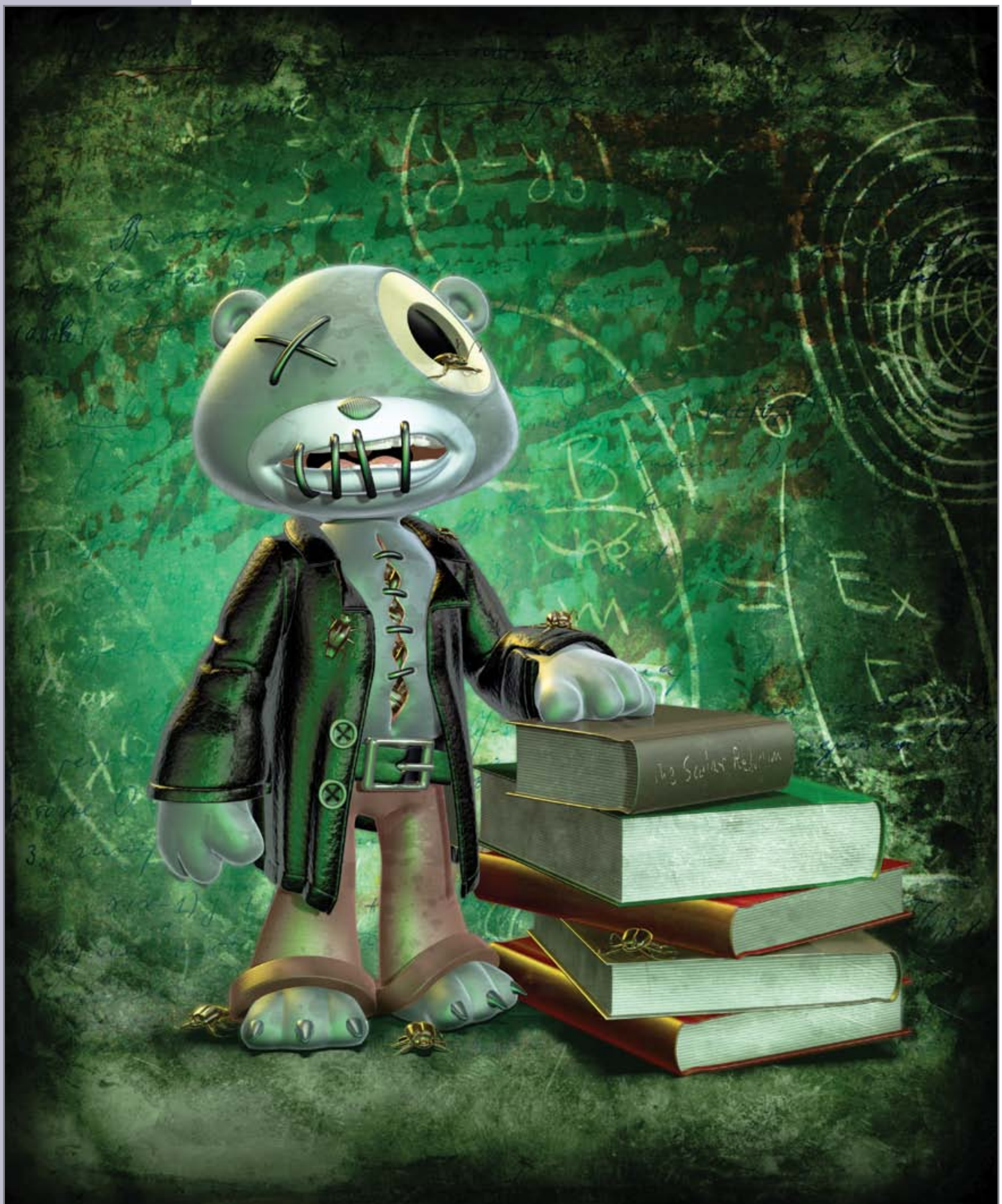
CHAPTER THREE



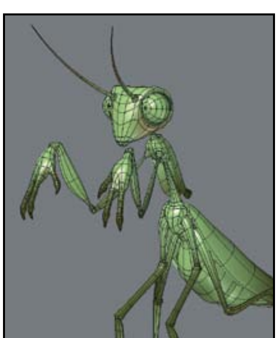
Preparing for Modeling

Throughout my career, I've tried to pass on my knowledge and experience to as many people as are interested. It's my philosophy that no information is too priceless for me to keep locked away for my use only. I love when new artists ask questions, because it gives me the opportunity to share any and all tips and tricks—many of which I wish I had known when I was learning how to model. I am asked questions of all sorts, ranging from networking ("How do I use my artwork to break into the industry?") to the technical ("How do I drop my selection in Photoshop?"). The questions neophytes ask of me all follow a continuous theme, and whether they are aware of it or not, the real question they are asking is: "How do I make my work look like what the pros are doing?"

Every artist who wants to make it in the industry has asked this question. I've done it, my colleagues have done it—heck, the reason you are reading this book is probably because you've also asked it.

My answer to this question (and its various forms) is always the same, and it will completely blow your mind. Here it is:

Use as much reference material as possible and hone your observational skills.



Not exactly what you were expecting, huh? But yes, that is the mind-blowingly simple trade secret of the pros. It's what separates a hobbyist from a professional. Remember that the sooner you come to the realization that there is no magic "Do My Job" button, the sooner you can start down the road of creating professional CG work.

The biggest problem I see for new artists is a lack of reference and observation. It immediately shows up in their work. Not only is it obvious to me, but most importantly, it's obvious to those doing the hiring. To help you avoid this common problem, let's take a closer look at using the tools of a professional digital modeler to prepare for modeling.

Tools of a Digital Modeler

When most modelers think of the term *tool*, it's usually in the literal sense. They think of the many options of the modeling tools in their chosen application—tools like Edge Bevel, Extrude, and Lathe. But the true tools of a professional digital modeler can be broken down into three important tools that are *not* a part of any package:

- Reference
- Observation
- Problem solving

Using and honing these three fundamental tools will allow you to raise the quality of your digital modeling from hobbyist to professional standards. Let's explore these tools in greater detail.

Reference

Good reference material coupled with attention to detail is the key to any successful project. Professional artists use any and all resources they can to attain the level of quality they produce in their work. Using reference is like using a cheat sheet in school—except the teacher doesn't care! *Not* using real-world reference for modeling is like washing your clothes without laundry detergent. It's like Batman fighting crime without his utility belt, or a person mowing the lawn with scissors. You get the idea. To put it simply: *Using reference makes your job easier, period.*

Don't fall victim to your faulty memory. Although eyewitness accounts can aid in the conviction of guilty parties, they can also lead to the conviction of the innocent. Artists that work from their "photographic" memories usually end up with mediocre work at best. You cannot imagine all of the little details that go into making up the simplest of items, such as the screws shown in **Figure 3.1**. Take note of the Phillips head on these screws and the shapes that make up the inset area. Without good reference, there's no way you could make up the fine minutiae, and those details would be overlooked.

One of the first modeling projects I usually start off new modelers with is to work with real-world items, like a standard key. **Figure 3.2** shows a few examples of keys. It's interesting to watch new modelers as they realize just how detailed the shape of a key can be, and that it isn't just a flat, extruded shape. As I stated earlier, their work made it quite obvious to me which students chose to use reference and which ones didn't. I can't say this enough: To make something look real, you need to reference something real.

I used to give my students weekly practical modeling quizzes that required them to create a model in a certain amount of time using the reference material that I supplied. It always amazed me how many students would leave the material unopened and proceed to model without ever using the reference! This would happen even after they listened to me go on and on about the importance of reference material. I don't think I need to describe in detail how inaccurate their models were.

