Introduction to Computer Graphics and 3D

This book will introduce you to the workings of 3D animation, also called *computer graphics* (CG), with one of the most popular programs on the market, the Autodesk® Maya® software. It will introduce you to many of the features and capabilities of Maya with the intent of energizing you to study further.

The best way to succeed at anything is to practice. Go through the exercises in this book (more than once if you care to), and also think of exercises and projects that can take you further in your learning process.

This is not to say you can't be a casual visitor to working in CG—far from it. Playing around and seeing what you can create in this medium is just flat-out fun. Understanding your own learning pace is important.

Throughout this book, you'll learn how to work with Maya tools and techniques at a pace you set for yourself. When you're learning how to work with Maya, the most important concept is discovering how you work as an artist.

Learning Outcomes: In this chapter, you will be able to

- Develop an appreciation for the CG process

- Discern between different types of digital image files

- Recognize key terms and principles in film and animation

A Preview of the CG Process

Try not to view this experience as learning a software package but as learning a way of working to an end. It's hard to relax when you're trying to cram so much information into your brain. You should try not to make this experience about how a software program works but about how you work with the software. Maya is only your tool; you're the boss.

CG and CGI are the abbreviations for *computer graphics* and *computer graphics imagery*, respectively, and are often used interchangeably.

The process of creating in CG requires that you either model or arrange prebuilt objects in a scene, give them color and light, and render them through a virtual camera to make an image. It's a lot like directing a live-action production but without any actor tantrums.

A large community on the Web provides free and for-pay models and textures that you can use in your scenes. Sites such as `www.turbosquid.com`, `www.cgtextures.com`, `www.doschdesign.com`, and `www.archive3d.net` can cut out a lot of the time you might spend creating all the models or textures for a scene.

After you build your scene in 3D using models, lights, and a camera, the computer *renders* the scene, converting it to a 2D image. Through setup and rendering, CGI is born—and, with a little luck, a CG artist is also born.

The CG animation industry inherited a workflow from the film industry that consists of three broad stages: preproduction, production, and postproduction. In film, *preproduction* is the process in which the script and storyboards are written, costumes and sets are designed and built, actors are cast and rehearse, the crew is hired, and the equipment is rented and set up. In the *production* phase, scenes are taped or filmed in the most efficient order. *Postproduction* (often simply called *post*) describes everything that happens afterward: the scenes are edited into a story; a musical score, sound effects, and additional dialogue are added; and visual effects may also be added.

Preproduction for a CG animation means gathering reference materials, motion tests, layout drawings, model sketches, and such to make the actual CG production as straightforward as possible. Production begins when you start creating models of characters, sets, and props from the storyboards, model sheets, and concept art. Then these *assets* are animated, and finally, shots are then lit and ready for rendering. Postproduction for a CG project is where all of a CG film's elements are brought together and assembled into the final form through editing, adding sound, and so on.

The CG Production Workflow

Modeling almost always begins the CG process, which then can lead into texturing and then to animation (or animation and then texturing). Lighting should follow, with

rendering pulling up the rear as it must. (Of course, the process isn't completely linear; you'll often go back and forth adjusting models, lights, and textures along the way.)

Modeling, the topic of Chapters 4 through 6, is usually the first step in creating CG. Downloading or purchasing models from the Internet can often cut down the amount of time you spend on your project, if you don't prefer modeling or texturing.

Knowing how an object is used in a scene gives you its criteria for modeling. Creating a highly detailed model for a faraway shot will waste your time and expand rendering times needlessly.

> Because your computer stores everything in the scene as vector math as opposed to pixels (called *raster*), the term *geometry* refers to all the surfaces and models in a scene.

