

Basic Concepts

There are several ways to learn a program such as Autodesk 3ds Max 9, or any other computer graphics (CG) package. Ultimately, you'll get the best education through months or even years of working with the software in different capacities. Ask any successful student, and they will tell you one thing: there is no such thing as book smarts when it comes to good CG production—it all comes down to what you can achieve.

Achievement comes only from practice. You can't avoid the many pitfalls of production work without falling into and climbing out of them. Some readers may find this idea frustrating, but it is an intractable truth. The more you work with 3ds Max, the better you will become with it.

Topics in this chapter include:

- **How to Read This Book**
- **What Is CGI?**
- **Production Workflow**
- **Core Concepts for Animation**

How to Read This Book

First and foremost, you needn't read this book cover to cover and front to back to get the most from it. If you are the type who loves to jump right into the pool to learn to swim, then skip all this and jump into Chapter 2, "Your First Max Animation" to start with the interface. If you already know how to get around 3ds Max, you can begin with any of the other chapters. You can leave this chapter for bathroom reading when you're bored or the cable goes out.

If you like dipping your toe in first, then by all means sit back, put on your bifocals, and have a long soak in this chapter. It will cover a lot of basic concepts and core topics that you may or may not be familiar with already. It serves as a gentle ease into the powerful program that is Autodesk 3ds Max 9.

No matter how you choose to read this book, it is crucial that you approach the lessons as a way to *begin* the learning process. This book aims to give you a solid foundation in many aspects of 3ds Max, so that you can take this beginning and move on to more study. In keeping with that ideal, you will need to understand that you will not necessarily become proficient in any one aspect of 3ds Max *just by reading* this book. Instead, you'll gain an understanding of how it works and how you can work with the program to create your animations and models.

Frequently, students are aggravated by tutorials that don't seem to lead them to perfection in the first go-around. This is the case for all tutorials and indeed all books teaching pretty much anything. The key is to use the lessons as a guideline not just once, but repeatedly. Doing a lesson multiple times will help you understand the concepts better and give you opportunities to try out a few different methods, stray a little from the dictated steps, and try your own ideas on for size. Ideally, you will obtain a stronger education, but doing so will perhaps be slower and require more patience from you the student. However, a good education must always be afforded this dedication.

What Is CGI?

CG is an acronym for *computer generated*. You may have heard the term *CGI* (Computer-Generated Imagery). They are indeed one and the same, and the terms refer to any image or images that are created with the aid of a computer. In this day and age, you'd be hard pressed to find anyone with any computer experience who hasn't messed around with computer images, from scanned pictures to digital photos. Learning a CG package such as 3ds Max is just an extension of that simple concept of playing around with a digital photo. The obvious differences are that 3ds Max adds the dimension of depth as well as control over time.

With the preponderance of cheap hardware and much easier-to-get software these days, CG is slowly becoming a more common toolset in the hands of the masses. Within the next decade or so, 3D should become as ubiquitous as *Photoshopping* a photo is today.

The following sections break down the common concepts behind CG.

3d Space

With *3d space*, the virtual canvas in which you create 3d objects, you have a simulation of space that is divided into three axes, *X*, *Y*, and *Z* representing (in loose terms) left-right, up-down, and in-out. Figure 1.1 shows 3d space in a Max window.

So what the heck do you with 3d space? In many ways, setting up a scene in CG is like setting up a photo shoot. With a photo shoot, you begin by gathering your subjects and posing them in your composition. You set up lights to illuminate however dramatically you need them to look and then take snapshots with your camera, framing the composition as needed. You then develop and fine tune your photos or adjust them with tools such as Photoshop before you print them. Finally comes the happy part of showing them off and sharing your work with others.

CG production has much the same workflow, although with CG you create everything from scratch (for the most part) in your 3d space. Instead of running out and hunting down the perfect models off the street and all the props and settings you need for a photo, you create them. You model everything in the beginning and then apply colors and texture to the surfaces you just created. Once you lay out your scene with all the settings and props you need, you set up your CG lights to illuminate the models. Lighting is perhaps the most important aspect of CG, as this stage in CG production really makes or breaks a scene.

Once your lighting is ready, you *render* the scene; this is akin to taking the photos and developing them. Knowing what the end result should be will dictate how you decide to render. You can choose several settings for quality and output, for example, so you can show off your scene to your friends—although hanging a QuickTime movie on the fridge is a bit hard to do.

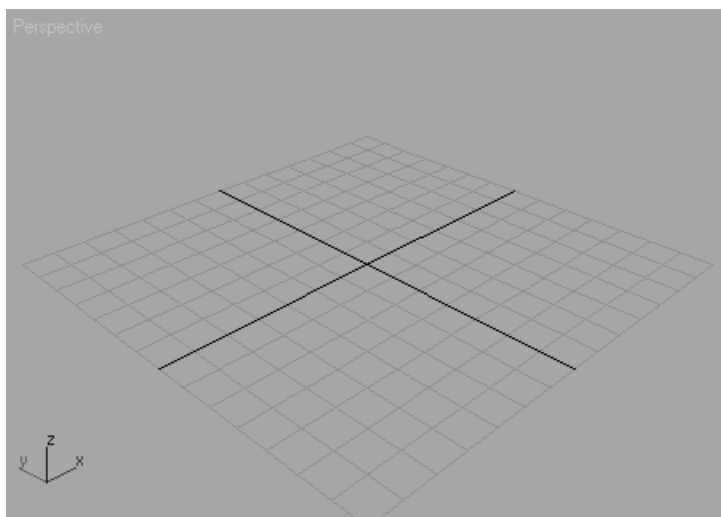


Figure 1.1
3d space never
looked so good!

Of course, with CG you also have control over time; you can animate your scene. This workflow perhaps lends itself best to how films are produced. The next section briefly describes a film production workflow and how it applies to CG production.

Production Workflow

There are three major stages to producing films: preproduction, production, and postproduction. In preproduction, the script is written, storyboards are drawn up to outline the action, costumes and sets are designed and built, the actors are cast and prepared, and a production crew is put together. During the production phase, the scenes are set up and shot according to a production schedule that lays everything out in the most efficient manner possible. Finally, in postproduction, everything else happens. That means the film is printed and edited, a score and soundtrack are laid, any digital effects are added, and scenes are colored to match an overall aesthetic. Upon completion, the film is distributed for people to see.

Although the actual work is vastly different between CG and live action photography, the framework is useful to understand.

Preproduction

Preproduction for a CG workflow requires that the artist or artists gather together all the reference materials, motion tests, layout drawings, model sketches, and such to make the actual CG production as uncomplicated as they can.

Because everything is essentially made from scratch, the CG artist must formulate a strong plan of attack. You can't simply run out with some actors into the park and begin shooting. With CG, you have to make it all from nothing. (You could, of course, use model libraries to help you set up a scene; however, someone still had to create those from scratch.) The time spent in preproduction planning is vital to smooth production and postproduction, and it helps the overall outcome of the project. Never underestimate how much time and planning you should put into a CG project. You will seriously sandbag your project if you don't plan it effectively. This point can never be overstated, and although I'm sure you may get sick of hearing it, it will always be true.

For the exercises in this book, you will work with sketches and other files supplied on the accompanying CD as your preproduction. Additionally, you are more than encouraged to put together as much information as you possibly can about your intended project, no matter how short it may seem.

A poorly planned production will always fall short of its potential and give you many headaches throughout your project.