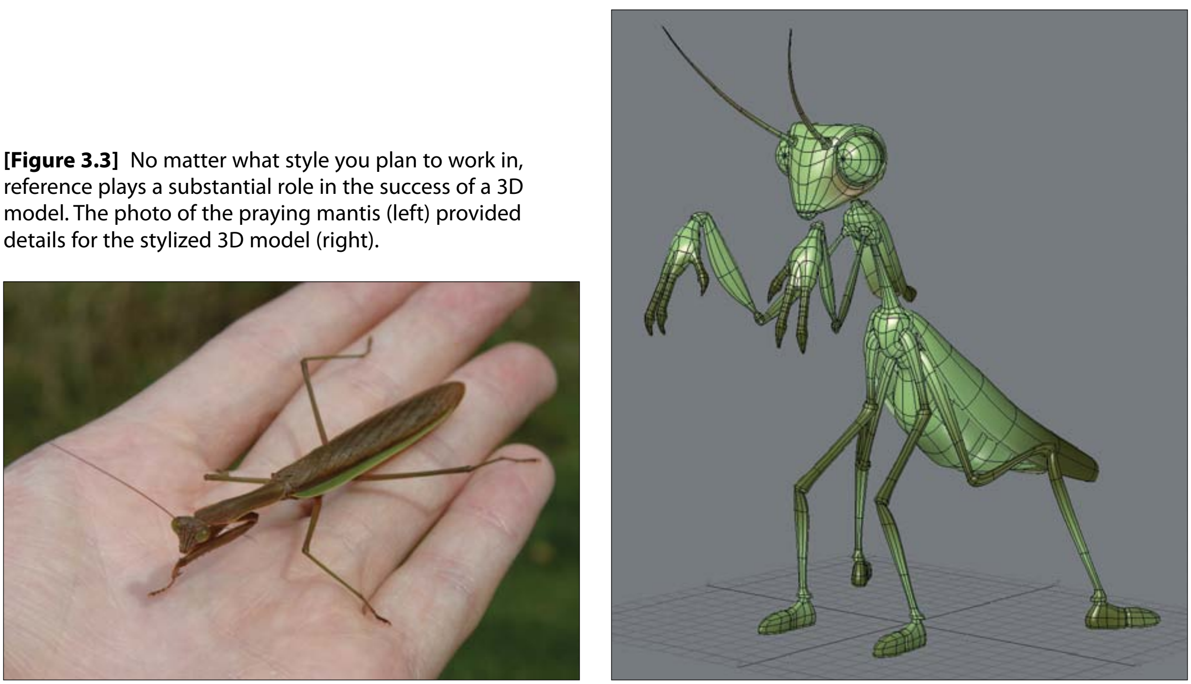
[Figure 3.1] Good reference material provides details that your memory leaves out, like the details in the head of this screw.

[Figure 3.2] This photo shows the intricate details that make up common keys.

It's very important that you constantly reference the material so that you never lose sight of what you are trying to create. Professional artists use reference material for every project they work on. This includes everything from photo-real work to highly stylized work. Even when I'm designing and modeling cartoon-style characters, I always have reference on the screen and at my desk. For example, when I was working on a cartoon version of *Praying Mantis* for Animation Factory, I contacted Chris O'Riley, a friend who has an amazing collection of insect photos he's taken over the years. Fortunately, he had some great images he'd taken of a praying mantis. I displayed them on my reference monitor while I worked on the character to make sure I captured the qualities that make that insect look the way it does. I also added elements to the model that I didn't even know about before studying the photos, and these extra details added to the overall personality of the character.

Figure 3.3 shows the 3D model and one of the photos I worked from. You can check out some of Chris's other photos on his site (www.chris3d.com/photos).

[Figure 3.3] No matter what style you plan to work in, reference plays a substantial role in the success of a 3D model. The photo of the praying mantis (left) provided details for the stylized 3D model (right).



Even when making something abstract or completely from your imagination, it's generally a good idea to base it on real-world objects so that the audience can relate to them easily. Industry veteran and director of *Postcards from the Future*, Alan Chan, once told me to not think of it as creating whole new worlds, but to think of it as repurposing different parts of reality to paint what you see in your mind's eye. When working in a more realistic style, it's important to pay attention to all the small details but not to get caught up in them.

Observation

It's not enough to just have a collection of reference material. You need to increase your observational skills so that you can study and compare what you're working on with the reference you have. Your job is not only to match the reference, but to also figure out what makes the reference look real. Don't just duplicate the object; duplicate what makes it look like the object.

Observation is a continuous process of learning. It should never be skipped. In the case of digital modeling, the model becomes a "problem," and you can use your observational skills to come up with an answer. The reason there are so many inferior digital models in the 3D community is that the artist has solved the problem without ever truly understanding what the problem was. It's like trying to assemble a plastic car model kit without the instructions, not ever knowing what kind of car you are building, what color it should be, or most importantly, why you are building it in the first place! The finished model will only ever be the potential of a great one, doomed to be forever unfinished.

Before you ever launch your favorite 3D software, you need to think about what it is you're going to model and fully understand it. Ask yourself questions about your subject so that you can formulate the problem and devise a solution.

Some questions you might ask include:

- What is the scale of the object?
- What is the object made of (wood, metal, living tissue)?
- What is the surface of the object like (rough, smooth, sticky)?
- Is the object seamless or is it composed of sub-objects?
- Does it have cracks and fissures?

- How does the object's surface interact with light?
- Does it have an organic or hard-edged shape?
- Where do parts meet or overlap?
- Are there hidden recesses?
- What is the volume of the object?
- Has the object been damaged, or is it in pristine condition?
- Is the object symmetrical or asymmetrical?
- What is the mass of the object? Is it that of a balloon or a boulder?
- How does it interact with its environment?
- How would the object behave in gravity?
- Is the object manufactured by man or born in nature?

You can never ask too many questions about your subject, and each subject matter will probably lead to different questions that you'll want to have answers for. To model a character, I'd want to know the character's name, how old it was, where it was from, whether it was an introvert or an extrovert, and whether it prefers Ginger or Mary Ann. Some of those questions may not apply to observing a vehicle, but asking how the vehicle articulates, its mode of mobility, or its fuel source could be important.

Learning to observe your subject matter can transform you into a better digital modeler and is a requirement for professionals.

Problem Solving

Reference and observation are crucial in deciding exactly which tools and techniques to employ during the modeling process. Digital modeling is simply the process of solving visual problems and the art of devising a strategy that you will use to see the model from start through to completion.

Visualization

Want to model quicker and more efficiently? Simply *see* it modeled before it happens. One great technique that I learned when I was a teenager on the school's track team was the power of visualization, which means envisioning the race in your mind (and your success) before performing at the actual event. Professional athletes use visualization to see the basketball going through the hoop, the bat connecting with the baseball, the perfect pass being thrown between defenders, or the soccer ball being kicked out of reach of the goalie's hands without missing the goal.

This may sound like a silly and complete waste of time, but it's not. It simply works and is a powerful problem-solving technique. Another great benefit of visualization is that you can hone your skills throughout your day, even when you're not in front of a computer.

Find a quiet space, preferably away from the computer. Take some time leading up to the modeling session and visualize yourself constructing the mesh. When visualizing, be as specific and detailed as possible. Imagine yourself sitting at your workstation and launching the software. Imagine creating the first element all the way to the last. Spin the model around to take a good look at how true you stayed to your reference. The more specific you can be with the details, the more calm and confident you'll be when you actually start modeling.

Visualization is the process of creating a blueprint of how you go about modeling, and this preplanning will go a long way toward making efficient use of your time.

Another technique for increasing your problem-solving skills is something I call *modeling pilates*. Yes, you read that right—modeling pilates. I've done it for years and continue to do it to this day. All you need to do is look at the environment around you, select any object you see, use your observational skills, and work out how you might construct it in 3D. You may never actually build that object, but the fact that you're giving your brain a mental workout will increase the speed at which you'll be able to develop solutions for modeling challenges. Do this throughout the day when you're commuting to work, waiting in line at lunch, or anytime that you have a free moment.

Practice, practice, practice

Of course, there is the old advice for any art form: practice, practice, practice. It may be cliché, but the simple fact is that it's true. The more modeling experience you have behind you, the more prepared you will be for what's to come.

You now know the secrets of creating stunning digital models. Always remember that the first step of any new production is to gather reference material. Then you need to study the reference and make mental and written observations so that you can develop modeling solutions and apply them to your work.

Gathering Reference Material

Knowing that you need good reference material, the next step is gathering as much of it as possible. You can never have too much. So where do the professionals get their reference material? Let's explore the most common resources.

Physical Reference

The best source for good reference is usually sitting right in front of you. If you're trying to model a realistic lamp, simply grab one from your home or office and take it to your workstation. **Figure 3.4** shows a few of my anatomy figures that I constantly reference when modeling both realistic and stylized characters.

Now I know this one will be hard for some, but you may need to leave your workstation to gather reference material. I can't tell you how many times I've seen artists working on re-creating something in the real world that may be just outside their door, yet they never get up to go look at it firsthand. I've also seen character modelers trying to work out the polygon flow of a character's hip without getting out of their chair and moving their leg or asking someone nearby to get into a particular pose to get an idea of the way that area might deform.

There are a few other tools you can use to aid you in collecting reference, and every digital modeler should have them at their side as often as possible.

[Figure 3.4] Anatomy reference is key to any digital character modeler wanting to produce quality meshes.

Digital Camera

A digital camera will blow away any human's ability to remember details. Digital cameras have come a long way over the years, and the best thing about their evolution is price. You may even have a perfectly good one in your phone.