When the models are complete, it's a good idea to begin *texturing* and *shading*, the process of applying colors and material textures to an object to make it renderable. In Figure 1.1, an elephant model is shown, with textures applied to its lower body.
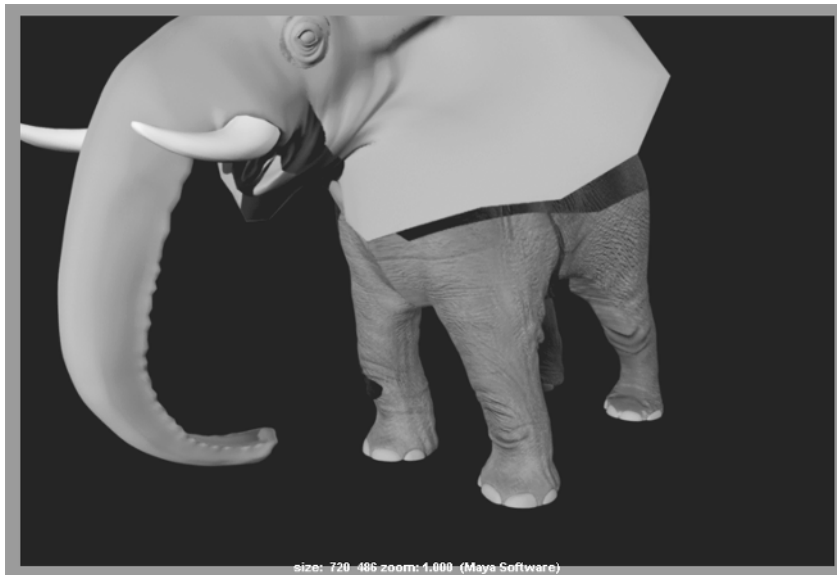

Figure 1.1

Texturing adds detail to an otherwise flat model.

Because the textures may look different after animating and lighting the scene, it's wise to leave the final adjustments for later. You'll learn more about texturing and shading in Chapter 7, "Autodesk Maya Shading and Texturing."

Next comes the process of animating. A*nimation* shows *change over time*. All animation, from paper flipbooks to film to Maya, is based on the principle of *persistence of vision*: that when we see a series of rapidly changing images (called *frames*), we perceive the changing of the image to be in continuous motion.

You know when something doesn't look right, and so will the people watching your animation. So, to animate something properly, you may need to do quite a lot of setup beyond just modeling and texturing. In character animation, for example, you'll need to create and attach an *armature*, or skeleton, to manipulate the character and to make it move like a puppet. I cover animation techniques in Maya in Chapter 8, "Introduction to Animation," and Chapter 9, "More Animation!"

Next there is lighting. *CG is fundamentally all about light.* Without light, we wouldn't see anything; simulating light is the one of the most influential steps in CG. During the lighting step, you set up virtual lights in your scene to illuminate your objects and action, as you'll learn in Chapter 10, "Autodesk Maya Lighting." Before long, you'll start modeling and texturing differently—that is, working with the final lighting of the scene in mind.

When you're done lighting, you move to rendering; your computer takes your scene and makes all the computations it needs to render your scene into images. Rendering time depends on how much geometry is used in the scene as well as on the number of lights, the size of your textures, and the quality and size of your output: the more efficient your scene, the shorter the rendering times. The more experience you gain, the more efficient your eye will become.

Digital Images

When you're finished with your animation, you'll probably want as many people as possible to see it (and like it!). Here is a primer on the types of digital images and how they are discerned.

As mentioned, each image file holds the color information in *channels*. All color images have red, green, and blue color channels. Some images have a fourth channel called the *alpha* channel (a.k.a. *matte* channel), which defines what portions of the image are transparent or opaque (solid). You can read more about alpha channels in Chapter 7.

First, an image file stores the color of each pixel as three values representing red, green, and blue. The image type depends on how much storage is allotted to each pixel (the *color depth*).

Grayscale   The image is black and white with varying degrees of gray (typically 256 shades). These are good for use as texture maps such as bump and displacement maps.

