** Warner Brothers
1993 **SCHINDLER'S LIST** Amblin/Universal
1993 **JURASSIC PARK** Amblin/Universal
Academy Award - Best Visual Effects
British Academy Award - Best Visual Effects
1993 **FIRE IN THE SKY** Paramount
1993 **RISING SUN** 20th Century Fox
1993 **MALICE** Castle Rock/Warner Brothers
1993 **METEORMAN** MGM
1993 **LAST ACTION HERO** Columbia
1993 **MANHATTAN MURDER MYSTERY** TriStar Pictures
1993 **THE NUTCRACKER** Warner Brothers
1992 **DEATH BECOMES HER** Universal
Academy Award - Best Visual Effects
British Academy Award - Best Visual Effects
1992 **ALIVE** Disney/Paramount
1992 **ALIEN ENCOUNTER** Showscan
Simulator Ride
1992 **MEMOIRS OF AN INVISIBLE MAN** Warner Brothers
1992 **THE YOUNG INDIANA JONES CHRONICLES** Lucasfilm Ltd.
1991 **HOOK** Columbia/Amblin
Academy Award Nomination - Best Visual Effects
1991 **STAR TREK VI** Paramount
Academy Award Nomination - Best Visual Effects
1991 **SPACE RACE** Showscan
Simulator Ride
1991 **TERMINATOR 2: JUDGMENT DAY** Carolco/TriStar
Academy Award - Best Visual Effects
British Academy Award - Best Visual Effects
1991 **THE ROCKETEER** Disney
1991 **BACKDRAFT** Imagine Films
Academy Award Nomination - Best Visual Effects
1991 **HUDSON HAWK** TriStar
1991 **THE DOORS** TriStar
1991 **ARACHNOPHOBIA** Amblin/Universal
1991 **SWITCH** HBO Films
1991 **MICKEY'S AUDITION** Disney
1990 **DIE HARD 2** 20th Century Fox
1990 **BACK TO THE FUTURE, PART III** Amblin/Universal
1990 **THE HUNT FOR RED OCTOBER** Paramount
1990 **GHOST** Paramount
1990 **THE GODFATHER, PART III** Paramount
1990 **JOE VERSUS THE VOLCANO** Warner Bros.
1990 **AKIRA KUROSAWA'S DREAMS** Kurosawa Prods./Warner Brothers
1990 **ROLLER COASTER RABBIT** Disney
1989 **ALWAYS** Amblin/Universal
1989 **BACK TO THE FUTURE, PART II** Amblin/Universal
Academy Award Nomination - Best Visual Effects
British Academy Award - Best Visual Effects
1989 **THE ABYSS** GJP Productions/
Academy Award - Best Visual Effects 20th Century Fox
1989 **GHOSTBUSTERS II** Columbia
1989 **INDIANA JONES AND THE LAST CRUSADE** Lucasfilm Ltd./Paramount
1989 **FIELD OF DREAMS** Universal
1989 **TUMMY TROUBLE** Disney