You don't have to get the latest and greatest camera to get good reference material. I've purchased several cameras over the years and will still use the Canon PowerShot that I bought in 1999 when I leave my newer camera at work. I use my phone's camera when I'm in a pinch. Although I envy some of my friends' high-end cameras, I typically stick with point-and-shoot cameras because I usually just need clear reference images, and I'm not using the camera in the same way a professional photographer would. I do find it interesting that most of the artists I know in the industry have a high-end camera and have taken up photography as a hobby. This can be very valuable when it comes to rendering your work; knowing how a camera works should never be overlooked.

Although a camera can help you obtain a great deal of information to work with, there are a few more tools that I would suggest as well.

Tape Measure

A perhaps surprising must-have tool is a standard tape measure (**Figure 3.5**). The information you can get with one can sometimes be even more useful than the photos you take with your camera. If you want to model something as accurately as possible, you should record its dimensions. A tape measure can't be beat in this regard. You can even include the tape measure in your photos for later reference, as the measurement of the antique chest in **Figure 3.6** shows. Some tape measures are quite small (and even fit on keychains); most usually have a convenient belt clip—so you have no excuse to be without one.

[Figure 3.5] Tape measures are a must-have item for every digital modeler.

[Figure 3.6] Including a tape measure in your reference photos can be a great way to determine the scale of a reference object later.

By including the tape measure in the actual photo, you can use it as a way to measure items in the image by comparing it to the size of the tape measure. I've also used business cards, credit and ID cards or even money for the same reason. If you know that a standard business card is 2 inches tall by 3 ½ inches wide, credit cards and IDs are 2 ⅛ inches by 3 ⅜ inches, a U.S. dollar bill is 2 7⁄12 inches tall by 6 ⅙ inches long (Canadian bills are 6 inches long by 2 ¾ inches tall), or that a one cent coin is ¾ of an inch across, you can easily figure out how large an item is in comparision placed next to it in a photo. **Figure 3.7** shows an automotive carburetor. The business card placed in front of it gives you an idea that this carburetor is about 10.5 inches long. This is a handy trick that has helped me avoid having to go back on location to get measurements after I'm back at the studio.

[Figure 3.7] Placing a business card in a photo is an easy way to determine size later.

Sketchbook

You'll also want to have a sketchbook or notebook and a writing utensil to record as many notes as you can. A smartphone can also give you the ability to take notes (or dictation) without needing to carry a pen and sketchpad (and some apps even allow for full-color sketches). Details to make note of will differ from reference to reference, but get down as much information as you can. Some specifics to make note of may include

- The dimensions you collected with the tape measure
- The number of sides the item has
- The type of material the item is made out of
- Whether the item looks new or old
- The time of day when you took photos of the item

If you don't have a camera, you can do rough sketches to refer back to when you're back in the office. I do this every week on my commutes from Philadelphia to New York. People on the train seem to take issue with you firing off photos of them, but I've never had anyone complain when they've seen me obviously sketching them in my sketchbook. Some of my favorite character designs have been based on sketches from my commute. **Figure 3.8** shows a few quick sketches of some interesting-looking commuters from my morning trips to New York City.

[Figure 3.8]
Rough sketches can make for great reference material when you're unable to get a snapshot with a camera.

Digital Reference

What if you can't get your hands on the item you need to re-create, even to take a picture? The next best resources are reference images that others have made available to everyone. You have a ridiculous amount of resources at your fingertips thanks to the Internet. You can find images of just about anything online if you know where to look. My biggest online resource for reference gathering is Google (www.google.com). Within seconds, you get a large collection of reference images without ever leaving your seat.

Another great tip I picked up from artist Jamie Clarke when I was visiting the crew at Zoic years ago is to use Ebay (www.ebay.com) to collect reference images. Sounds like a strange idea, right? It is actually a brilliant one that has proven to be invaluable. When people try to sell something on Ebay, they usually take loads of large pictures of it from many different angles. I introduced Ebay to my searches a couple years ago, and it has made a massive impact on my ability to gather good reference of any given item.

Printed Reference

You can still gather great reference material at the bookstore, even though they are a dying breed. Libraries can also supply a wealth of material for just about any subject matter. Most of the artists I know have large libraries of books and magazines at their houses or studios. One of my friends—a digital modeler who owns a tattoo shop—has an impressive collection of books that I usually get caught up in when I visit.

My personal collection of books and magazines has become so large that it can be found all over the studio at Applehead Factory. A portion of my collection is shown in **Figure 3.9**. I look for any reason to grow my collection, because I have learned over the years that good reference books come in handy on almost every project, especially my anatomy books.

[Figure 3.9] You can never have too much reference material. Most artists I know have impressive book and magazine collections to pull from.

Movie Reference

Movies are also great sources for reference. With the growing collection of clips on sites like YouTube (www.youtube.com), it's now easier than ever to pull great clips together for reference. It's also extremely important to have a wealth of knowledge of movies in general, because directors and supervisors reference them all the time. Do your homework on this one, especially because all it requires you to do is *watch movies*. Being able to communicate with directors or supervisors is incredibly important to your job, and getting a film reference (particularly a very obscure one) will give you a leg up on the competition, possibly even making you their go-to artist. This seems to be a weak area for many of the new artists coming into the industry. I'm always shocked when I'm talking to someone in this field who has not seen the movies that have helped shape this industry. *Star Wars: The Clone Wars* CG supervisor, Lee Stringer, and I were teaching a class a few years ago, and no one in it knew who the legendary stop-motion animator Ray Harryhausen was. How can you think you can master your craft if you haven't studied how the greatest artists did it?

Copyrighted Material

An extremely important judgment needs to take place when it comes to using reference material and whether it's okay to use copyrighted material as reference for your digital models.

In this case, copyrighted material includes photographers' photos, artists' illustrations and paintings, movies, and animation, as well as someone else's concept or likeness.

Although digital modeling is quite different from traditional art, the same copyright laws apply when working from copyrighted material.

Basically, if you're only using someone else's material as reference, you can simply collect the information you need and apply it to your digital model. On the other hand, if you intend to *essentially re-create* a specific image in 3D, you need permission from the copyright holder of that material.

There is a big difference between using an image for reference and copying the image. Think of it like this: If you show others the reference material and an image of your model and they say the model is clearly based on the reference material, assume it's a derivative use of the other person's work, not just a reference use. Simply put, if your model looks "exactly" like the copyrighted material, you've broken the copyright laws.

Many copyright-free resources are available online that you can pull from if you are questioning whether or not you should use a copyrighted image. 3D.sk (www.3d.sk) has been a favorite of mine for years; it has more than a quarter of a million royalty-free images available for instant download.

Disclaimer: The information given here is based on U.S. copyright law and is given for guidance only; you're advised to consult a copyright lawyer on copyright issues.

References to Avoid

With the wealth of amazing reference materials available to a digital modeler, you should know that there are some you should stay away from beyond the copyrighted material I discuss in the preceding section.

Inadequate reference

Common mistakes modelers make when gathering reference are selecting images that lack detail. Their imagination fills in the missing element, which in turn means they are no longer working from reference but their interpretation of the reference. Which image in **Figure 3.10** gives you a better idea of the details that make up the engine of the boat? Personally, the image with the boat in the water tells me more about the environment than the boat.

Try to find reference material with clear detail and that is easy to explore. Photos taken from newspapers or photocopied pictures are notorious for not having enough detail.

[Figure 3.10] The boat in the image on the left is too far away to gather proper details, whereas the engine details in the image on the right are very clear, making it ideal for reference material.

Having a blurry image is also one of the worst types of references you can use. It distorts the shape of an object and makes it difficult or even impossible to differentiate details. **Figure 3.11** shows an example of how a blurry image makes it difficult to work out specific details on this toy truck.

It may seem obvious, but I've seen many an artist trying to work from thumbnail-size reference images. Just as with blurry or low-detail images, if you can't make out the detail, you're no longer working from reference; instead, you're just working from your interpretation of the reference. **Figure 3.12** is a perfect example of an image you'd want to avoid because it's too small.

[Figure 3.11] Blurry images don't provide enough information and should be avoided when gathering reference material.

[Figure 3.12] Small images don't provide adequate details and should be avoided.

Illustrations

Illustrations created by the visual design department for the project you are working on should be good reference, but you should avoid using art created by others artists as reference for your own work. It's like making a photocopy of a photocopy. Eventually, some attributes will get lost in translation, and you'll be relying on another artist's interpretation of the subject matter.

Figure 3.13 shows a 2D sketch of a horse by Graham Toms. Although it appears to be true to life, it's still his interpretation of reality. You'd be better off working from a photograph of the real deal.

[Figure 3.13] Illustrations aren't ideal reference material unless they were created either by or for you.

If I were going to model a horse, I would probably have ten or more real horse photos open on my secondary monitor instead of someone else's interpretation, no matter how accurate it may appear to be. Also, keep in mind the information covered earlier in the "Copyrighted Material" section.