Writing a Script

Whether a CG project has a ton of dialogue or doesn't have a single spoken word, both the project and you will benefit from having a script. Even abstract animations can benefit from

a highly detailed explanation of timings and colors laid out in a script, whether highly polished or scribbled on a roll of toilet paper in the back of a jail cell.

A script serves as your *intent*. Without having a clear intention stated in your production that defines what you wish to say with your film, your production time may as well be spent lying around with an ice tea in your hand; you will not get much done in either case.

Storyboards

A storyboard is an advanced definition of the script. It shows the timings and framing for the camera, as well as the action and dialogue—if any. To create an effective storyboard, you must first dissect your script into scenes, and then scenes into shots, with each shot being a distinct view from the camera or a distinct cut of action. A storyboard panel describes, shot-by-shot, what is happening in the script in a linear fashion to show you the overall action of the project and how it should come together in editing.

Even simple boards scribbled on napkins with stick figures are important to have in preproduction.

Concept Art

Conceptuals are the design elements that are needed for the CG production. If you don't have concept art, whether they're your own drawings or a smattering of photos or images grabbed from the Internet, you are seriously hosed. You must have an idea of how you want your CG to look; otherwise, you are just flapping your gums and not saying anything.

If you have CG characters, create *character sheets* for each character where characters are drawn into character sheets in three different neutral poses from the front, from the side, and from an angle called a 3/4 view. You can even sculpt reference characters in clay or Play-Doh if you need to have a better idea of how they should look in 3d space. In the following graphic, you can see a character sheet generated for a student produced short at The Art Institute of California at Los Angeles.

Sketch or download images of the props and sets you need in your scene. Essentially, map out the look for everything that you need to have in your scene. When you are working on your project, you won't be limited to the things you've already picked out; however, you will find that knowing how things should look will help enormously in getting you to your final product. The better your concept art and research, the smoother the production and the better your end result will be.



Production

Production is the meat of any project. Film production begins when you start filming your project. In the case of CG, production begins when you start creating assets for your projects, such as models or textures based on well-researched reference materials. The production phase lasts until the rendering phase, where you actualize your scene into image files.

Animation, texturing, and lighting are performed between the modeling and rendering phases. Later in this chapter, the CG production phase will be divided into more stages; however, most of the techniques you'll learn in this book are pretty much in the production phase.

Postproduction

Postproduction begins when your scene elements and animation are all set up and raring to be completed. Postproduction for a CG project is very similar to postproduction for a film. When you click the Render button, you'll end up with several image files or movie files that are then edited and essentially put together to make your project. You add sound, correct color, combine elements, and add any finishing touches in postproduction. Here is a quick rundown of the CG postproduction pipeline.

Rendering

All CG scenes need to be rendered to their final image or movie files. Again, this is the process by which the computer calculates how everything in the scene should look and displays it. Rendering places great processing demands on your computer. It usually requires the full attention of your PC, and it can take a lot of time. As you'll learn throughout this book, the decisions you make, such as how much detail you give the objects you create for a scene, can make a big difference in the rest of the process and can affect the rendering speed.

You can render one scene while another scene is in production, but working on a system that is rendering is not advisable unless you're using a dual-processor machine with plenty of memory. When everything is rendered properly, the final images are sorted and the CG project assembly begins. Rendering is the subject of Chapter 11, "3ds Max Rendering." Compositing, editing, and adding sound are advanced postproduction activities and beyond the scope of this book. However, you will find a multitude of books on these topics for further study.

Compositing

CG is often rendered in different layers where segments need to be put back together. For example, you could have multiple characters interacting in one scene and have each character rendered separately from the others and from the setting. *Compositing* is the process of bringing together rendered elements to form the final scene, usually using compositing software such as Adobe's After Effects or Apple's Shake.

Compositing programs allow you to compose CG elements together, but they also give you additional control over color, timing, and a host of other additions and alterations you can make to a scene. Compositing can greatly affect the look of a CG project; professionals consider it an integral part of CG creation.

Students new to the CG process frequently assume that they need to generate a scene in one fell swoop. CG has an inherent component nature, and you can render items separately and composite them in the finishing stage and still make some changes in your project's show.

Editing

During the editing process, rendered and composited CG footage is collected and edited to fit the script and boards. This process is usually more straightforward for a CG film, as long as the preproduction has output good storyboards to follow when assembling the finished film.

When you are working with live-action, you shoot much more footage than necessary for the film. You do this to make sure you have enough material for all your scenes and to leave extra room for creative editing. If your preproduction was done well, it's just a matter of putting the shots together using an editing program such as Adobe's Premiere or even Apple's Final Cut Pro. With a live action film, you have the added exhaustion of running through all the footage and choosing takes to cut down to the final.

Because CG footage is much more time-consuming to generate than most live action, scenes and shots should be tightly arranged in preproduction boards. The entire production can be edited beforehand in storyboards, so the scenes that are built and animated can match the story, almost down to the frame.

Sound

Sound design can add an entirely new dimension of reality or mood to any CG. The audience needs to associate visuals with audio. Even a basic soundtrack adds a boost to a simple animation by helping provide realism, mood, narrative, and so on. A good music soundtrack and well-placed sound effects are very powerful.

Sounds effects, such as footsteps, can be added to match the action in the animation; this type of sound effect is also known in film as *foley sound*. Just as with any film, adding music to most animations can help with pacing as well as mood. In this case, music and live action sound design are pretty similar. Once you combine everything, you assess the sound needs. The one glaring difference is with dialogue.

When you shoot live action, you generally capture the sound and dialogue live as you shoot. With CG any dialogue needs to be recorded and edited *before* CG production begins. In CG, dialogue becomes a part of the preproduction and postproduction phases. In short, animators need to hear dialogue spoken so they can animate to match the lips of the char-

actors speaking; this is known as *lip-sync*. Recording the dialogue with actors can also help you animate the CG characters; you can imitate the gestures and actions of the live actors to help make your animation more real.

CG Workflow

Due to how CG comes together, a typical production pipeline or workflow generally works best. You begin by modeling, texturing, animating, lighting, and then rendering. You can texture after you animate, of course; however, for the most part, this workflow works best. What is universally true, however, is that you will go back and forth between these stages several times throughout the process. You may have to change some textures once you see the lighting or change a model according to an unexpected animation need. CG becomes a collaborative effort where the stages of CG production work hand in hand to render your final images. The layout of this book and its exercises follow this overall workflow.

Modeling

Modeling is the topic of Chapters 4 through 6 of this book. Modeling is usually the first step in CG creation, and it can sometimes take the longest time. You probably already know that modeling and modeling tutorials are popular on the Internet, where you will find a generous amount of free and fee-based models. You might be able to find a lot of the props and characters you need for your scene online. Unless you enjoy modeling, take a look through Google and see what's already available.

When you do model, of course, you'll be faced with many choices about how to proceed. Most Max modeling is done using *polygons*; however, the specific tools you use will depend on how you like to work. The process of modeling can be easier when you have a good idea of your whole story via a storyboard and general reference. Identify your project needs as fully as you can first, and you'll be able to fulfill them more easily when you start modeling or gathering models.

With forethought, you will know how detailed your models need to be. If that park bench is shown in a wide shot from far away, there is no need for abundant detail or complicated surfacing. If you create a highly detailed model for that far-away shot, you will have wasted your time and increase your rendering times. In many cases, you can add detail to a model just through its textures.