8-Bit Image File (a.k.a. 24-Bit Color Display)   Each color channel is given 8 bits for a range of 256 shades of each red, green, and blue channel, for a total of 16 million colors in the image.

16-Bit Image   Used in television and film work with such file types as EXR and TIFF, a 16-bit image file holds 16 bits of information for each color channel, resulting in an impressive number of color levels and ranges.

32-Bit Image   32-bit image files, such as the HDR and OpenEXR formats, give you an incredible amount of range in each color channel. EXR files in particular are a standard at many film studios and are finding use with television productions more and more because of their impressive image range and quality.

File Formats

Several image file formats are available today. The main difference between file formats is how the image is stored. Some formats compress the file to reduce its size. However, as the degree of compression increases, the color quality of the image decreases.

The popular formats to render into from Maya are Tagged Image File Format (TIFF) and Targa. These file formats maintain a good color image, include an alpha channel, and are either uncompressed or barely compressed (lossless compression) for high quality. Note that some image file types such as TIFF may have 8, 16, or even 32 bits of color depth, while some other file types such as JPEG can have only 8-bit color depth.

To see an animation rendered in a file sequence of TIFFs or JPEGs, for example, you must play them back using a frame player, such as FCheck (which is included with Maya) or compile them into a movie file using a program such as Adobe After Effects.

Animations can also be output directly to movie files such as AVI or QuickTime. These usually large files are self-contained and hold all the images necessary for the animation that they play back as frames. Movie files can also be compressed, but they suffer from quality loss the more they're compressed.

Maya can render directly to a movie format, saving you from having to render a large sequence of files, though it's always best to render a sequence of files that can be compiled into a movie file later using a program such as Adobe After Effects, Adobe Premiere Pro, or QuickTime Pro.

Resolution, Aspect Ratio, and Frame Rate

Resolution denotes the size of an image by the number of horizontal and vertical pixels, usually expressed as #×# (for example, 640×480). The higher the resolution, the finer the image detail will be, and the larger the files. Full HD, for example, is defined as 1920×1080. *Aspect ratio* is the ratio of the screen's width to its height. Finally, the number of frames played back per second determines the *frame rate* of the animation. This is denoted as *frames per second* (fps). Most digital movie files are output at 24fps to mimic the frame rate of movies.

You should have your frame rate set properly before animating to match the frame rate you intend on using for playing the animation back. Playing back a 24fps animation at 30fps will show a slower-moving animation. Conversely, playing a 30fps animation at 24fps will create a faster-moving animation that will either skip some frames or end later than it should.

3D Coordinate Space, World Axis, and Local Axis

Space is defined in three axes—*X*, *Y*, and *Z*—representing width, height, and depth. The three axes form a numeric grid in which a particular point is defined by *coordinates* set forth as (#,#,#), corresponding to (*X,Y,Z*), respectively. At the zero point of these axes is the *origin*. This is at (0,0,0) and is the intersection of all three axes. The 3D space defined by these three axes is called the *World axis*, in which the *XYZ* axes are *fixed references*. The axis in *World Space* is always fixed and is represented in Maya by the XYZ Axis icon in the lower-left corner of the Perspective window.

Because objects can be oriented in all sorts of directions within the World axis, it's necessary for each object to have its own width, height, and depth axis independent of the World axis. This is called the *Local axis*. The *Local axis* is the *XYZ*-coordinate space that is attached to every object in Maya. When that object rotates or moves, its Local axis rotates and moves with it. This is necessary to make animating an object easier as it orients and moves around in the World axis. Figure 1.2 shows an example of a Local axis in action, where you can see a large yellow planet and its moon rotating around the central Sun.