Digital models

For reasons similar to avoiding illustrations as reference, using another artist's digital model as reference, such as the CG strawberry in **Figure 3.14**, is probably not the best road to travel. First, you have to assume that it's copyrighted material; second, once again you are relying on that artist's interpretation of the subject matter.

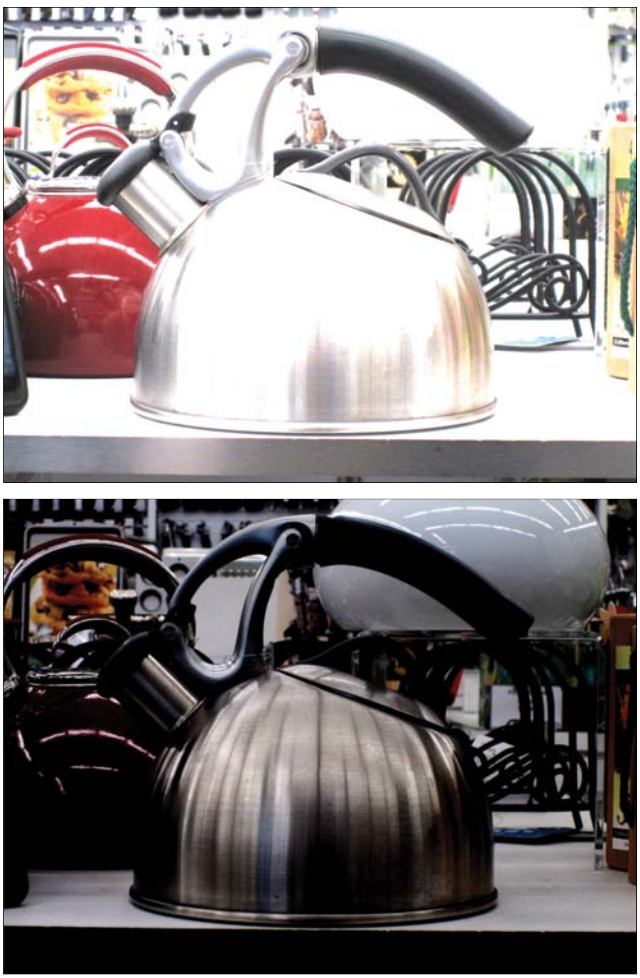
[Figure 3.14] Chris O'Riley created this amazing 3D strawberry model, and although it appears to be accurate, you'd be better off working from a photo.

Photos with extreme lighting conditions

Whether the shadows in an image are hiding details or the lighting is blowing out or clipping the material (losing image detail due to maximum brightness), bad lighting conditions can ruin an otherwise perfect reference image. Look for images that show even lighting. Remember that these images don't need to win awards—your model work does.

Figure 3.15 shows the same teapot photo taken using both ends of the bad lighting spectrum. Both distort the important details that make up the shape of the object. Modeling from either of the images would result in a 3D model that isn't 100 percent accurate.

Note that if you're the one taking the photos, the best time of day to get even lighting outside is just as the sun is coming up and just as it's going down. At those times, the sun isn't high enough to cast those pesky harsh shadows. You avoid strong shadows and get a nice even light over everything, which is exactly what you're looking for in good modeling reference.



[Figure 3.15] The bright teapot has areas that are clipping and blending into the background.

The darker image has areas that blend into the shadows. Both are far from ideal to work from.

Preparing Reference Material

Once you have all of the reference material you feel you need for a modeling project or you've simply run out of time to gather it (which is usually the case for me), you'll want to prepare the content.

If your reference is a physical object, make sure it's in an ideal spot where you will be working. You don't want to have to get up every few minutes to go examine it for details, because it will most likely break your concentration and workflow, which leads to an inefficient use of your time. Most digital artists I know prefer to work in a dark environment, but make sure your physical reference is well lit. Being able to glance over at the reference and back to your model without even turning your head is ideal.

When dealing with images, the following sections suggest some common tasks you may want to perform before you launch your 3D software.

Scan or Transfer

Even though you can place books, magazines, and photographs at your workstation, I've found it to be more efficient to have them onscreen (this is another time when a second monitor comes in handy). That usually means scanned. The higher the resolution at which you scan your reference material the better. As a general rule, 300 dots per inch (dpi) usually does the trick. Good resolution allows you to zoom into areas for closer inspection of details.

If you've captured your reference photos with a digital camera, transfer them to your system. Believe it or not, I've seen artists using their tiny LCD screen on their camera to view their reference while they model! At that point, it doesn't matter which resolution you used to take the picture, because you are viewing it at postage-stamp size. Put it up on a big screen so you can get a good look.

Adjust Color and Levels

Using image manipulation software, such as Photoshop or Paint Shop Pro, you should adjust the images' color balance and levels to optimize their quality. Often, an image that is too dark can be salvaged with a few tweaks to Brightness and Contrast or Levels. Some artists prefer a lower contrast and/or a grayscale image for backdrop images they plan on modeling on top of, because it can be easier to read a model's wireframe when displayed over the images.

Avoid overprocessing (making too many adjustments to) your images while editing them, or they may fall into the references-to-avoid category. It's also a good idea to save any and all changes to a new file so that you can always return to the raw source file when needed.

Rotate, Size, and Crop

If the camera was tilted when you took the photo and the object you are modeling is crooked, it is good practice to rotate the image and level the object to straighten it as much as possible. Although most 3D applications have this option built in, it's usually quicker to handle it before ever opening the 3D program.

Rotating and sizing your images is extremely important when preparing multiple views of the same object. For example, I always prepare the front and side images when modeling a human head from reference, making sure they are the same size and that they line up with each other. **Figure 3.16** shows reference photos that I prepped for a CG model of my friend Sam.

[Figure 3.16] Taking the time to align reference images in the beginning will speed up the modeling process later.

It's usually OK to size down an image, but you want to try to avoid sizing up an image larger than its original size. There is a safe tolerance for sizing up photos without losing too much quality, but it's a fine line—so be careful not to destroy on otherwise perfect reference image. It's usually best to just zoom in and out of the picture without ever having to scale the image permanently.

You can also crop your reference images to display only the required details you need from that particular image, which will not only decrease the file size, but you'll avoid having to zoom in each time you access the image.

Composite

A task that I've done for years that I find very useful is to composite reference images into one large image. Merging these images allows you to quickly load one image onto your second monitor without needing to load several separate images and organize them each time you prepare to model. **Figure 3.17** shows the composite I created for the modeling session of Sam.

[Figure 3.17] Compositing multiple images into one large image is an efficient way to work with multiple references.

Rename and Organize

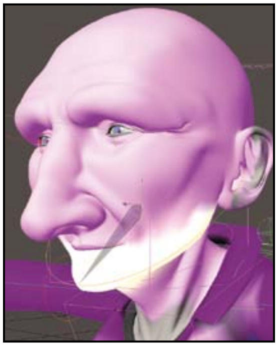
Renaming and organizing are steps most artists skip in their race to start modeling. By default, most digital camera naming conventions are those of a mindless robot. Which name best describes an image: 2079033 or Sammy_Head_Front?

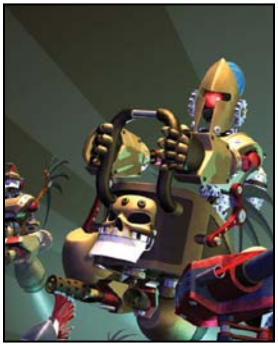
Giving proper naming conventions to your reference material will make them easier to recall at a later time. You should also save them in organized directories. Taking shortcuts with your reference's naming and organization may save you time up front but will always come back to bite you in the digital rear later on.

[CHAPTER FOUR]

Fundamentals of a Digital Model

Before we go too far down the rabbit hole, I want to introduce some of the elements of digital models and the terms you'll encounter throughout the book. If you have some experience already, you may be inclined to skip this section, but I recommend you at least skim through it just to make sure we're on the same page. You can think of this chapter as a refresher course of 3D models 101.





A Model's Anatomy

Digital models can be broken down into three types:

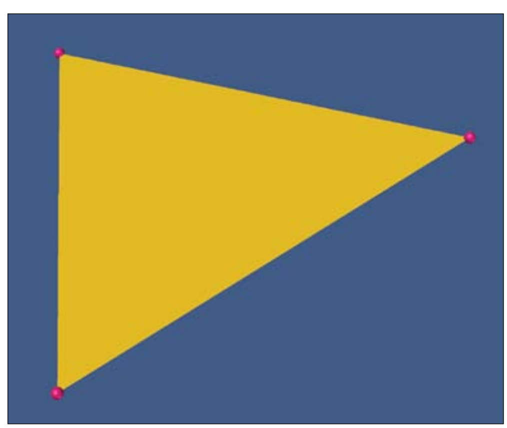
- Polygonal models are made up of a collection of points, edges, and polygons.
- NURBS surfaces consist of a network of curves with smooth surfaces between them.
- Subdivision surfaces are similar to polygonal models because they are made up of points, edges, and polygons but also share some of the benefits of NURBS surfaces, placing them into their own category.