1989 **MICKEY - EISNER SPOT** Disney
1989 **BODY WARS** Disney
Simulator Ride for Disney World's EPCOT Center
1989 **SKIN DEEP** Blake Edwards Co
1989 **THE 'BURBS** Renfield Productions/Universal
1988 **THE LAST TEMPTATION OF CHRIST** Universal
1988 **COCOON, THE RETURN** 20th Century Fox
1988 **CADDYSHACK II** Warner Brothers
1988 **WHO FRAMED ROGER RABBIT?** Touchstone Pictures/Amblin
Academy Award - Best Visual Effects
British Academy Award - Best Visual Effects
1988 **TUCKER: A MAN AND HIS DREAM** Lucasfilm Ltd.
1988 **STAR TREK ATTRACTION** Universal/Paramount
Universal Studios Tour
1988 **WILLOW** MGM/Lucasfilm Ltd.
Academy Award Nomination - Best Visual Effects
1987 **EMPIRE OF THE SUN** Warner Bros./Amblin
1987 **STAR TREK: THE NEXT GENERATION** Paramount Television
"Journey to Farpoint"
1987 **BATTERIES NOT INCLUDED** Universal/Amblin
Academy Award - Technical Achievement
1987 **INNERSPACE** Warner Bros./Amblin
Academy Award - Best Visual Effects
1987 **HARRY AND THE HENDERSONS** Universal/Amblin
1987 **THE WITCHES OF EASTWICK** Warner Brothers
British Academy Award - Best Visual Effects
1987 **STAR TOURS** Disney/Lucasfilm Ltd.
Simulator Ride for Disneyland
1986 **THE GOLDEN CHILD** Paramount
1986 **STAR TREK IV: THE VOYAGE HOME** Paramount
1986 **CAPTAIN EO** 3D Film for Disneyland Disney
1986 **HOWARD THE DUCK** Universal
1986 **LABYRINTH** TriStar/Henson Prod.
1986 **GENERAL CINEMA TRAILER** General Cinema Corp.
1986 **THE MONEY PIT** Universal/Amblin
1985 **OUT OF AFRICA** Universal
1985 **ENEMY MINE** 20th Century Fox
1985 **YOUNG SHERLOCK HOLMES** Paramount/Amblin
Academy Award Nomination - Best Visual Effects
1985 **EWOKS: THE BATTLE FOR ENDOR** 20th Century Fox
Emmy Award - Best Visual Effects Television/Lucasfilm Ltd.
1985 **AMAZING STORIES** Universal Television/Amblin
1985 **MISHIMA** Warner Brothers
1985 **EXPLORERS** Paramount
1985 **BACK TO THE FUTURE** Universal/Amblin
British Academy Award Nomination - Best Visual Effects
1985 **COCOON** 20th Century Fox
Academy Award - Best Visual Effects
1985 **THE GOONIES** Warner Bros./Amblin
1984 **STARMAN** Columbia
1984 **THE EWOK ADVENTURE** 20th Century Fox
Emmy Award - Best Visual Effects Television/Lucasfilm Ltd.
1984 **THE NEVERENDING STORY** Bavaria Studios
1984 **STAR TREK III: THE SEARCH FOR SPOCK** Paramount
1984 **INDIANA JONES & THE TEMPLE OF DOOM** Paramount/Lucasfilm Ltd.
Academy Award - Best Visual Effects
British Academy Award - Best Visual Effects
1983 **TWICE UPON A TIME** Korty/Lucasfilm Ltd.
1983 **RETURN OF THE JEDI** 20th Century Fox/Lucasfilm Ltd.
Academy Award - Best Visual Effects
British Academy Award - Best Visual Effects
1982 **THE DARK CRYSTAL** Henson Productions
1982 **E.T. THE EXTRA-TERRESTRIAL** Universal
Academy Award - Best Visual Effects

1982 **STAR TREK II: THE WRATH OF KHAN** Paramount
1982 **POLTERGEIST** MGM/UA
Academy Award Nomination - Best Visual Effects
British Academy Award - Best Visual Effects
1981 **DRAGONSLAYER** Paramount
Academy Award Nomination - Best Visual Effects
1981 **RAIDERS OF THE LOST ARK** Paramount
Lucasfilm Ltd. Academy Award - Best Visual Effects
1980 **THE EMPIRE STRIKES BACK** 20th Century Fox/Lucasfilm Ltd. Academy Award - Best Visual Effects
1977 **STAR WARS** 20th Century Fox/Lucasfilm Ltd.
Academy Award - Best Visual Effects

14 APPENDIX C : 3D Glossary

3D: Three-dimensional. Descriptive of a region of space that has width, height and depth.

Algorithm: A procedure or formula for solving a mathematical problem. Algorithms are commonly used for such tasks as generating textures, rendering images and controlling mathematically based behaviour patterns.

Alpha Channel: The top byte of a 32-bit pixel that is used for data other than colour. The alpha channel commonly holds mask data, enabling an image to be separated from its background for use in compositing.

Ambient Light: An artificial illumination level representing infinite diffuse reflections from all surfaces within a 3D scene, ensuring that even surfaces without direct illumination become visible to the user.

Animation: A medium that creates the illusion of movement through the projection of a series of still images or 'frames'. The term is also used to refer to the techniques used in the production of an animated film - in 3D animation, primarily those controlling the motion of the objects and cameras within a scene. These include keyframe animation, in which the artist sets the positions of objects manually at certain key points in the action, and the computer calculates their intervening positions through a process of interpolation or 'inbetweening',and procedural animation, in which the motion is controlled automatically via a series of mathematical formulae.

Animatic: A rough animation that is used by animators to give some idea about the timing of a sequence, used as a kind of animated storyboard.

Anti-aliasing: A method of reducing or preventing rendering artefacts by using colour information to simulate a higher screen resolution. The term is often applied to the process of softening the unnaturally precise or stepped edges (sometimes known as 'the jaggies') created when a computergenerated object is placed against a contrasting background by using pixels of intermediate shades as a buffer between the two.