However, when you have to show a park bench prominently in a close-up, it will need as much detail as possible. In such cases, viewers will see more of the bench and have more of an opportunity to question it. The more you use models in scenes, the better you will develop your eye for knowing how exactly much detail to give a specific model. As you begin with CG, however, it's better to give more attention to detail than needed. The

detailing process will teach you a majority of what you learn of modeling. This in turn will benefit your overall speed and technique. With more experience, you will be able to discern the level of detail you really need.

Here is a quick rundown of some different kinds of modeling.

Character Modeling

Character modeling includes the modeling of any characters in your scene, from humanoids to animals to ordinary objects that are animated to life. Most characters are organic forms, such as animals, humans, aliens, and so on. However, a talking cheese sandwich is just as much a character as the person holding it. A good character modeler always keeps in mind the animation needs of a character when modeling. It's important to know what you need from your shot way ahead of time, so you can model appropriately.

Traditional characters, like people, need to appear seamless once they're modeled. Character animation usually requires the model to deform in some way—bending and warping at certain points such as at the elbows. The pieces that make up the model may tear apart if the character is not built to properly account for deformation and movement.

Similar to the park bench analogy, your character must also be built to the level of detail required by the scene. As a matter of fact, several models for a single character can be built to account for any differences. Using different versions of the same character can help keep the scene efficient and workable. A low-resolution (meaning it uses few polygonal faces) model of a character can easily be placed in wide shots, and a more-detailed higher resolution model can be used in close-ups.

Architectural and Environmental Modeling

3ds Max is a natural in this arena, where architectural and environmental modeling is used to previsualize during building design. This type of modeling includes the generation of backgrounds for sets and environments. For this, you model any buildings or interiors, as well as mountains and other required scenery, such as trees, roads, lamp posts, post office boxes, and so on.

Of course, you should keep in mind the level of detail you need to use. Do not create overly detailed environments when they are far off in the background. The biggest common mistake that new CG professionals make is over-creating detail. Doing this adds more geometry to a scene, creates inefficiency, and can crash a scene. The more geometry that is used in a scene, the slower the computer will run and the more time the scene will need to render.

You can create a good deal of the environment using clever textures on simple geometry. Detailed maps on bare surfaces are used frequently for game environments. The rule of thumb for all kinds of CG is “use whatever works.”

Because your computer stores everything in a scene as vector math, the term *geometry* refers to all the surfaces and models in a scene.

Props Modeling

A *prop* is any object in a scene that is actively used by a character in his or her action. Any objects not used by the characters as props are called *scenics*, as they are often used to add realism to the set. Think about it. If your scene takes place in front of a desk, that desk will need scenics such as pens, notebooks, papers, etc. to make it look more realistic. Just showing an empty desk may not be enough to make the scene believable. You usually can find the props and scenics you need on the Internet, frequently in a format for 3ds Max.

Props, on the other hand, are useful in the narrative of the story. They help the characters' actions. A prop can be anything from a baseball bat that a character is swinging to a purse that another character is carrying.

Texturing

Texturing is typically applied immediately after modeling. Once you create a model, you'll want to finish its look. You can apply materials to its surface(s) to make it look right, whether it is supposed to look "real" or not. The process of texturing essentially applies colors and tactile feeling to models. 3ds Max automatically assigns simple colored materials to objects as you create them.

Of course, once you create materials for your scene, they may look different when you light and animate everything. You don't need to finalize every texture, as you'll be coming back and making adjustments all the time.

You'll learn more about texturing in Chapter 7, "Materials and Mapping."

Animation

Animation puts your scene into action and adds life to your characters. In essence, *animation is change over time*. Anything in a scene that needs to change from one second to another will need to be animated to do so.

Everyone, in their own way, has a reflexive sense of how things move. This knowledge is gleaned through years of perception and observation. Because of this, your audience can be more critical of a CG scene's motion than lighting or coloring or anything else. You know when something doesn't look right, and so will your audience.

Animation takes quite a lot of setup, sometimes beyond just modeling. For a character, you will need to create a *rig* (such as a Character Studio Bipod) to attach to the model and then create controls to make animation easier to operate.

It's naturally very thrilling to see your hard work on a scene come to life with animation. On the flip side, it can also be extremely aggravating seeing your creation working improperly. This is how you learn things, and your frustrations will ease over time.

Chapter 8, “Animation Part I: Introduction to Animation,” and Chapter 9 “Animation Part II: Character Studio and IK,” cover animation techniques in 3ds Max.

Lighting

Lighting is often seen as the most important aspect of CG production. This area is where you get to see your models and textures, as well as set the mood of the project. During the lighting phase, you set up virtual lights in 3d space to illuminate the objects in your scene when it comes time to render. Lighting can drastically change how your scene looks. Using lighting wisely is a learned skill, and it takes tons of time to master. Not only are you dealing with the aesthetics of getting your shot to look great, but you are also dealing with rendering issues and bottlenecks that could make rendering your shot a nightmare. These issues come up with much larger scenes than what you will be using in the first years of your CG education; however, it's important to start learning how to use lighting efficiently as well as aesthetically.

Lighting can really make or break all your hard work. You can use lighting to affect the believability of your models and textures as well as to create the proper mood and tone.

In this stage of the pipeline, the lighting workflow begins in part when you are texturing your objects. You will need to very generally light your scene to evaluate how your textures are progressing. However, the final lighting and look really happen after everything else is done, and you are left to go back and forth with the render to check and recheck, fix and refix issues that come up in the rendered images. You may even find, for example, that a model you've built needs to be altered because a lighting scheme works for everything but that model. Therefore, a back and forth workflow with lighting does not just apply to texturing.

As a matter of fact, the more experience you gain with lighting, the more you will start to notice that lighting affects every stage of CG creation. Once you start mastering the subtleties of lighting and after years of modeling, you may change how you model to accommodate how you now light. Even your animation and texturing preferences may take a back seat to how a scene needs to be lighted.

In short, *CG is fundamentally all about light*. Manipulating how light is created and reflected is what you're doing with CG. Without light, we would not see anything, so it makes sense that simulating light is the most influential step in CG.

Luckily, in 3ds Max, lighting is set up to mimic the behavior of real lights used in live action (at least in principle), making the lighting process easier to use. You will learn how to light in 3ds Max in Chapter 10, “3ds Max Lighting.”

Rendering

You've modeled it all, textured it, and lit your scene like a pro. Hundreds of hours and several cases of Red Bull later, you are ready to render. *Rendering* is the stage where your computer makes all the computations necessary to create images from your 3d objects. Depending on how much stuff is in your scene, rendering may be super quick or dog slow. The amount of geometry you used to model (the amount of polygons), the number and types of lights, the size of texture images, and the effects in your scene all affect render times. When time or resources are limited, you need to build your scene intelligently so that you don't spend hours rendering a single frame. The more efficient your scene is, the faster the rendering will go.

Having said that, there is really no magic formula to figure out how long is too long for a render. Some scenes require a magnificent amount of time to render, for whatever reason, and you are stuck with that—but most do not. Through time you'll be able to ascertain for yourself how long is too long for your renders.

A good gauge for render times is to identify what computers you have to render with and how much time you have before a project has to be completed. With a little simple math, you can determine an acceptable render time for your scenes and adjust your quality and output settings, as well as your lighting setup, to fit within your constraints.

The general rule in production is: you're always out of time. Therefore, the most efficient pipeline will be your savior, because eventually your producer or boss will tire of hearing, "But I'm still rendering...."

For now, go ahead and use as much geometry and lighting as you think is necessary. With more experience, you'll start pruning your scenes and getting more efficient renders. Right now, knowing *how* a scene is put together is more important than knowing how efficient it needs to be.