In this section I explain some of the terminology used in the creation of all three types of digital models.

Points

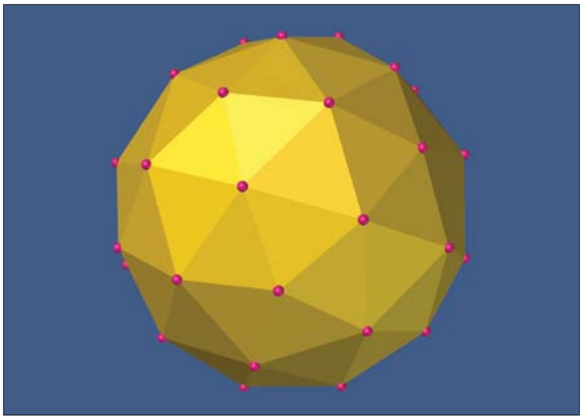
A *point*, also called a *vertex* (plural: vertices), is the lowest-level component that makes up a 3D model. Each point exists in 3D space with a specific X, Y, and Z coordinate. Because points alone do not have height, width, or depth, they cannot be rendered.

When two points are connected, a *line* is drawn. When three points are connected, they can become corners of surfaces on a model called a *polygon*. Without points, there would be no polygons. A triangle, for example, consists of three points and one polygon, as shown in **Figure 4.1**.



[Figure 4.1] The three points (shown here in pink) define the shape of the triangle and its placement in 3D space.

Multiple polygons can share the same points when used on a *contiguous* (seamless) mesh. The tessellated sphere in **Figure 4.2** shows individual points being used to define the multiple polygons that make up the object.



[Figure 4.2] Polygons that share a common edge also share points to define their shape.

Vertex Maps

Every point in an object stores information about its position and rotation, although you normally don't access the rotational values of an individual point. Points also have the ability to store a variety of additional information using vertex maps. Simply put, a *vertex map* is information saved to a point.

The most common types of vertex maps include:

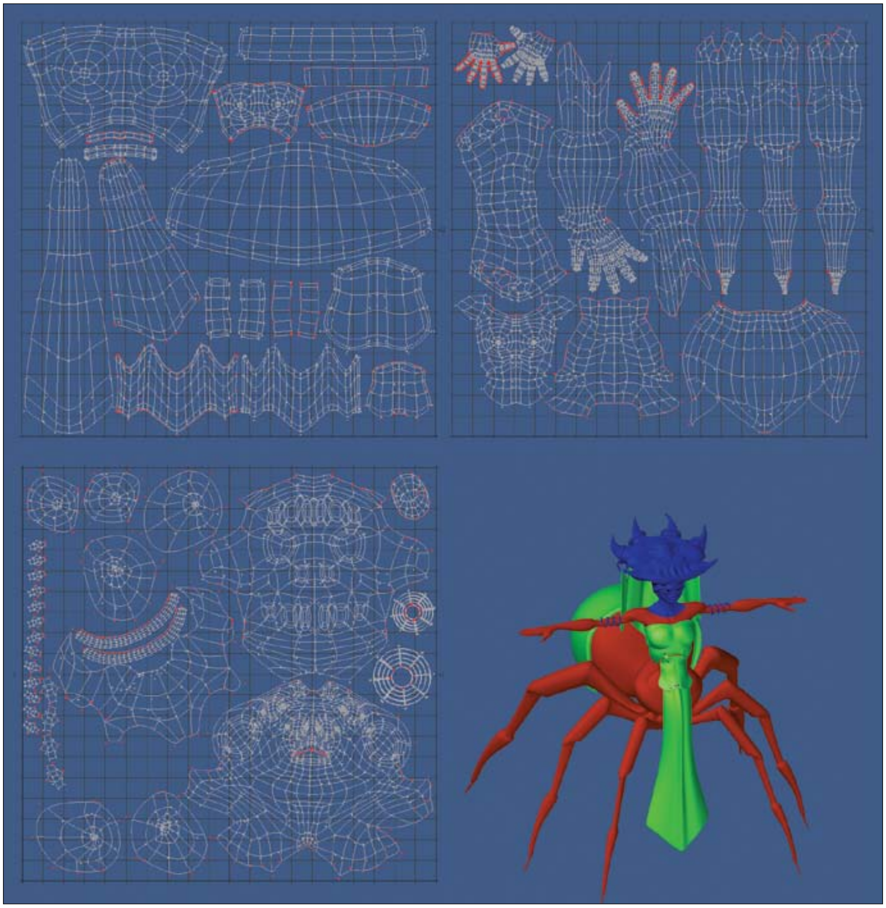
- Texture (UV)
- Weight
- Morph
- Color
- Selection

Texture (UV)

Texture, or UV, maps store texture placement information and are the most common vertex map. UV mapping adds two extra coordinates to the points in your object; those on the U (horizontal) and V (vertical) axes, running horizontally and vertically through the flat plane of the texture map, on which you can paint your texture. UV coordinates are a 2D representation of 3D space. They set up a relationship between a two-dimensional image and the three-dimensional surface the image will be applied to.

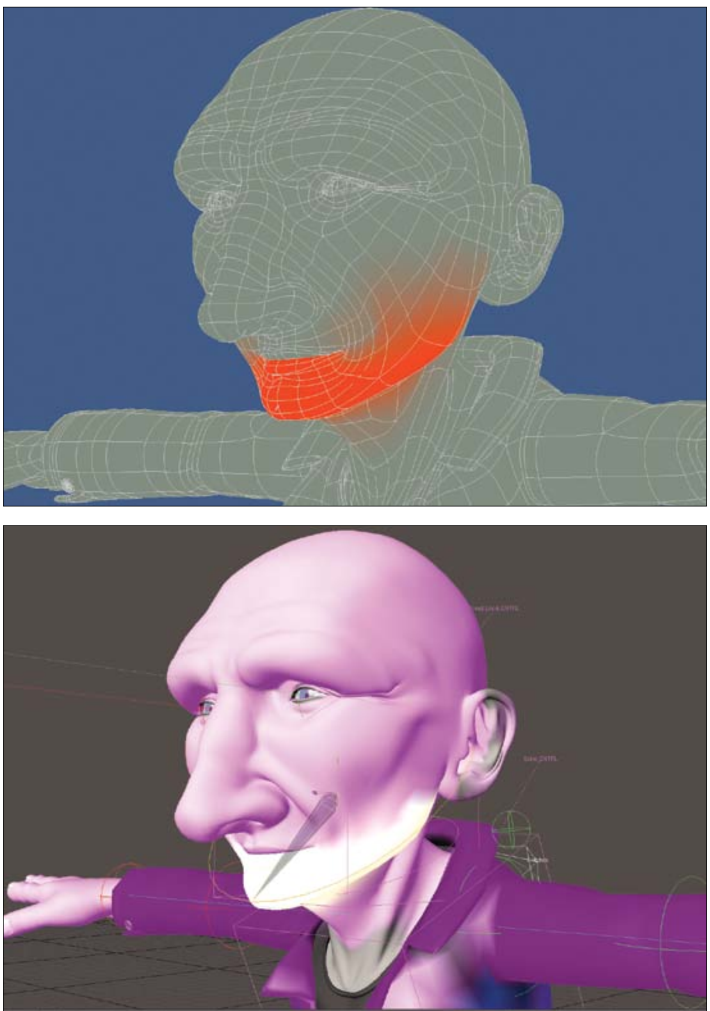
Points can have as many UV maps assigned to them as you'd like. **Figure 4.3** shows three UV maps that were created for the Spiderbait character that you can download from my site at www.pushingpoints.com/2011/07/spiderbait-rig.

[Figure 4.3] Three separate UV maps were assigned to the points that make up the character mesh on the right.



Weight

Weight maps store a single value, usually between -100 and 100 (although in some instances lower and higher values are possible). The most common use of a weight map is for defining a bone's influence on a point when *rigging* (placing bones and controls to allow a model to be deformed for animation). **Figure 4.4** shows positive weight values applied to the points that make up the character's jaw. When the weight map is assigned to the jaw bone, the points will move when the bone moves. This allows for seamless organic meshes to deform in localized areas.