Aperture: In a real camera, the size of the opening that light passes through (usually given in terms of its f-stop) in order to reach the film. The larger the f-stop, the smaller the opening. 3D software packages sometimes mimic the effects of different aperture settings on a recorded image during the rendering process.

Aspect Ratio: The ratio of the width of an image to its height. Common aspect ratios for broadcast images include 4:3 and 16:9 (widescreen).

Axis: A hypothetical linear path around which an object can be rotated, or across which it can be mirrored. In the Cartesian co-ordinate system, the three world axes, X, Y and Z (width, height and depth) define directionality within the 3D universe. Hence, a co-ordinate of (0,0,0) defines the origin of the world.

Beauty Pass: When rendering multiple passes of a scene, the beauty pass is the one that features the most significant information about the objects within it. This usually includes the main, full-colour rendering of those objects, including diffuse illumination and colour. A beauty pass will not include reflections, highlights, and shadows, which are usually separate passes.

Bit Depth: The number of bits used to define the shade or colour of each pixel in an image, a 'bit' being the smallest unit of memory or storage on a computer. (One 'byte' is eight 'bits'.) A 1-bit image is black and white. An 8-bit image provides a 256-colour palette. A 24-bit image provides 16.7 million possible colours: a palette sometimes known as 'True Colour'. A 32-bit image provides the same palette, plus an 8-bit greyscale alpha channel.

Bitmap: Strictly speaking, a bitmap is a 1-bit black-and-white image. However, the term is often loosely applied to any two-dimensional image, regardless of bit depth. Still image manipulation packages such as *Photoshop* and *Paint Shop Pro* are sometimes referred to as 'bitmap editors'.

Blinn: See: Shading.

Bluescreen Footage: Live footage shot against a backdrop of a single uniform colour (usually blue or green) with a view to compositing it into a computergenerated background. Every pixel with the same colour value as the backdrop is replaced by the CG image.

Bone: A rigid object analogous to a real bone, placed inside the 'skeleton' of a character during the process of rigging it for animation. When a bone is moved, it acts upon the mesh of the character model, deforming it.

Boolean: An object created by combining two objects using mathematical operators. The two objects may be subtracted from one other, merged, or intersected to form the new object.

Bounding Box: The smallest regular-shaped box that encloses a 3D object, usually rectangular in shape.

Bump Map: A black-and-white image used by a 3D software package to simulate the three-dimensional detail on the surface of an object. When projected over the surface of the object, parts of the surface beneath white areas of the image are raised; those beneath black areas are depressed. Bump mapping is purely a rendering effect, however, and does not affect the underlying geometry of the model.

CAD: Computer Aided Design. The use of computer-based models of objects for visualisation or testing as an aid in the design process. CAD software packages usually contain more precise real-world measuring tools than ordinary 3D packages, but fewer surfacing and animation features.

Camera: A virtual viewpoint in 3D space that possesses both position and direction. In a 3D scene, the camera represents the viewer's eye. When the scene is rendered at final quality, it is the camera view that is used, rather than the one seen in the software's workspace. This enables the artist to move around the workspace without disturbing the camera view.

Camera Mapping: A technique by which geometry matching the size and perspective of objects shown within a still image is constructed, and the original image mapped back onto those objects. This permits limited camera movement around the picture, giving the illusion of a 3D environment from a 2D image.

Camera Move: A movement of the virtual camera within a 3D software package analogous to one in real-world cinematography. Common camera moves include dollying, in which the camera angle remains fixed, but the camera moves towards or away from the subject; panning, in which the camera position remains fixed, but the camera tilts or swivels in any direction to follow the action; and tracking, in which the camera moves in a single plane at right angles to the area of interest.

Camera Path: The path in virtual space along which the camera moves during the course of an animation.

Camera Tracking: Also known as match moving, camera tracking is the process of 'extracting' the motion of the camera in space from a piece of live-action footage. This motion data can then be imported into a 3D software package and used to animate the virtual camera, in order to better match the rendered output to that of the source footage during the compositing process.

Caustics: Patches of intense illumination caused by the refraction of light through a transparent object or the reflection of light from a reflective surface. One common example would be the shifting patterns of light and shade cast on the floor of a swimming pool on a sunny day. Rendering software has only recently become sophisticated enough to mimic such complex real-world lighting effects as caustics.

CGI: Computer Generated Imagery. An image or images created or manipulated with the aid of a computer. The term is often used to refer specifically to 3D computer animation, although it is really more widely applicable.