CG Specialties

As in most professions, CG professionals specialize in specific areas. Those areas coincide with the stages of CG production preciously outlined.

Modelers create models for shows or projects. They need to have a keen eye for detail, as well as a sense of how objects come together. Environment modelers create settings, and character modelers specialize in creating organic surfaces for characters, such as people. In all cases, professional modelers need to understand form and function and be experienced in lighting, rendering, and texturing to effectively model professionally.

Animators are artists who work directly with the animation of a project. Character animators specialize in character movement, ranging from mimicking human movement to outlandish cartoon animation. There are also animators who specialize in mechanical objects. Frequently, good animators can span the divide between character animation and other types of animation because they inherently understand motion and timing.

In some cases, great animators are also great *riggers*. Studios sometimes hire character TDs (technical directors) who specialize in rigging characters for motion. This usually includes creating skeleton structures, such as Biped or Bones, for the character as well as skinning the model to such a system before handing it off to the animator(s). Character TDs can also work with motion-capture systems to transfer motion to a character. They use recorded data from a live action stage where actors are outfitted in special equipment that records their movements.

Effects TDs are specialists who generally animate special effects such as tornadoes, clouds, or explosions. These specialists generally rely on particles and dynamics, as well as textures, lights, and rendering tricks to perform their effects. This specialty requires a strong eye in all stages of CG production and a strong ability to troubleshoot and come up with solutions that are frequently not standard techniques in a program such as 3ds Max.

Lighters are used to light and render a scene once it is completed. Lighters specialize in being able to *final* a shot; in other words, to complete a shot for final approval and output. A good lighter needs to understand how models and textures behave in a scene and sometimes must remodel or retexture an object to make it work. More and more these days, good lighters are also being asked to be good compositors, because so much of CG can be broken into elements that later need to be put back together.

Compositing as a specialty requires much less knowledge of CG, although today's competitive compositors should know as much as they can cram in their brains about CG. Compositors not only have to assemble and *color time* (make final color decisions) CG shots, but they also have to work with live action footage that needs to be altered or affected. For example, a compositor will need to remove a green screen from behind an actor and effectively place that actor into a virtual rendered set. With color correction and other tools at their disposal, the compositors must make sure everything looks like it belongs in the shot. In many cases, the line between lighter and compositor is blurred, and the two specialties become one.

Generalists are CG artists who can do everything. This is not to say they are the be-all and end-all of all things CG. Many studios and boutiques have short term jobs that are small in scale (as compared to a production of the DreamWorks film *Madagascar*, for example). When a short turnaround is required, you need artists who can take a shot from beginning to end—to model, texture, light, animate, and render a scene. Commercials, for example, use generalists more than films.

Core Concepts

CG touches many disciplines, and you will come across many different concepts as you learn CG. There are issues to understand in physics, computer output, film, photography, sculpting, painting, and so on. This section introduces several key concepts that will make it easier for you to understand how CG is created. Again, if you've been around the block a few times, you can skip large parts of this chapter. However, you never know when you might come across a little tidbit that fills in an educational gap you never thought you had.

Computer Graphics Basics

Here are some general terminologies and methodologies used in computer graphics to help you understand how 3ds Max works. First on our plate is the critical distinction between *raster* (bitmap) and *vector* graphics and how this distinction affects you as a 3ds Max user.

Raster Images

Raster images (also known as bitmap images or bitmaps) make up the world of computer images today. Colored pixels are arranged to display a raster image on a screen; these pixels come together to form the image like a tapestry. The same is true of printouts, where dots of ink serve as pixels to form the printed image.

When you work in a program such as Photoshop, you are editing the pixels of an image directly by adjusting existing settings such as color, size, and position for all or part of an image. In this manner, you can bring a scanned photo or a digital picture of your house into Photoshop and paint one wall red, just to see how it would look before you shell out bucks for paint at the store.

Essentially, a raster or bitmap image is a mosaic of pixels, each pixel corresponding to a mosaic tile. The *resolution*—fineness of detail—of an image is defined by the number of pixels per inch (or other unit of measure) in the horizontal and vertical directions. Because raster images are based on a fixed grid, these images do not scale larger very well. The closer you zoom into a raster image (or the larger a raster image is scaled), the larger the pixels seem, which makes the zoomed or enlarged image blocky, or *pixilated*. To use larger raster images, you need to start with a higher resolution when the image is created. The higher the resolution, the larger the file size. Figure 1.2 shows what happens when you blow up a raster image.

So why are raster images even used if you can't scale them well? Most common displays and output methods such as television or computer screens, or even a printer, are actually raster displays. The term *raster* originally referred to the display area of a television or computer monitor. To form an image, the electronics in these devices essentially paint it as a grid of red, green, and blue pixels on a glowing screen. Every image generated by a computer, therefore, must either begin as a raster image or be *rasterized* as part of rendering for display.

Figure 1.2

A raster image does not scale up very well. Here is the front of a stereo receiver that is blown up by several hundred percent. The pixels look blocky.



Vector Images

So why does the interface for 3ds Max look so different from Photoshop's interface? Where is the original image to alter in 3ds Max? Autodesk 3ds Max and other 3d programs work with vectors. Vectors are created using mathematical algorithms and geometric functions. A vector program defines its images using coordinates and geometric formulas to plot points that define *areas*, *volumes*, and *shapes* instead of defining the color of each and every pixel in a grid of a raster image.

Popular vector-based image applications include Adobe Illustrator and Macromedia Flash, as well as practically all computer-aided design (CAD) programs such as AutoCAD and SolidWorks. These programs let you define shapes and volumes and add color and texture to them through their toolsets.

Vector files store the scene in 3d space using coordinates and equations of points in space and the color values assigned through materials. Therefore, when a vector image is scaled, the image does not suffer from the same blocky limitations as raster images. As you can see in Figure 1.3, vectors can be scaled with no loss of quality; they will never pixelate because they always redraw at the new scale.

Motion in a raster movie, such as a QuickTime movie, is stored in a long sequence of image files that, when played back, show animation or movement. On the other hand, motion in vector programs is stored in the changes in the coordinates of the geometry and in the math that defines the shapes and volumes.

When a Flash cartoon is played on a web page you are visiting, for example, the information for that cartoon is downloaded into your computer in vector form. The data contains the position, size, and shapes of all the elements of the animation. The vector information is then converted into raster images (called *rasterization*) so you can view the final image or animation. Your computer *renders* this information on-the-fly, in real time, into a raster display that you can enjoy on your screen.

This is roughly how things are done with 3d programs such as 3ds Max. You begin your work in Max's 3d space in vectors. When you are ready to render, Max renders the scene contents into raster images or movie files that you can display. You use the tools in



Figure 1.3

A vector image of a girl at its original size (left) and blown up to a few hundred percent (right) shows no loss in quality. The curves are not stepped or pixelated.

3ds Max to simply change the geometric information to change the scene, and then rerender to show the output. Changing a raster image, such as a digital photo, alters that original file (assuming you do not have a backup file) once you save your work because it directly affects the pixels of the image.

Image Output

When you're done with all your CG, you will probably want as many people to see your work as possible. As you well know, you will need to render the scene out to image files or a movie file. These files can be output and saved in many different ways. The kind of file output to use is determined by a combination of disk space, personal preference, project needs, and output requirements.

COLOR DEPTH

An image file stores the color of each pixel as three values, representing red, green, and blue. Image type depends on how much storage is allotted to each pixel (the *color depth*). These are the color depths common to image files in CG production:

Grayscale The image is black and white with varying degrees of gray in-between, typically 256. Grayscale images are good for rendering out black-and-white subjects; no extraneous color information is stored in the image file.