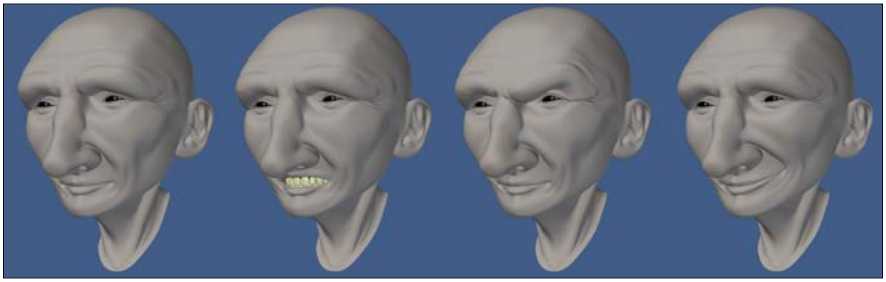


[Figure 4.4] Weight values assigned to points in the mesh (top) can be assigned to a specific bone (bottom) during the rigging process.

There are far more uses for weight maps than rigging. For example, you can use weights to mask a surface when texturing, influence dynamic simulations over an object, aid during the modeling process, and do much more.

Morph

Morph maps store offset information (alternate XYZ values) for a point's position and are commonly used for creating morph targets for animation. **Figure 4.5** shows several morphs applied to the base mesh. Each morph relies on multiple points being moved to new coordinates, and that information is saved to each vertex.



[Figure 4.5] Morph maps are commonly used to create facial poses for animation.

Similar to weight maps, morph maps have a variety of uses during the modeling and texturing processes.

Color

Color maps hold values for Red, Green, Blue, and Alpha (RGBA) color information. I often use color maps on my character models to add color variation to the object's surfaces, like adding blush to a character's face. **Figure 4.6** shows an example of using a color map to add a five o'clock shadow and some color to a character's face.

[Figure 4.6] A color map was applied to the character's face (right) to give the appearance of a five o'clock shadow.

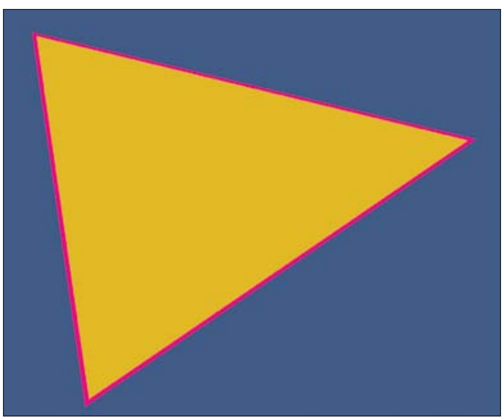
Selection

A *selection map*, also referred to as a *selection set*, stores a single state of a point—either selected or unselected. Selection maps allow a modeler to recall a selected group of points quickly and can be extremely useful for defining which points will be affected by dynamic simulations.

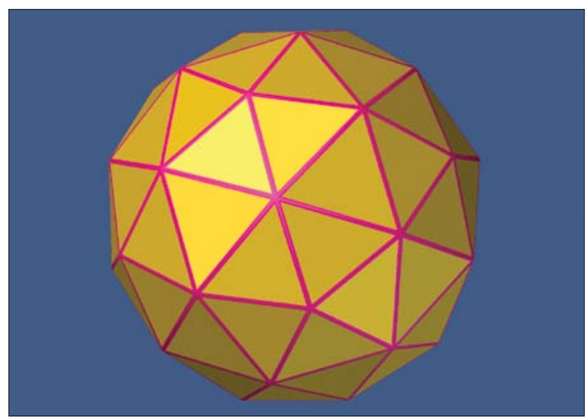
Edges

An *edge* is a one-dimensional line that connects two points in a polygon. Another way to describe edges would be to say that they are the line segments that border a polygon. A triangle, for example, has three edges, three points, and one polygon, as shown in **Figure 4.7**.

Similar to points, multiple polygons can share the same edges when used on a contiguous mesh. The tessellated sphere in **Figure 4.8** shows individual edges bordering the multiple polygons.



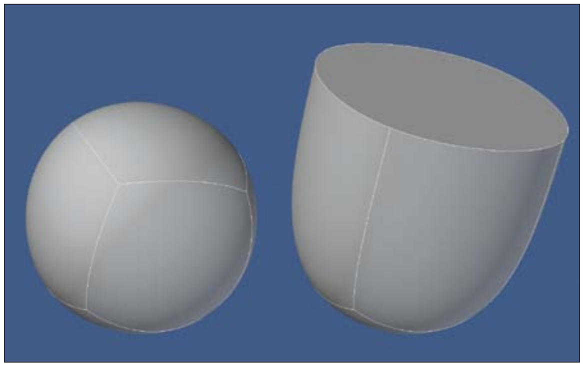
[Figure 4.7] The polygon in this image consists of three edges, shown here in pink.



[Figure 4.8] Each polygon shares common edges in this mesh.

Edge weights

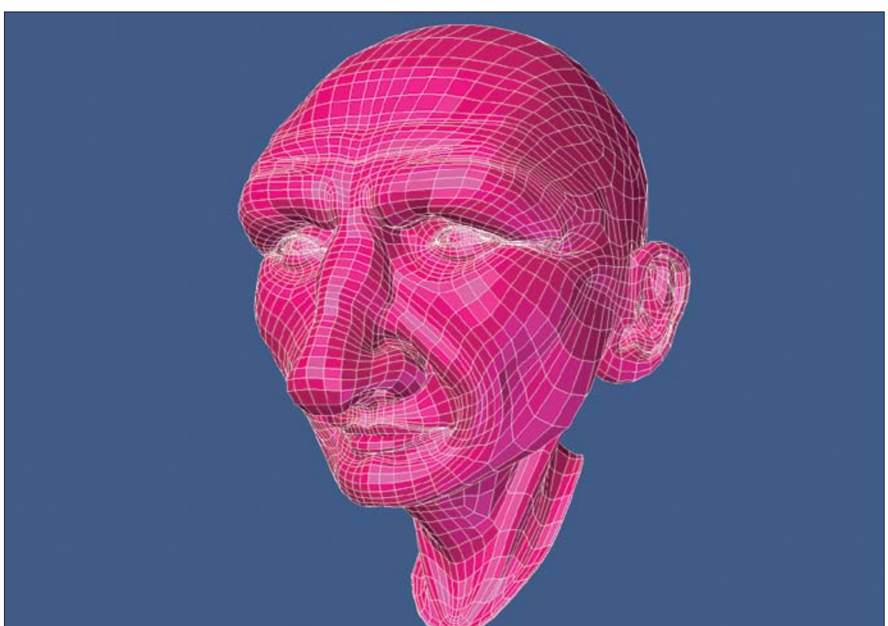
Edge weighting increases or decreases the sharpness of an edge between two subdivision surface (SubDs) polygons, allowing for harder or softer corners without additional geometry being added (**Figure 4.9**). The main issue with edge weights is that there is no universal, widely supported format that allows you to transfer edge weights from one 3D application to another. In today's mixed software pipeline, this can be a showstopper. Most modelers I know avoid edge weighting and opt for additional geometry to accomplish the same end goal.



[Figure 4.9] Edge weighting has been increased to 100 percent to the four edges on the top of the SubD object on the left to produce harder edges.

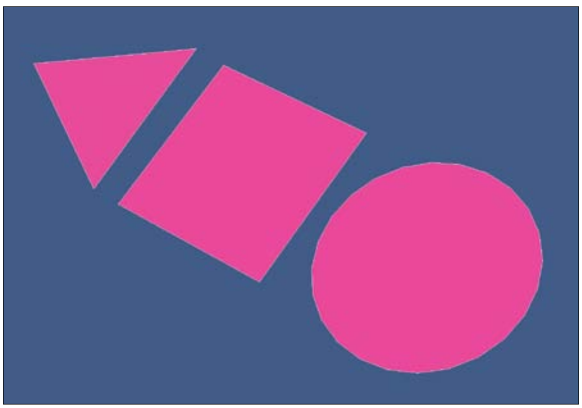
Polygonal Models

Polygons, often shortened to *polys* and commonly referred to as *faces*, are geometric shapes consisting of a number of points that define the surface of a 3D object. A polygon is what you actually see in a render, and a typical 3D model will consist of hundreds or thousands of polygons (**Figure 4.10**).



[Figure 4.10] This head mesh consists of over 6000 polygons.

Although some 3D applications allow the creation of one- and two-point polygons, it's more common that a polygon be made up of at least three points. Three-point polygons are commonly called *triangles* or *tris*. Polygons made up of four points are called *quads*, and a polygon that has more than four points is usually referred to as an *n-gon*. The term *n-gon* means a polygon with *n* sides, where *n* is the number of the polygon's sides. For example, a polygon with six sides is a 6-gon. Examples of a triangle, a quad, and an n-gon are shown in **Figure 4.11**.



[Figure 4.11] Polygons come in all shapes and sizes. The triangle (left) consists of three points, the quad (middle) is made up of four points, and the n-gon (right) is made up of 24 points.