Channel: For a two-dimensional image, a channel is a sub-image composed only of the values for a single component of a given pixel. A greyscale image has one colour channel, an RGB image has three, and a CMYK image has four. When applied to materials, the term refers to one particular subset of the properties which determine the way in which a surface reacts to light, including colour, reflectivity, transparency, diffusion, specularity and bump.

Character Animation: A sub-area of animation that deals with the simulation of the varied movements of living creatures. Usually, before a character model can be animated, it must be set up with an underlying skeleton, constraints and controllers: this process is known as rigging.

Child: See: Hierarchy.

Colour Bleeding: A physical phenomenon by which the colour of one object is seemingly transferred to a neighbouring object by light bouncing from one surface to the other. Like caustics, colour bleeding is a complex real-world lighting effect, and one that rendering software has only recently become able to simulate accurately.

Colour Space: A mathematical method for defining the way in which colour is represented within an image. Common colour spaces include RGB (Red, Green, Blue), which has a bit depth of 24, and is commonly used in broadcast applications, and CMYK (Cyan, Magenta, Yellow, Black), which has a bit depth of 32, and is used for print illustration work.

Compositing: The process of combining multiple images into a single image. This is often performed in films to make a live actor appear on a computergenerated background, or vice versa. It can also be used following multi-pass rendering to combine the various render passes in different ways to control the look of a scene.

Compression: A technique for reducing the quantity of data required to make up a digital image. Compression techniques can be non-destructive ('lossless') or destructive ('lossy'), in which part of the data set is discarded permanently. Converting still images into JPEG format is one example of lossy compression.

Constrain: To restrict the motion of an object to one or two planes, or to a certain range of values within a plane, in order to simplify the process of animation. Constraints are commonly imposed on joints within a skeleton during the process of rigging a character for animation, in order to prevent that character from performing actions that would be physically impossible.

Constructive Solid Geometry: A modelling technique that combines simple solid forms, or primitives, into more complex models, by means of Boolean operations. Common primitives include the plane, the cube, the sphere, the cone and the torus.

Co-ordinate System: A set of numerical values used to denote a location in 3D space. In the Cartesian co-ordinate system, three orthogonal 'world axes' (the X, Y and Z axes) are used to define the position of a point relative to the intersection of these axes, or origin. Other co-ordinate systems can be used for modelling and texture projection.

CV: Control Vertex. A control point used to manipulate the shape of a NURBS curve.

Deformer : Usually: a modelling tool which deforms the structure of an entire object. However, the exact meaning of the term varies from software package to software package.

Dirt map: See: Grime Map

Displacement Map: A recent advance on Bump Mapping. Like a Bump Map, a Displacement Map is a black-and white image that a 3D software package projects over the surface of a model to generate surface detail. Unlike a bump map, however, a Displacement Map modifies the actual underlying geometry and is not merely a rendering effect.

DoF: Depth of Field. The depth of field of a specific lens is the range of acceptable focus in front of and behind the primary focus setting. It is a function not only of the specific lens used but also of the distance from the lens to the primary focal plane, and of the chosen aperture. Larger apertures will narrow the depth of field; smaller apertures will increase it.

Environment Map: An image intended to entirely enclose a scene, either to provide a convincing background, or to project real-world lighting or reflection data onto the surface of an object

Expression :A mathematical formula used to define the value of a given attribute of an object during animation. The use of expressions forms a procedural alternative to hand, or keyframe, animation.

Extrusion: A modelling technique in which a two-dimensional outline or profile is duplicated outwards along a linear path, and the set of duplicated profiles joined to create a continuous three-dimensional surface.

Face: The front or back of an extruded object. The shape from which a 3D object has been extruded.

Fall-off: The way in which the intensity of a light diminishes with the distance from its source. In the real world, the fall-off of light is governed by the inverse square law, which states that the intensity is inversely proportional to the square of the distance. However, in 3D software packages, it is possible to use a variety of different mathematical formulae to describe the relationship.

F-Curve: Function Curve. An F-Curve is displayed in the Graph Editor of a 3D software package, and is used during the animation process both to display and to control the way in which a particular attribute of an object varies with time.

File Format: The format in which the data making up a particular 3D object or scene is stored. File formats come in two types: object formats, such as the LWO format in *LightWave* or 3DS format in *3ds max*, which contain only details of the geometry and surface properties of an object; and scene formats, such as their LWS and MAX equivalents, which contain such global information as lighting, animation or camera data. Other file formats supported by most major 3D software packages include the DXF and IGES formats for CAD and NURBS models, the OBJ object format, and the cross-platform FBX format developed by Kaydara for the interchange of motion data between 3D applications.