16-Bit Color Display or High Color 5-Bit Image File Each color channel (red, green, blue) gets 5 bits of space to store its value, resulting in an image that can display a maximum of 32,768 colors. Each color channel has a limited range of shades, but still gives a nice color image. You might notice the gradation in the different shades of each color that can result in *color banding* in the image.

8-Bit Image File This format is commonly referred to as 24-bit color display or True Color. 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. This color depth gives the best color quality for an image and is widely used in most animation applications. The human eye cannot see quite as many shades of color as there are in a True Color image. Most of your renders from 3ds Max will probably be as 24-bit color files.

16-Bit Image File Used primarily in film work using such file types as TIFF16, this type of image file holds 16 bits of information for each color channel, resulting in an astounding number of color levels and range. Each file can exceed several megabytes even at low resolutions. These files are primarily used in the professional workplace and are standard for film work because outputting CG to film can require high levels of color and brightness range in the image.

Floating Point/32-Bit Image File Thirty-two-bit floating-point images are commonly used in film production to give the utmost attention to color depth. Your PC is capable of rendering a huge range in tone and color, and 32-bit floating-point images capture that range

effectively. These files (such as EXR) are not easy to work with and require a lot of tweaking in compositing to output properly. HDR (High Dynamic Range) images are in 32-bit float format and are incredibly detailed in the range of contrast they store. You should not worry about high dynamic ranges such as this until you have gained a considerable amount of experience.

COLOR CHANNELS

As mentioned, each image file holds the color information in channels. All color images have a red, green, and blue color channel. Each channel is a measurement of the amount of red, green, or blue in areas of the image. A fourth channel, called the *alpha* channel, is used as a transparency channel. This channel, also known as the matte channel, defines which portions of the image are transparent or opaque. Not all image files have alpha channels.

FILE FORMATS

In addition to image types, several image file formats are available today. The most common perhaps is JPEG (Joint Photographic Experts Group), which is widely used on the Internet.

The main difference between file formats is how the image is stored. Some formats compress the file to reduce file size. However, the greater the compression, the poorer the image's color.

The popular formats to render into from 3ds Max are TIFF (Tagged Image File Format) and Targa (TGA). These file formats maintain a good 24-bit color depth using an 8-bit image file, are either uncompressed or hardly compressed (*lossless* compression), and are frequently used for broadcast or film work. These formats also have an alpha channel, giving you better control when you later composite images together.

To see an animation rendered in a file sequence of TIFFs, for example, you will need to play them back using a frame player, such as 3ds Max's RAM Player, or compile them into a movie file, such as a QuickTime file.

Your final image output format will depend on the project's needs. If, for example, you need to composite your CG together, you will need to output a format that can be used in your compositing or editing program. TIFF files are perhaps the best format to use as they are widely compatible, store uncompressed color, and have an alpha channel.

MOVIE FILES

Animations can also be output 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. Like image files, movie files can be compressed to keep their sizes to a minimum, but they suffer from quality loss as well.

3ds Max can render directly to an AVI or QuickTime movie file. This may seem like it saves you the hassle rendering out large sequences of TIFF files or such. In reality, you shouldn't render directly to a movie file at least for your final output. It is best to render a

sequence of files in the end, because image sequences can easily be compiled into a movie file later using a program such as Autodesk Combustion, Adobe After Effects, Premiere, or even QuickTime Pro.

Rendering to images is less risky than rendering to a movie. In addition to having a sequence you can easily manipulate, you do not have to worry about crashing and losing rendering time. Sometimes, your render will crash or your machine will freeze. If you are rendering to a movie file when that happens, you'll need to restart rendering from the beginning, because you can't append to a half-rendered QuickTime. With a file sequence render, you can simply pick up the render from the last good frame, when your PC crashed.

With a sequence, you also have the option of reordering the frames or easily adjusting a few individual frames' properties, such as hue or saturation, without affecting the entire movie file.

Color

Color is how we perceive the differences in the frequency of light. The wide range of colors that we see (the visible spectrum) result when any of three *primary colors* of light—red, green, and blue—are “mixed” together. Color can be mixed in two ways, subtractive and additive. These color definitions are most often displayed in *color wheels*, which place primary colors equally spaced around a ring and place the resultant colors when the primaries are mixed in-between the appropriate primaries.

Understanding how color works will help you gain more from your CG's color scheme and help you design your shots with greater flexibility and better outcomes.

SUBTRACTIVE AND ADDITIVE COLOR

Subtractive color mixing is used when an image will be seen with an external light source. It's based on the way reflected light creates color. Light rays bounce off colored surfaces and are tinted by the different pigments on the surface. These pigments absorb and reflect only certain frequencies of the light hitting them, in essence *subtracting* certain colors from the light before it gets to your eyes. Pile up enough different colors of paint and you'll get black; all the color is absorbed by the pigment and only black is reflected.

With subtractive color mixing for painting, the traditional color wheel's primary colors are *red*, *blue*, and *yellow*. These three pigments can be mixed together to form any other color pigment. This is the basis for the color wheel most people are exposed to in art education. However, in the world of print production, a CMYK (Cyan, Magenta, Yellow, and black) color wheel is used, which places cyan, yellow, and magenta ink colors as the primary colors used to mix all the other ink colors for print work.

Projected light, however, is mixed as *additive color*. Each light's frequency adds upon another's to form color. The additive primary colors are *red*, *green*, and *blue*. These three colors, when mixed in certain ratios, form the entire range of color. When all are equally mixed together, they form a white light.

A computer monitor uses only additive color, mixing each color with amounts of red, green, and blue (RGB). Output for print is converted to a CMYK color model.

Warm colors are those in the magenta to red to yellow range, and *cool colors* are those in the green to cyan to blue range of the additive color wheel. Warm colors seem to advance from the frame, and cool colors seem to recede into the frame.

HOW A COMPUTER DEFINES COLOR

Computers represent all information, including color, as sets of numeric values made up of binary 0s and 1s (bits). In a 24-bit depth RGB color image, each pixel is represented by three 8-bit values corresponding to the red, green, and blue “channels” of the image. An 8-bit binary number can range from 0 to 255; therefore, you have 256 possible levels for each primary color. With three channels, you have $256 \times 256 \times 256$ (16.7 million) possible combinations of each primary color mixed to form the final color.

Color value can also be set on the hue, saturation, and value (HSV) channels of a color. Again, each channel holds a value from 0 to 255 (in a 24-bit image) that defines the final color. The hue value defines the actual tint (from red to green to violet) of the color. The saturation defines *how much* of that tint is present in the color. The higher the saturation value, the deeper the color. Finally, value defines the brightness of the color, from black to white. The higher the value, the brighter the color.

HSV and RGB give you different methods to control color, allowing you to use the method you prefer. All the colors available in 3ds Max, from textures to lights, are defined as either RGB or HSV values for the best flexibility. You can switch from HSV to RGB definition in 3ds Max at any time.

CMYK COLOR SPACE

A CMYK color wheel is used for print work, and this is referred to as the four-color process. Color inkjet printers produce color printouts by mixing the appropriate levels of these inks onto the paper.

All output from a computer, which is RGB based, to a printer goes through a CMYK conversion as it's printed. For professional print work, specially calibrated monitors are used to better preview the CMYK color of an RGB image before it is printed. Fortunately, only the print professionals need to worry about this conversion process because most of it is handled by graphics software to a fairly accurate degree.