NURBS

A *Non-Uniform Rational B-Splines (NURBS)* surface is a smooth mesh defined by a series of connected *splines*, which are polynomial curves. This smooth surface is converted to polygons at render time, so NURBS surfaces can contain an arbitrary number of polygons. NURBS can be converted to polygons or subdivision surfaces and are useful for constructing many types of organic 3D forms because of the minimal nature of their curves. NURBS geometry is smooth by default and doesn't need to be subdivided to "become" smooth like polygon geometry does.

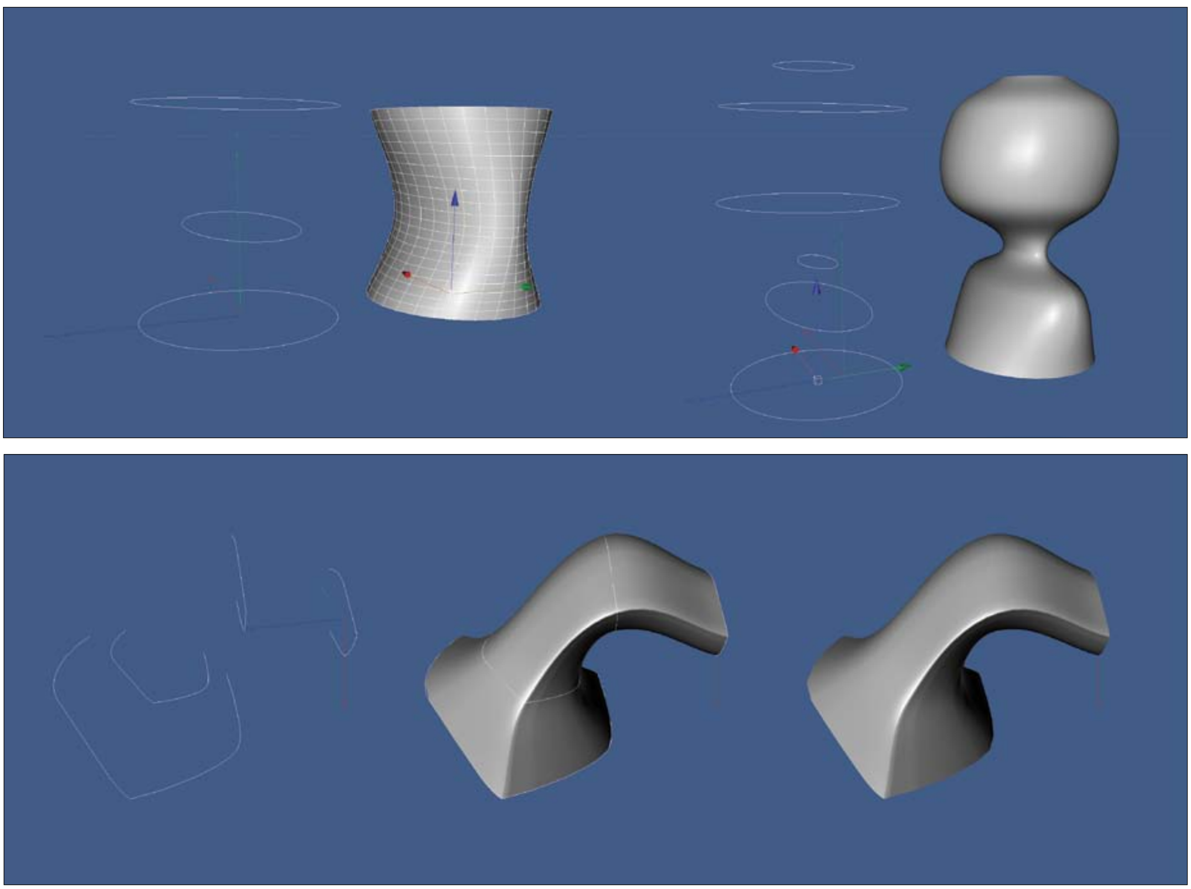
Non-Uniform refers to the parameterization (defining the parameters) of the curve. Non-Uniform curves allow, among other things, the presence of *multi-knots* (a sequence of values that determines how much and where the control points influence the shape), which are needed to represent Bézier curves.

Rational refers to the underlying mathematical representation. This property allows NURBS to represent exact conics (such as parabolic curves, circles, and ellipses) in addition to free-form curves.

B-splines are *piecewise* (a function that changes) polynomial curves (splines) that have a parametric representation. Simply put, a B-spline is based on four local functions or control points that lie outside the curve itself.

The best way to understand NURBS is to see them in action. **Figure 4.12** shows multiple examples of the splines that define the NURBS surfaces.

[Figure 4.12] Each of these three NURBS surfaces are defined by a series of splines, shown to the left of each object.



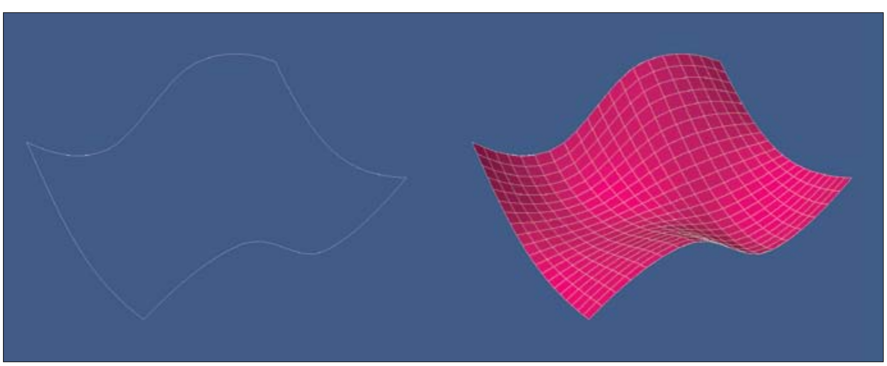
NURBS are most commonly used in computer-aided design (CAD), manufacturing, and engineering. Although they were once used heavily for organic objects (see the forthcoming section "Model Classification: Hard Surface and Organic") in the film and broadcast markets, subdivision surfaces have since replaced them in almost all instances in movies and television.

Splines

A *spline* is a curve in 3D space defined by at least two points. The most common spline used in digital modeling is the Bézier curve. *Bézier curves* are used to model smooth curves using far fewer points than a polygonal model would require. *Control points* make up the curve and can be used to dramatically manipulate the curve with little effort. Also, splines are resolution independent, unlike a polygonal mesh, which can appear faceted when you zoom in close enough to a curved surface.

Splines in 3D applications can be likened to vector curves in software such as Illustrator, Flash, and Photoshop. Splines are similar to NURBS in that they can create a "patch" of polygons that extends between multiple splines, forming a 3D skin around the shape (**Figure 4.13**), a feature which is extremely useful when modeling. Unlike NURBS, the splines must be converted to polygons before rendering.

Splines are also useful in many other modeling techniques, including but not limited to, *extrusion* (adding depth to a flat surface) and *cloning* (duplicating) along a spline and deforming a mesh based on the curves of a spline.

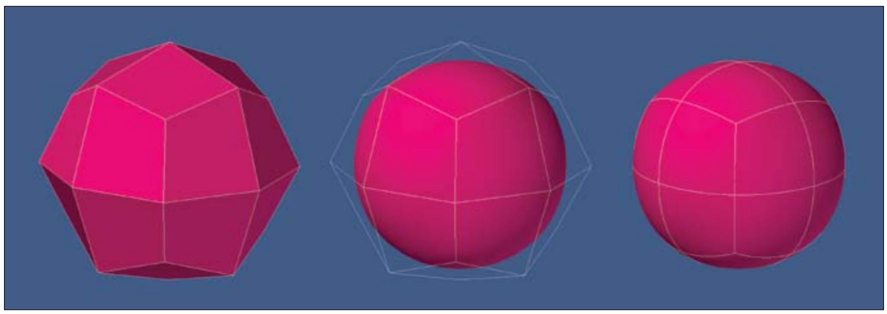


[Figure 4.13] The four splines on the left were used to patch the polygonal mesh on the right.

Subdivision Surfaces

Subdivision surface (*SubD*) is a refinement algorithm that creates a smooth curved surface from a coarse *polygonal mesh* (also called a *base mesh*). This process takes the base mesh and creates a smooth surface using the original vertices as control points, also referred to as the control cage. **Figure 4.14** shows the polygonal mesh (left), the control cage (middle), and the resulting SubD mesh (right).

[Figure 4.14] Subdivision surfaces allow you to work with a very light and simple polygonal mesh to create smooth organic shapes.



The number of polygons, or subdivisions, generated from SubDs can be adjusted to a varying level of density, and complex smooth objects can be created in a fast and predictable way from simple base meshes, as shown in the character model in **Figure 4.15**. This makes SubDs a popular option for most digital modelers.

[Figure 4.15] This character was created with a very simple polygonal mesh (left). But with SubDs applied (middle), a smooth, high-poly mesh was generated (right).