Flythrough: A type of animation in which the camera moves around a scene, rather than objects moving in front of a stationary camera.

Forward Kinematics: Often abbreviated to FK, Forward Kinematics is a character animation technique for controlling the motion of the bones in a chain – for example, a limb – in which rotations propagate from bone to bone towards the free end of the chain (in the case of a limb, towards the hand or foot).

Frame: A still two-dimensional image. In computer animation, the term 'frames per second' (fps) is a measurement of the number of still frames displayed in one second to give the impression of a moving image. For film work, this value is usually 24; for the European PAL broadcast format, 25; and for the US NTSC broadcast format, 30 fps.

F-Stop: See: Aperture

Global Illumination: A superset of the radiosity and raytracing rendering techniques. The goal of Global Illumination rendering is to compute all of the possible light interactions between surfaces in a given scene, and thus obtain a truly photorealistic image. All combinations of diffuse and specular reflections and transmissions must be accounted for. Effects such as colour bleeding and caustics must also be included in a global illumination simulation.

Graph Editor: The part of the GUI of a 3D software package where a particular attribute of an object changes over time is displayed graphically, in the form of an F-Curve.

Grime Map: Also known as 'dirt maps', grime maps are two-dimensional images applied to a particular channel of a material. When the image is projected across the surface of an object, it breaks up that channel's flat, even value, creating realistic surface variations.

Group: A set of sub-objects within a model or scene that move and behave as a single entity, yet can still be split apart (ungrouped), if necessary. Most complicated models are constructed from several less complex parts that need to maintain the same spacing and orientation; grouping provides a way of locking the relative positions of the objects without joining them permanently.

GUI: Graphical User Interface. An iconbased interface that controls a 3D software package. Although the GUI varies from program to program, there are certain basic conventions governing the layout of the main professional 3D applications.

Hard-Body Dynamics: Also known as rigid-body dynamics, hard-body dynamics simulate the physical behaviour of rigid objects that do not deform upon collision.

Hardware Rendering: Also known as display rendering, hardware rendering previews a 3D scene within the viewports on a 3D software package, providing real-time on-screen feedback about the effects of changes made to that scene, but omitting certain processor-intensive effects such as volumetrics, shadowing and realistic refraction.

HDRI: High Dynamic Range Image. A 2D image stored in a file format with a greater range of luminance values than a standard bitmap image. HDR images are often used as environment maps in image-based lighting techniques to create subtle, real-world lighting effects.

Hierarchy: The relationship of the sub-objects within a model or a scene to one another. Sub-objects may exist as parents, children or independents. A parent object controls the motion of all child objects linked to it, although the motion of a child object does not affect that of the parent.

History: A record of the previous values of the attributes of a 3D scene, enabling an artist to revert immediately to a particular earlier state. The history is especially valuable during the modelling process.

Hull: A series of straight lines connecting the CVs of a NURBS surface.

Image-Based Lighting: A technique in which a photographic reference image is used as an environment map to control the surface illumination of a 3D object, in order to create subtle real-world lighting effects.

In-betweening: The generation of intermediate transition positions between two keyframes. The term is drawn from traditional cel animation, where a lead artist generates the beginning and end keyframes of a sequence (typically one second apart), a breakdown artist does the breakdowns (typically four frames apart), and an 'in-betweener' completes the rest.

Interpolation: The mathematical procedure by which a 3D software package calculates the in-between positions between two keyframes.

Inverse Kinematics: Often abbreviated to IK, Inverse Kinematics is a character animation technique in which the end bone of a chain - for example, a limb – is assigned a goal object. When the goal object moves, the bone moves with it, dragging the rest of the chain behind it. The movement propagates from the free end of the chain towards the fixed point: the reverse of Forward Kinematics.

Isoparm: Lines on a NURBS surface connecting points of constant U or V co-ordinate values, and representing crosssections of the NURBS surface in the U or V directions.

Joints: Points of articulation between the bones in a character rig.

Keyframe: An image, or set of attributes for a 3D scene, used as a reference point in animation. The artist usually sets up keyframes manually at significant points in the action, and the computer calculates the inbetween values automatically.