Figure 1.2

The Sun at the origin, with Earth and other planets orbiting the World axis while rotating on their own axes
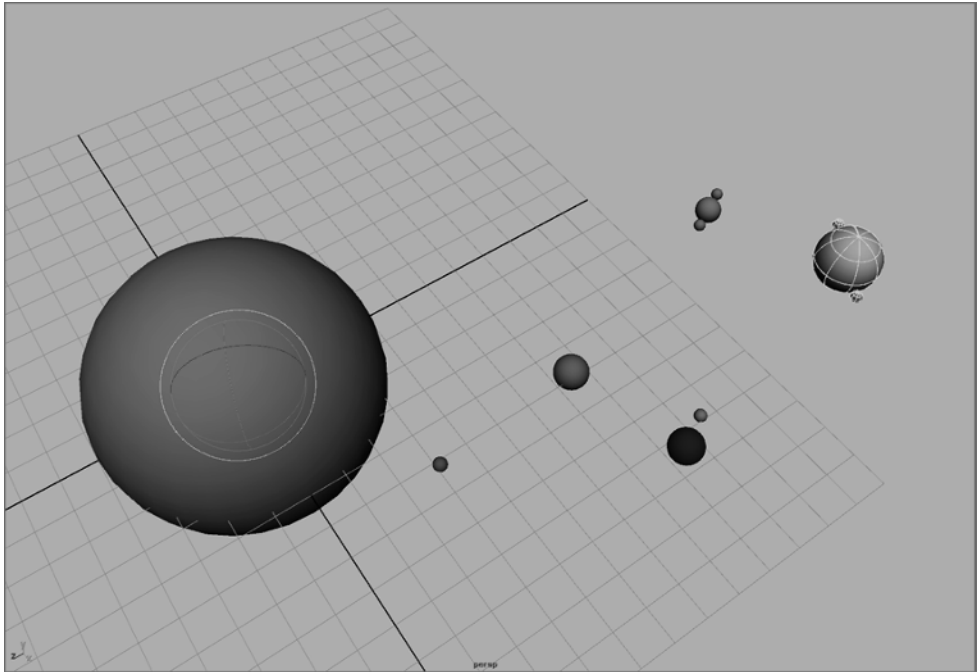
Basic Animation Concepts

The following sections define the key terms you'll come across numerous times on your journey into animation and CG.

Frames, Keyframes, and In-Betweens

Each drawing of an animation—or, in the case of CG, a single rendered image—is called a *frame*. The term *frame* also refers to a unit of time in animation whose exact chronological length depends on how fast the animation will eventually play back (frame rate).

Keyframes are frames in which the animator creates a pose or other such state of being for an object or character. Animation is created when an object travels or changes from one keyframe to another. In CG, a keyframe can be set on almost any aspect of an object—its color, position, size, and so on. Maya then interpolates the *in-between* frames between the keyframes set by the animator. Figure 1.3 illustrates a keyframe sequence in Maya.

Weight

Weight is an implied, if not critical, concept in design and animation. How you show an object in motion greatly affects its weight and therefore its believability. Weight in animation is a perception of mass. An object's movement, how it reacts in motion, and how it reacts to other objects together convey the feeling of weight. Otherwise, the animation will look bogus—or, as they say, "cartoonish."

Weight can be created with a variety of techniques developed by traditional animators over the years. Each technique distorts the shape of the object or character in some way to make it look as if it's moving. The following are a few animation principles to keep in mind:

Squash and Stretch This technique makes a character, for example, respond to gravity, movement, and inertia by squashing it down and stretching it up when it moves. For example, a cartoon character will squeeze down when it's about to jump up, stretch out a bit while it's flying in the air, and squash back down when it lands.

Ease-In and Ease-Out Objects never really stop suddenly; everything comes to rest in its own time, slowing before coming to a complete stop in most cases. This is referred to as *ease-out*. Objects don't immediately start moving either; they accelerate a bit before reaching full speed; this is referred to as *ease-in*. The bouncing-ball tutorial in Chapter 8 illustrates ease-in and ease-out.