VIEWING COLOR

The broadcast standard for North America is called NTSC, as listed in the next section. Jokingly, industry folks sometimes refer to the acronym as Never The Same Color, calling attention to the fact that the color you see on one TV screen will inevitably differ on another TV. The same is true for computer monitors, especially flat panel displays. Unless made to do so, different screens are not calibrated to show the same color the same way, so what you see on one screen will display differently on another screen. If it is paramount that the color appear as you see it on a specific screen, it makes sense to finalize the work and show

it on that screen. You can also download color bars from the Internet to display on monitors in an attempt to calibrate them to your eye. This is not the best way to go, but at least it will help a little, without exacting the costs and trouble of using color calibration equipment.

Resolution, Aspect Ratio, Frame Rate

Resolution denotes the size of an image in the number of horizontal and vertical pixels, usually given as $\# \times \#$, such as 640×480 . The higher the resolution, the finer the image detail.

You will adjust your final render size to suit the final medium for which you are creating the animation. The following are some standard resolutions:

VGA (Video Graphics Array)	640 × 480	Formerly, the standard computing resolution and still a popular television resolution for tape output.
NTSC D1 (National Television System Committee)	720 × 486	The standard resolution for broadcast television in North America.
NTSC DV	720 × 480	Close to the NTSC D1 resolution, this is the typical resolution of digital video cameras.
PAL (Phase Alternation Line)	720 × 586	The standard broadcast resolution for most European countries.
HDTV (High Definition TV)	1920 × 1080	The emerging television standard, sometimes also referred to as 1080i.
1K Academy (1K refers to 1000 pixels across)	1024 × 768	Typically, the lowest allowable resolution for film production at Academy ratio. Because film is an optical format (whereas TV is a raster format), there is no real set defined resolution for film. Suffice it to say, the higher the better.
2K Academy (2K refers to 2000 pixels across)	2048 × 1556	Most studios output CG for film at this resolution, which gives the best size-to-performance ratio.
4K Academy (4K is 4000 pixels across)	4094 × 3072	A high resolution for film, used for highly detailed shots.

Any discussion of resolution must include the matter of *aspect ratio*. Aspect ratio is the ratio of the screen's *width* to its *height*, and of course, there are standards:

Academy Standard	1.33:1 or 4:3	The most common aspect ratio. The width is 1.33 times the length of the height. This is the NTSC (National Television Standards Committee) television aspect ratio as well as the aspect ratio of 16mm films and some 35mm films, especially classics such as <i>Gone with the Wind</i> .
Widescreen (aka, Academy Flat)	1.85:1 or 16:9	The most often used 35mm film aspect today. When it's displayed on a television, horizontal black bars appear above and below the picture so that the edges are not cropped off (letterbox).
Anamorphic Ratio	2.35:1	Using a lens (called an anamorphic lens), the image captured to 35mm film is squeezed. When played back with a projector with an anamorphic lens, the image is projected with a width at 2.35 times its height. On a standard TV, the letterboxing would be more severe to avoid cropping the sides.

The number of frames that are played back per second determines the *frame rate* of an animation. This is denoted as *fps*, or frames per second. The following shows the three standard frame rates for media:

- NTSC: 30fps
- PAL: 25fps
- Film: 24fps

Knowing what your final output medium is going to be before you begin your project is pretty important. It is not crucial by any means, but knowing what the screen will look like (i.e., whether it is going to a small web window or a large television, for example) will help you better compose your scenes. You can always change your frame rate and render resolution at any time, but it is much simpler to begin with that already worked out.

Playing back a 24fps animation at 30fps will yield a slower-moving animation and will either require repeating some frames to fill in the gaps or ending the animation early. 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.

Games, on the other hand, do not typically have a set playback rate for animation. When a scene is created for a game, the assets in the scene are rendered and played back on the user's computer system in real time; therefore, many factors contribute to the playback speed of scenes created for games.

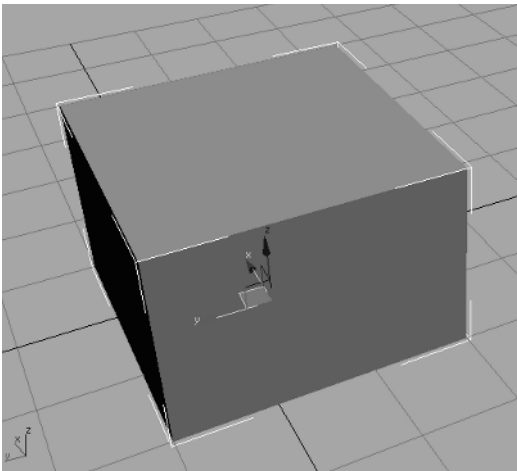
Coordinate Systems

Coordinates are numerical representations of where an object is in 3d space. Every object in 3ds Max has a coordinate of where it exists. Without this coordinate, it would be gone—poof into thin air! Max's 3d space is organized with the Cartesian Coordinate System, which uses a three-pronged axis to define width, height, and depth as *X*, *Y*, and *Z*, respectively.

The overall coordinate system in Max is called the World Coordinate System. It is an absolute coordinate that is fixed and unchangeable.

Objects in Max can have their own coordinate systems as well. When an object is created, it has its own width, height, and depth, again expressed as *X*, *Y*, and *Z*. Upon creation, the Local Coordinate System (belonging to the created object) and the World Coordinate System are aligned. However, when the object is rotated, its Local Coordinate System rotates with it. Because of this, an object created in a Front viewport (for instance) will have a different Local axis than if it were created in the Top viewport.

Figure 1.4
The Object space of
the box aligns with
the World Space.



In Figure 1.4, you see a box. The X-, Y-, and Z-axes of the box are displayed in the center of the box and align with the axes of the home grid (which shows the World Space axes) displayed in the lower-left corner of the window.

However, when the box in the scene is rotated, instead of tossing out its own axes, Max retains them as Local space. The X-axis of the box does not change. Now the Local axis and the World Space axis are not aligned. This is not a bad thing, this is actually very good. It allows you to manipulate the box based on its original Local axes.

Basic Animation Concepts

A litany of information regarding animation concepts and techniques is available on the Internet. There are tons of books out there that also teach the basics of animation. In this very brief section, you will be exposed to a few important concepts behind animation. These concepts will help you better understand what you're doing in 3ds Max.

Frames, Keyframes, In-Betweens

Animation is based on change over time, so naturally you need a measurement of time. In animation, this is almost always expressed in *frames*. One frame is a single rendered image in an animation, or a single drawing in a traditional animation. Frame also refers to a single unit of time in your animation. The exact length of that time depends on the final frame rate with which the animation will be played back. For example, at film rate (24fps), a single frame will last 1/24 of a second. At NTSC video rate (30fps), that same frame will last 1/30 of a second.

Keyframes (or *keys*) are key frames at which the animator creates a pose for a character (or whatever is being animated). A keyframe in CG terms, is a frame in which a pose, a position, or some other parameter's value has been saved in time. Animation is when the object travels or changes between the keyframes. These frames, as the change is happening between *keys*, are called *in-between* frames. The computer extrapolates what needs to happen to get the object from its state in keyframe 1 to its state in keyframe 2. You will have plenty to keyframe in the coming chapters of this book.