Lathing: A modelling technique in which a two-dimensional profile is duplicated in rotation around a reference axis, and the duplicates joined up to create a continuous three-dimensional surface. Lathing is particularly useful for creating objects with rotational axes of symmetry, such as plates, glasses, vases or wheels.

Layer: A level of an image that can be edited independently of the rest of the image.

Lens: In a real camera, a lens is a curved piece of glass or other transparent material that focuses light onto the film. Modern 3D software is capable of simulating a variety of optical distortions created by imperfections in real-world lenses, adding realism to the rendered output.

Lens Flare: A bright pattern on an image caused by the reflection and refraction of light within a camera. Although lens flares are actually artefacts of the photographic process, many 3D software packages offer artists the opportunity to add them deliberately in order to increase the realism of rendered output.

Light: A point or volume that emits light onto a 3D object. Types of light supported within 3D packages include Point lights, which emit light in all directions from a single point; Spot lights, which emit light in a cone; Distant or Directional lights, which emit light rays in parallel, illuminating all surfaces within a scene; and Area lights, which emit light from two-dimensional surfaces.

Lip Synching: The process of matching a character's facial movements to a spoken soundtrack during facial animation.

Lofting: A modelling technique in which a continuous three-dimensional surface is created by selecting and joining multiple two-dimensional cross sections or profiles.

Look Development: The process of developing the look of a 3D scene by compositing separate render passes together in different permutations.

Low-Poly Modelling: The process of creating simplified models with low polygon counts, usually for use in videogames, where scenes must be rendered in real time, by software with a limited ability to handle complex models.

Match-moving: See: Camera Tracking.

Material: A set of mathematical attributes that determine the ways in which the surface of a model to which they are applied reacts to light. These attributes are sub-divided into individual channels.

Mask: An area that can be protected and isolated from changes applied to the rest of the image.

Mesh: The surface geometry of a 3D model, made up of a series of linked geometry elements such as polygons, patches or NURBS surfaces.

Metaball modelling: A technique in which models are created using spheres (or, more rarely, other primitive objects) that attract and cling to each other according to their proximity to one another and their field of influence. Metaball modelling is particularly useful for creating organic objects.

Model: Used as a verb, to model means to build a 3D object. Used as a noun, it means the 3D object created as the end product of the modelling process. A variety of different methods are used in 3D modelling, including polygonal, NURBS, Sub-D and metaball techniques.

Modifier: See: Deformer.

Morph: To transform from one state to another. Morphing is commonly used in lip-synching, in order to transform the head model of a character between a variety of preset states (or 'morph targets'), corresponding to common facial expressions, in order to create the illusion of speech.

Motion Blur: An artefact of real-world cinematography in which the camera's target object is moving too quickly for the camera to record accurately, and therefore appears blurred. Many 3D software packages simulate motion blur as a rendering effect, in order to increase the realism of 3D images or animation.

Motion capture: Often abbreviated to mo-cap, motion capture is the process of recording the movements of a live actor, and converting them to a 3D data format which can then be applied to a virtual character.

Multi-pass rendering: To render out the lighting or surface attributes of a scene as separate images, with a view to compositing them together later. Multi-pass rendering can be used simply to speed up the rendering process, or in order to develop the look of a scene by compositing the different passes together in various permutations.

Negative Light: A light within a 3D scene that decreases the illumination on a surface instead of adding to it. Negative lights can be used to remove 'overspill' in brightly lit scenes.

Normal: An imaginary line drawn from the centre of a polygon (or other geometry object) at right angles to the surface.

Null: A point within a 3D scene that does not render out, but which is used as a reference for other objects.

NURBS: Non-Uniform Rational B-Splines. NURBS curves are two-dimensional curves whose shape is determined by a series of control points or CVs between which they pass. When a series of such curves are joined together, they form a threedimensional NURBS surface. Such surfaces have a separate co-ordinate space (known as UV co-ordinate space) to that of the 3D scene in which they are situated. NURBS are commonly used to model organic curved-surface objects.

Object: A generic term describing any item that can be inserted into and manipulated within a 3D scene. Models, lights, particle emitters and cameras are all objects.

Object file: See: File format.

Origin: See: Co-ordinate System, Axis.

Parent: See: Hierarchy.

Patch: An area of a NURBS surface enclosed by a span square: the shape created by the intersection of four isoparms, two in the U direction, and two in the V direction.