Model Classification: Hard Surface and Organic

When 3D was still in its infancy, digital modelers were usually put into one of two distinct groups based on the type of meshes they constructed. Although the lines have become blurred, these groups still exist today and play a role in how modelers define themselves in the industry. Also, the distinction of the types of meshes a modeler creates makes it easier for studios looking for talent to find the right digital modeler for their specific modeling needs.

Every 3D mesh can be grouped or classified as either a hard surface or organic. What's the difference? What defines an object as hard surface? What defines an object as organic? So many objects nowadays seem to blur the lines between the two. How would you make a distinction between these classifications?

What may come as a surprise is that if you ask 20 professional digital modelers what the difference between these two classifications is, you'll receive 20 different responses. I did just that before writing this section of the book and was quite surprised at some of what I heard.

How can something so seemingly clear-cut bring about so many different ways to classify a 3D model? Before coming to a conclusion, let's explore the most common responses.

Production Driven

Many artists felt that a model would be classified by how it would be used in a production. A static object, such as a stone statue, gas pump, or street sign, would be considered a hard surface object, whereas objects that would deform or animate, such as an animated human character, flag, or animal would fall into the organic category.

The same item could be classified two different ways depending on what the object is called to do for the shot/project. A statue is made of stone and doesn't usually deform; therefore, it is a hard surface object. But if it becomes a moving statue, as in the world of Harry Potter, it is organic.

Although a gun has moving parts that can be animated, it is still a rigid object, which makes it a hard surface object, unless of course, someone with super human strength comes along and bends (deforms) the barrel—then it becomes organic.

If the mesh is going to deform in some way, it needs to be modeled differently and it should then be classified as an organic object.

Attribute Driven

Some believed that it was a model's *attributes*, or what an object looks like, that defined whether it was hard surface or organic. So if the mesh had flowing "organic" curves where any shape could smoothly transform into any other, like a character, ornate piece of furniture, or a sleek sports car, it was an organic mesh.

Hard surface objects would be defined as meshes typically involving tight edges or simpler shapes joining together with distinct edges, even if the shapes were soft or sleek, like guns, power tools, and retro robots.

Also, if the object's surface attributes were that of stone, metal, or glass, it would fall into the hard surface category, whereas objects made up of living tissue, like animals, plants, and people, would be considered organic.

Construction Driven

One artist defined the two by focusing solely on the modeling aspect. Objects that require a more "organized" topology could be classified as an organic mesh and easily created using "organic" modeling tools and techniques. He believed that organic meshes tend to have more polygons and could benefit from SubDs more than hard surface objects. Hard surface objects don't require an organized, semi-regular topology and could be created with fewer polygons with less concern about the object's underlying mesh.

Model Classification Evaluation

Although each of these schools of thought has valid arguments and may work for a particular artist, we simply can't classify an object based on how it is constructed, will be used in production, or by its appearance. To do that would cause confusion, because every object could find its way into each category.

Take, for example, my dog Jack. He's a chocolate lab, which is classified as being part of the *Canidae* family. For the most part, Jack acts like your average dog, wanting to eat, play, and sleep most of the time. He does, however, show attributes of a cat at times, and every now and then he will scratch at the ground after he urinates, like a cat pawing at its litter box. Although this is common in cats, it doesn't make Jack part of the *Felidae* family.

Organic modeling goes beyond the fact that the shape of the model is rounded. Many hard surface objects have organic shapes, like cars, cell phones, and robots, whereas organic objects can have rigid shapes like rocks, insects, and crustaceans. Industrial design has moved more towards organic shapes over the years, and the entertainment industry is taking things that were traditionally hard surface, static objects and deforming them in animation—having gas pumps dance in commercials, for example.

Also, modeling something to perform well when animated is just good modeling technique and shouldn't determine whether something is hard surface or organic. For example, look at a mesh sculpted in ZBrush, or modeling with metaballs or voxels. You can create something very organic, but these modeling techniques will make the model nonconducive to animating. Would that then be considered hard surface modeling? Of course not.

Most modelers don't limit their tool and technique use based on whether a model is organic or hard surface. Generally, they use good modeling techniques, which include building a model that'll hold up if deformed, even if it's not intended to, and apply those same techniques regardless of whether the model is hard surface or organic.

You hear the terms *hard surface* and *organic modeling* all the time in the 3D modeling community, and artists are often defined as one or the other. If you make mostly characters meshes, you are an organic modeler. If you make more architectural or mechanical objects, you are a hard surface modeler. I usually describe myself as an organic character modeler, but it is simply not that straightforward, because I create products and vehicles that are defined as hard surface too.

So back to the point: What's the difference between hard surface and organic models, and how do we define the two? I suppose, essentially, there is no difference at all, and it is a question of semantics. For the purposes of this book (and based on my personal philosophy), I use the following distinction: Characters, creatures, plant life, and more naturalistic environments are organic models, and architectural environments, vehicles, and mechanical products are hard surface. This is very loose as a definition, and as I've tried to emphasize, the lines between the two are indeed very blurred.

Hard surface

Hard surface objects are anything man-made or constructed. Architectural structures, vehicles, robots, and anything machined or manufactured could fall into this category. The robots from FunGoPlay's *Grid Iron Gladiators* (www.fungoplay.com), shown in **Figure 4.16**, would fall into the hard surface category.

[Figure 4.16] Although these robots have smooth organic shapes, they still fall into the hard surface category.

Organic

Organic models are subjects that naturally exist in nature. This would include humans, animals, plants, trees, rocks, boulders, terrains, clouds, and even lightning bolts. The nonplayer characters that roam the world of FunGoPlay (**Figure 4.17**) would be considered organic models.

[Figure 4.17] These characters from FunGoPlay would be classified as organic models.

Model Styles

As with a model's classification, a mesh usually has a specific style associated with it. A *style* refers to a specific philosophy, goal, or look. Realism, impressionism, abstract expressionism, and surrealism are common styles found in traditional art. Although a digital model could easily fall into any of the traditional art styles, the 3D industry usually places them into one of two different model styles: photo-real and stylized.

Photo-real

When a model depicts an object with realistic accuracy, the term *photo-real* is applied. Digital artists use photographic reference and their observation skills to transfer the realistic properties to the details that make up their models.

It's important to understand that the subject matter is not required to be a real-world object, like a car, human, or architectural structure. Models of robots, dragons, and other fictional subjects can also be modeled in a photo-realistic style using real-world reference as a guide.

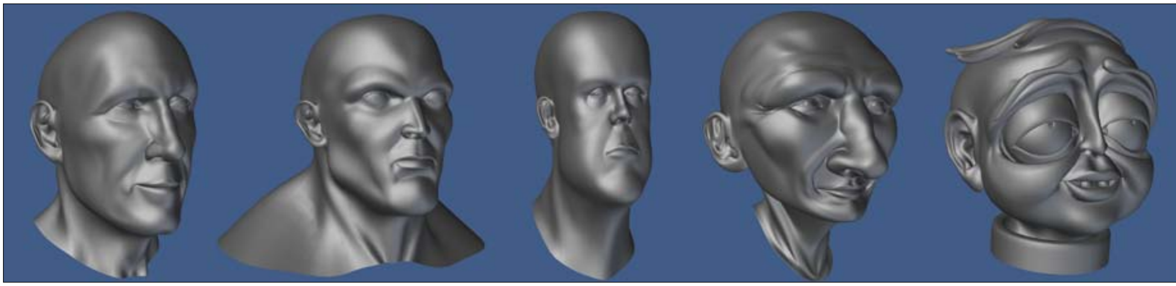
Stylized

When a digital model consists of artistic forms and conventions in a non-realistic style, it is referred to as a *stylized* model. Simply put, a stylized model is one that is not photo-real. Cartoon characters and environments are classic examples of stylized models.

The best stylized modelers I know still gather and use just as much real-world reference material as a photo-real modeler. The only difference is how they interpret it and apply that information to the model.

Choosing a Style

Although many artists would argue otherwise, I don't find either style of modeling to be more difficult than the other. Both styles require the same attention to detail, and the same care needs to be put into the poly-count and topology of the mesh. At the end of the day, the only real difference between the two styles is where the points are arranged on the model, as shown in the head models in **Figure 4.18**.



[Figure 4.18] Each of these head models consists of the same elements, but only the head on the far left would be classified as photo-real.

Most artists gravitate towards a particular style. I prefer creating stylized models and creating meshes that have otherworldly proportions and attributes, but I also tackle photo-real models on a regular basis. My modeling toolset and techniques don't change depending on the style of the mesh I'm tasked with. Digital modelers' goals should be to hone their observational skills and to have the ability to work across styles.

Learning to work in both styles will only enhance your ability in the style of your choice and will open up more opportunities to you as a professional modeler.