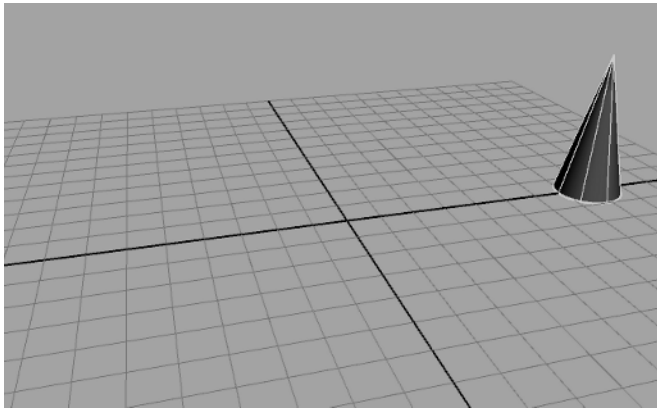
In 3ds Max, a keyframe can be set on almost *any* parameter of an object—its color, position, size, and so on. In reality, you can set several keyframes on any one frame in CG animation. Figure 1.5 illustrates a keyframe sequence.

Weight

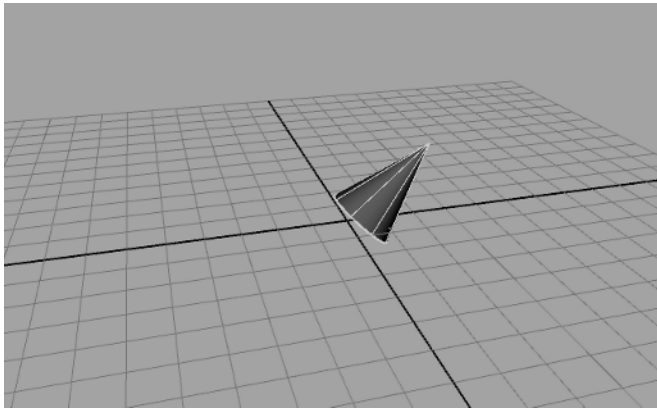
Weight is an implied facet of design and animation. Weight denotes the heaviness or presence of an element in a design. The more weight an element has, the more power it has in the composition. The weight of an object in a composition is affected by its color, the contrast, the background, position in the frame, and so on.

Figure 1.5

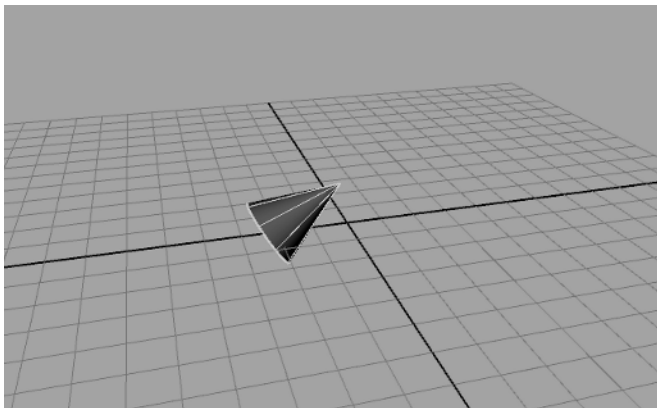
In the first frame of this sequence, a keyframe is set on the position, rotation, and scale of the cone. On frame 30, the same properties are again keyframed. The computer calculates all the movement in-between.



Keyframe at Frame 1

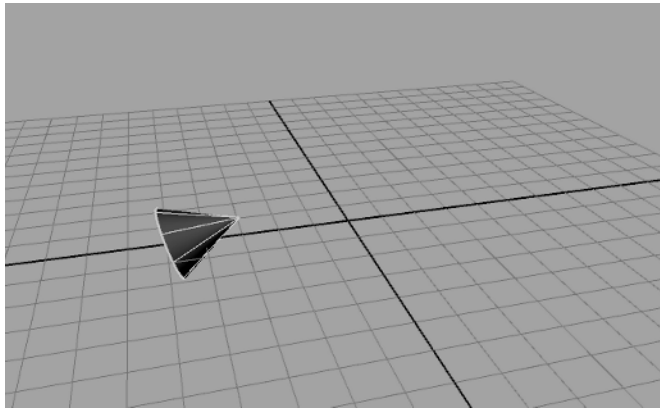


Frame 5

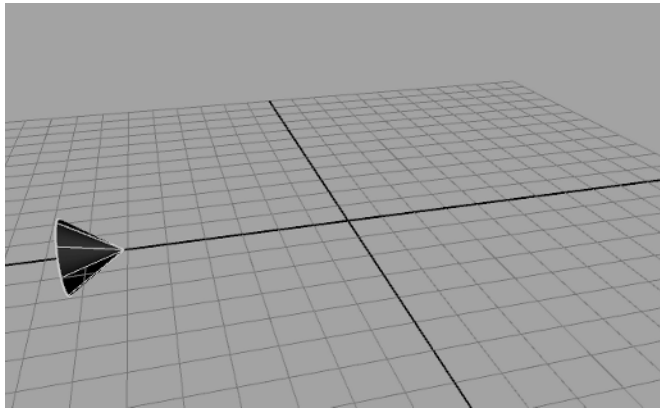


Frame 10

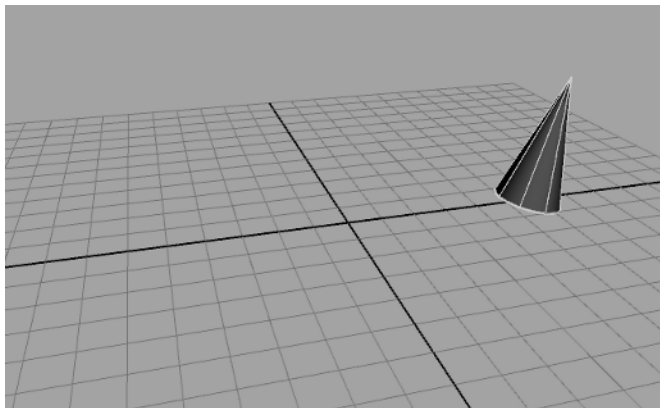
Figure 1.5
continued



Frame 15

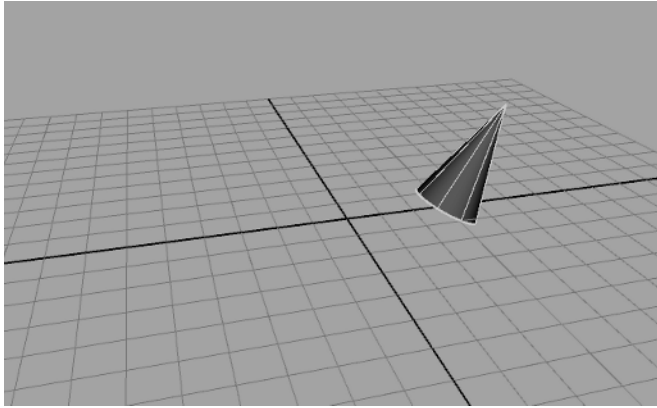


Frame 20



Frame 25

Figure 1.5
continued



Keyframe at Frame 30

The weight of an object in animation roughly follows that idea, but more pragmatically denotes the actual weight of the object as it relates to its environment. Giving an object a good weight in animation is critical in the believability of the animation. You will have a chance to animate an object and edit the animation to give it weight in Chapter 8's Bouncing Ball and Knife exercises.

Weight in animation is a perception of mass. An object's movement and how it reacts in motion and to other objects need to be used to convey the feeling of weight. Otherwise, the animation will look bogus, or as they say, "cartoonish."

Over the years, animators have created a set of techniques they use to offer their subject weight in animation. Manipulating these concepts correctly in your work will greatly help your animations.