Particle System: An animation system consisting of a large number of very small points whose behaviour is determined mathematically. A particle system typically consists of an emitter (which may be a point, surface or volume, and may emit particles directionally or in all directions) and a series of fields that determine the motion of those particles. Individual particles have a finite lifespan, and may possess attributes (such as colour, radius, and opacity) that vary over the course of that lifespan. Particle effects are commonly used to simulate fire, smoke, steam and other fluids, or to control complex animations such as crowd scenes.

Phong: See: Shading.

Photogrammetry: Also known as image-based modelling, photogrammetry is the process of generating a fully textured 3D model from a series of photographs of a real object. Although it was once an expensive high-end technique, there is now a range of increasingly inexpensive photogrammetry software packages on the market.

Plane: A two-dimensional surface in Cartesian co-ordinate space. Essentially a flat sheet extending infinitely in all directions, a plane may be used to aid object manipulation, positioning and construction, and is not usually made visible in a final render.

Plugin: A small piece of third-party software that is loaded into a 3D application in order to extend its functionality. Plugins commonly perform such specialist tasks as file conversion or data export, texture generation, and physics or fluid simulation. There are thousands of plugins currently available on the Internet, both commercially and as free downloads.

Point: A one-dimensional point in coordinate space. Points can be linked up to form polygons, used as control vertices for NURBS curves, or employed as nulls to control lights or cameras, amongst other functions.

Polygon: A geometry element formed by connecting three or more points. A triangle, or three-point polygon, is the simplest form of polygonal geometry. Polygonal modelling is a fast, intuitive method of creating 3D objects, but does not easily generate smooth curved surfaces.

Post Processing: The manipulation of a rendered image, either to improve the quality of that image, or to create effects that cannot easily be achieved directly within the 3D software itself. Some 3D software packages can be set to automatically apply post-processing effects, such as motion blur or Depth of Field, after a frame is rendered.

Preset: A pre-generated list of settings for a particular 3D software package. Presets are usually used to control and customise properties such as rendering or lighting styles. Like plugins, they may either be commercial products, or freely downloadable from the Internet.

Preview: A time-saving method of checking the progress of a project by rendering it at a lower quality, resolution or frame rate than will be used for the final project.

Primitive: A simple three-dimensional form used as the basis for constructive solid geometry modelling techniques. Typical primitives include the plane, the cube, the sphere, the cone and the torus.

Procedural Texture: A texture map that is generated by a mathematical function, rather than a real-world bitmap image projected over the surface of an object.

Projection: The process by which a twodimensional texture map is applied over the surface of a threedimensional object, as if it were an image projected from a slide projector. There are several common projection types, including Planar, Cubic, Spherical and Cylindrical. Which one is most appropriate depends on the type of map being projected, and the shape of the object it is being projected upon.

Quad view: A method of displaying 3D scenes adopted by many high-end software applications, in which a scene is shown simultaneously in Top, Side, Front and Perspective views.

Radiosity: A technique for rendering 3D scenes. Radiosity simulates the way in which light bounces from surface to surface within a scene, and is more accurate, but also more processor-intensive, than raytracing.

Raytracing: A technique for rendering 3D scenes. Raytracing traces the path of every ray of light from its source until it either leaves the scene or becomes too weak to have an effect. The term is also sometimes applied to the reverse method: tracing the path of every ray of light from the camera backwards to the light source.

Reflection Map: An environment map used to simulate real-world reflection effects on the surface of a 3D object. Reflection maps render more quickly than methods that generate true surface reflections, such as raytracing.

Rendering: The process of converting the 3D data stored in a software package into the two-dimensional image 'seen' by the camera within the scene. Rendering brings together the scene geometry, Z-depth, surface properties, lighting set-up and rendering method to create a finished frame. Rendering comes in two forms: Display or Hardware rendering, used to display the scene on-screen in the software package's viewports; and the more processorintensive Final-quality or Software rendering, which generates an image for output, and takes account of properties that Display rendering overlooks, such as shadows, reflections and post-process effects.

Resolution: The size of the final image in pixels when rendering out a scene. Higherresolution renders contain more detail, but take longer to complete.

Rigging: The process of preparing a character model for animation, including setting up an underlying skeleton, complete with constraints, controllers and kinematic systems, and linking it to the mesh of the character model.

Scene: A set of 3D objects, including the models themselves and the lights and camera that will be used when rendering them out.

Scene file: See: File format.

Script: A small piece of code created in a 3D software package's own internal programming language, and used to automate common or complex tasks.

Shading: The mathematical process of calculating how a model's surfaces react to light. A variety of alternative algorithms can be used for the task, including Phong, Lambert, and Blinn shading models. Shaders are often built up as node-based shading trees, with each node controlling a specific aspect of the process.