Follow-Through and Anticipation Sometimes you have to exaggerate the weight of an object in animation, especially in cartoons. You can exaggerate a character's weight, for instance, by using well-designed follow-through and anticipation.
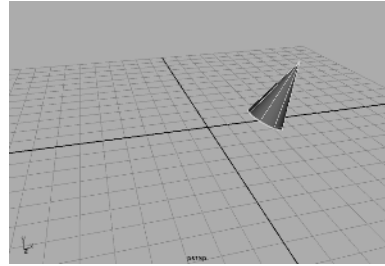
Figure 1.3

In the first frame of this sequence, a keyframe is set on the position, rotation, and scale of the cone. On frame 30, the same properties are again keyframed. Maya calculates all the movement in between.
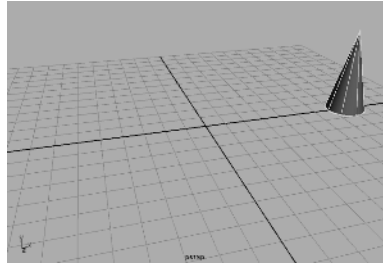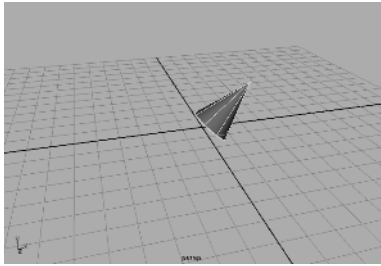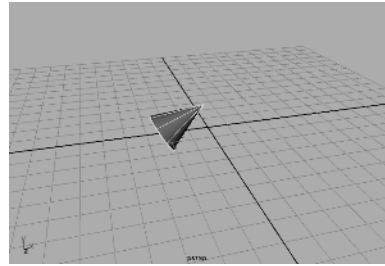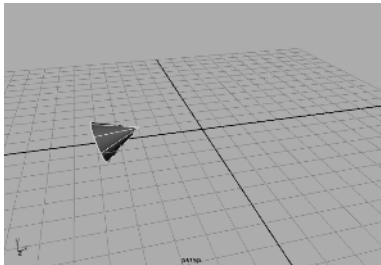
Keyframe at Frame 1
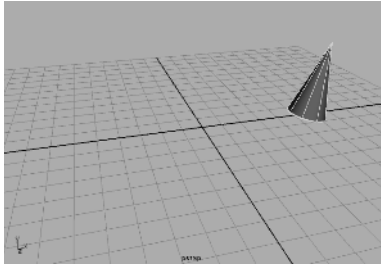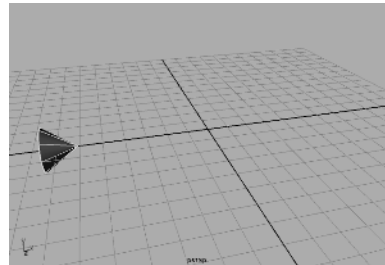
Frame 5

Frame 10

Frame 15

Frame 20

Frame 25

Keyframe at Frame 30

You should create a bit of movement in your character or object *before* it moves. *Anticipation* is a technique in which a character or object winds up before it moves, like a spring that coils inward before it bounces.

Likewise, objects ending an action typically have a *follow-through*. Think about the movement of gymnasts. When they land, they need to bend a bit at the knees and waist to stabilize their landing. In the same way, a cape on a jumping character will continue to move even after the character lands.

The axe tutorial in Chapter 8 will give you a chance to implement these two concepts.

FOR FURTHER REFERENCE

Some of the exercises in this book also have videos created for your use; you can find them at www.sybex.com/go/introducingmaya2016. For more video tutorials and reference on Maya, you can visit www.koosh3d.com.

Summary

In this chapter, you learned the basic process of working in CG, called a *workflow*. In addition, you were introduced to some fundamentals of digital images and animation principles.

Now that you have a foundation in CG and 3D terminology and core concepts, you're ready to tackle the software. Maya is a capable, intricate program. The more you understand how *you* work artistically, the better use you'll make of this exceptional tool. Have fun!