Squash and Stretch

Squash and Stretch is a cartoon concept that allows a character to physically squash down when he is landing from a jump, or stretch out thin while he is jumping up. The overall mass of an object should never really change. When you squash an object down, you should also reduce its height to make it seem as if it's squashing down. Similarly, when you stretch an object up, you should also thin it. This technique will make a character seem to respond to gravity. You will see how this applies in the Bouncing Ball exercise in Chapter 8.

Ease-In and Ease-Out

Things in the real world don't immediately come to an abrupt stop. There is always a slowing before a stoppage, no matter how fast the stop may be. This is called ease-out.

Just as objects don't suddenly stop, they don't immediately start moving either. Pretty much everything needs to gain speed, or accelerate, no matter how fast it begins moving. This is called ease-in. You will have a chance to animate a bouncing ball that will teach you the mechanics of ease-in and ease-out in Chapter 8.

Follow-Through and Anticipation

Exaggerating the weight of an object in animation is sometimes necessary. Objects ending an action usually have some type of *follow-through* motion. For example, a pony tail on a girl jumping down from a chair will continue to move about after she lands on the floor and stops moving herself. There is a slight resting follow-through to her action, such as bending slightly at the waist to center herself once she lands.

You can also create a small amount of movement before your action is in full swing. Before committing to an action, a character can wind up even if the wind-up is slight. Doing so will create a slight *anticipation* in the movement, like a hammer cocking back slightly before it strikes down or a spring that coils in before it springs out. These concepts are covered in Chapter 8.

Basic 3ds Max Terms and Concepts

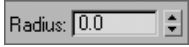
Any 3d program has terms and concepts you need to nail down to become a good artist in that tool. Most of these terms are fairly transcendent in concept, meaning they apply to other packages in theory and general application as well—although you may find some of the names are slightly different. Here are several terms and concepts you will encounter in the world of CG as it relates to 3ds Max.

Object—Simply put, an element in your 3ds Max scene is called an object. An object may be converted to a more easily editable mesh at any time. You will learn about this concept in Chapter 4.

Primitives—Primitives are basic Max objects, such as spheres or boxes. Primitives can be shaped and altered to suit the needs of the model.

Sub-Object—Objects themselves are made up of components such as polygons, faces, vertices, etc. You can select and manipulate sub-objects in 3ds Max to alter the look or function of an object. Kinds of sub-objects include vertices, faces, polygons, edges, gizmos, centers, etc. The type of sub-object you are able to manipulate depends on the type of object you are manipulating. See Chapter 4 for more on sub-objects. Not all objects have sub-object components.

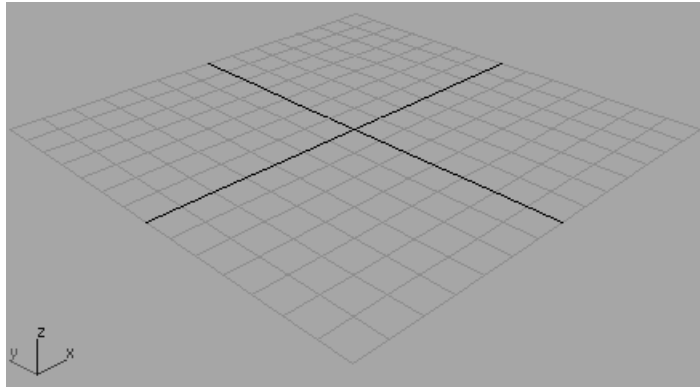
Normals—The face of a polygon has a direction in which it faces. A normal is a vector that defines which way a face points.



Spinners—Spinners are a function of the User Interface (UI) in Max. Spinners are the little arrows to the right of a value readout that allow you to adjust the value by clicking up or down on them. A spinner for a sphere's radius value is shown here.



Flyouts—Another UI term, a flyout is the name given an icon in 3ds Max that is actually several icons in one. If you press and hold a flyout icon, the other icons “fly out” and display themselves. Simply scroll to the icon you need and click to activate it. A flyout icon has a black triangle in its lower-right hand corner as shown here. These icons are further covered in Chapter 3, “The 3ds Max Interface.”



Home Grid—The Home Grid is a gray grid that displays the origin (0,0,0). It is useful for grounding yourself in the viewports, and it helps with proportion and direction as well. A Perspective viewport home grid is shown here.

Absolute/Relative—Absolute refers to an adjustment on an object that is based on a fixed reference, such as world space. An absolute scale of 2 will scale the object to a flat unit of 2. Relative refers to an adjustment made to an object that takes its current state into account. Scaling with a relative value of 2 will make that object twice its current size.

Track—A track is a term in 3ds Max used for an animated object. When an object has animation on several parameters, such as Translation X and Y, as well as Scale in X and Z, it is said to have four tracks. One track defines one animation on one parameter of that object on one axis.

SUGGESTED READING

The more you know about all the arts that are used in CG, the more confident you'll feel among your peers. To get started, check out the following excellent resources.

Art and Design

These books provide valuable insights into the mechanics and art of design. The more you understand design theory, the stronger your art will be.

Bowers, John. *Introduction to Two-Dimensional Design: Understanding Form and Function*. New York: John Wiley & Sons, 1999.

Itten, Johannes. *Design and Form: The Basic Course at the Bauhaus and Later*. New York: John Wiley & Sons, 1975.

Ocvirk, Otto G., and others. *Art Fundamentals: Theory and Practice*. New York: McGraw-Hill, 1997.

Wong, Wucius. *Principles of Form and Design*. New York: John Wiley & Sons, 1993.

CG

CG has an interesting history and is evolving at breakneck speeds. Acquiring a solid knowledge of this history and evolution is as important as keeping up with current trends.

Kerlow, Isaac Victor. *The Art of 3-D: Computer Animation and Imaging*. New York: John Wiley & Sons, 2000.

Dariush Derakhshani. *Introducing Maya 8: 3D for Beginners*. San Francisco: Sybex, 2006.

Kuperberg, Marcia. *Guide to Computer Animation*. Burlington: Focal Press, 2002.

Masson, Terrence. *CG 101: A Computer Graphics Industry Reference*. Indianapolis: New Riders Publishing, 1999.

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Computer Graphics World (free subscription for those who qualify) cgw.pennnet.com

cinefex www.cinefex.com

HDRI3D www.hdri3d.com

3D World www.3dworldmag.com

Websites

www.area.autodesk.com

www.animationartist.com

www.awn.com

www.ighend3d.com

www.3dcafe.com

Film

Block, Bruce. *The Visual Story: Seeing the Structure of Film, TV, and New Media*. Burlington: Focal Press, 2001.

Must Read

Myers, Dale K. *Computer Animation: Expert Advice on Breaking into the Business*. Milford: Oak Cliff Press, 1999.

Summary

In this chapter, you learned the basic concepts that drive the CG field. Starting with production workflow and moving into CG workflow, we discussed how productions are generally run. Then this chapter covered the different types of tasks used in CG production and the specialties that have risen from them in the professional field. Then you learned about core computer concepts, color space, and some output formats. Finally, you moved on to some important 3ds Max terms and concepts in which you will be immersed in the following chapters.

No matter how you take this chapter—or even if you skip it entirely to get right to the action—there is a lot of background information that can be useful in your overall knowledge of CG production. Although it takes some extra time to develop a base foundation, having one is always a good idea because a true understanding of a subject is fundamental to its mastery. Having said this, take the rest of the book as it comes, enjoy the challenges of the exercises, and remember that *some* frustration with an exercise will inevitably help you learn the concepts better, so keep at it.