Skinning: The process of binding the surface of a model to the underlying skeleton during character rigging.

Skeleton: An underlying network of bones used to define and control the motion of a model during character animation. Moving a bone causes the mesh of the model to move and deform.

Snapping: The automatic alignment of one object to another or to a reference grid, intended to aid the precise placement of objects within a scene or modelling hierarchy.

Soft-Body Dynamics: The simulation of the behaviour of soft bodies that deform on collision with other objects, such as cloth or fluid flows.

Specularity: A surface property of an object that determines the way in which highlights appear on that surface.

Spline: See: NURBS.

Subdivision Surface: Also known as Sub-Ds, subdivision surfaces are surfaces created using a technique midway between polygon and NURBS modelling. They consist of an underlying polygonal base mesh, which is automatically subdivided by the software to create a smoothed final form. Sub-Ds combine much of the power of NURBS surfaces with the intuitive characteristics and ease of use of polygonal modelling tools.

Sweep: A modelling technique similar to extrusion in which a twodimensional profile is replicated along a path, then joined to form a continuous three-dimensional surface. Unlike extrusion, however, this path need not be perpendicular to the profile. By sweeping a circular profile along a helical path, for example, it would be possible to model a coiled cable of the type commonly found on telephones.

Symmetry: A modelling option in which any changes made to the model are duplicated across an axis of reflectional symmetry. This makes it possible to create complex symmetrical objects, such as a human or animal head, without having to work directly on more than one half of the model.

Texture: A bitmap image that is applied to the surface of 3D object to give it detail. Texture maps may be either photographic images or procedural textures, and may be applied in each of the material channels of an object using a variety of mapping or projection methods.

Three-Point Lighting: A system of CG lighting derived from real-world cinematography, in which a scene is illuminated by three light sources: a Key light, which acts as the primary source of illumination for the scene; a Fill light, which illuminates shadow areas; and a Rim light, which illuminates the edges of objects and helps them stand out from the background.

Tiling: The process of duplicating a texture across the surface of an object. Tiling textures must be created so that the edge of one aligns perfectly with that of its neighbour, otherwise the result is a series of ugly seams. Highfrequency textures are those in which patterns repeat at short intervals over an object's surface; low-frequency textures are those in which the intervals are larger.

Timeline: A fundamental element of the graphical user interface of most modern 3D software packages which shows the timing of the keyframes in a sequence of animation. Playback of the animation may be controlled either by a series of VCR-like controls, or by clicking and dragging with the mouse to 'scrub' a slider to and fro along the timeline.

Trimming: The process by which NURBS surfaces are edited. The trimming tools allow 3D artists to define areas on a NURBS surface that will be made invisible and not render out, even though their CVs still exist. Separate trimmed surfaces may be joined together by using a variety of techniques, including Attaching, Aligning, Filleting and Stitching.

UV Texture Co-ordinates: The co-ordinate system used for assigning textures to polygonal models. Since UV co-ordinate space is two-dimensional, one of several projection methods must be used to 'unwrap' the UVs from the model and lay them flat on a plane. Once unwrapped, the UV map may be screengrabbed and exported to a paint package for texture painting.

Vertex: See: Point.

Viewport: The region of the interface of a 3D software package in which the scene is displayed to the artist.

Volumetrics: Volumetric lights are lights whose illumination can be observed throughout a volume of space, rather than simply where the light strikes a surface. In similar fashion, volumetric textures are textures applied throughout a volume of space, rather than to a surface.

Walk Cycle: A short sequence of animation containing the keyframes necessary to make a bipedal character take two consecutive steps. The sequence may then be repeated over and over again to animate the character walking forward. Walk cycles may be modified in many subtle ways to suggest information about a character's age, gender, emotional state or personality.

Weighting: The process of determining which bone in a skeleton affects which part of a model's surface mesh. In many cases, this is achieved by painting weight maps onto the surface of the model that delineate a particular bone's area of influence.

Wireframe: A shading method in which a simple grid of lines is used to represent the basic contours of the underlying model. For many 3D artists, this is a favoured mode to work in, since it permits them to see faces and surfaces that would otherwise be hidden by overlying geometry.

World axes: See: Co-ordinate systems.

Z-depth: The distance a particular point or surface lies inside a scene. Z-depth information is used to calculate where a light casts shadows, and also to calculate which surfaces are visible to the camera during rendering, and which are obscured by nearer geometry.

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