AN EXCERPT FROM



The Art of Maya

AN INTRODUCTION TO 3D COMPUTER GRAPHICS



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The Art of Maya

AN INTRODUCTION TO 3D COMPUTER GRAPHICS





3D Computer Graphics

Animation is an art form created and cultivated over the last century. While drawing, painting, sculpting and photography allow artists to represent shape and form at a single point in time, animation lets artists explore a world in motion. Through animation, new worlds can be imagined. This modern art form evokes emotion through the movement of a sequence of drawings, paintings, photographs or rendered images.

The introduction of 3D computer graphics over the last couple of decades has had a big impact on the world of animation. Digital characters and sets can now be built and animated, then presented in different media formats such as film, video and interactive games. Characters and visual effects can even be seamlessly integrated into live-action footage.

Autodesk[®] Maya[®] is a 3D animation system that lets artists play the roles of director, actor, set designer and cinematographer.



3D Computer Animation

The world of 3D computer graphics has grown from experimental short films to full integration into the creative process for many types of media. From flying logos to digital actors, the field of 3D computer graphics has evolved rapidly over the last two decades. The use of 3D graphic tools is now an important part of many television, film and multimedia projects.

What makes 3D such a useful tool is the way it simulates real objects. The way objects appear in perspective, the way a surface bends and twists, or the way a light illuminates a space—all of these complex 3D effects can now be recreated on the computer. The resulting digital images can then be integrated into other media types using familiar compositing and editing techniques.

Autodesk[®] Maya[®] is a 3D animation system that addresses the needs of a wide variety of digital content creators. The Maya software tools and techniques have been developed with the artist in mind, while command-based scripting offers ways to build customized tools that suit more integrated production workflows.



Broadcast

There is a good chance that anyone involved in the early years of 3D computer graphics has had to animate a flying logo. This use of 3D offered a new and dynamic way of getting the message across – always important in the world of advertising. Since then, the use of 3D in broadcast has evolved and more sophisticated artwork is being produced.

Flying logos are now integrated into more complete 3D environments where a product is advertised or a corporate message introduced. Character animation is also used more to bring objects to life and help sell the message.

Maya has helped open the door to a more complex use of 3D in the broadcast world. With integrated modeling, animation, characters, visual effects and rendering, a smaller video production house can now easily add 3D into their existing 2D workflow.



Animated Short Films

For many years 3D computer graphics were used primarily in animated short films. The experimental nature of these films was a good match for this new computer graphics technology. Smaller teams of artists, or even individual artists, could explore the use of computers to generate animation without the pressures of a larger feature production schedule.

In fact, Chris Landreth's *Bingo*, an animated short film, was created while Maya was still in development. Using Maya, Chris and his team were able to tell a compelling story about the influences of our society on the average person.

Short films provide a fertile ground for experimentation that help drive innovation in the computer graphics industry. It is also a great way for young animators and students to begin using their animation skills as a vehicle for storytelling.



Feature Films

The last few years have seen a sharp rise in the use of 3D in feature films. While many films have integrated 3D into existing live-action scenes, Pixar's *Toy Story*[®] became the first feature-length animation that used 3D exclusively for characters and sets. Sony Pictures Imageworks' *Stuart Little*[®] took this one step further and made a digital mouse the star of a live-action movie. Digital creatures, characters and sets continue to show up in the movies and even traditional filmmakers are starting to consider 3D a standard part of the production process.

Feature films tend to use many computer programs to complete a project, including in-house software and off-the-shelf software such as Maya. Maya is most often used for modeling, animation, character animation and dynamics simulations such as cloth. The Maya software open architecture makes it easy for computer graphics (CG) supervisors to build custom tools to help streamline production.



Visual Effects

While CG actors star in movies of their own, 3D computer graphics is changing how visual effects are used for both film and television. Smaller productions can now afford to integrate 3D graphics into their work, while large film productions can now achieve effects only dreamed of in the past.

Film sets can be partially built and then extended with detailed 3D digital sets. Also, animated stunt people can be thrown off buildings in ways not recommended for real people. And smoke, fire and exploding



objects can now be simulated within the safety of a computer screen.

The Maya software tools, especially Maya dynamics, are ideal for generating visual effects that can be fully integrated into live-action shots. The best effects make it impossible to find the line between reality and where computer graphics are used.



Interactive Video Games

Over the years, video games have developed from black and white pixels to real-time virtual environments built with 3D characters and sets. The graphics used in these games have always conformed to the capabilities of the game console on which they are delivered. Next-generation game consoles are continually increasing their computing power to be comparable to the workstations used to run Maya. This is breaking down limitations of the past.

Game artwork is becoming more sophisticated with complex 3D models, texture maps, lighting and even dynamics. Maya is an ideal tool for generating this kind of 3D artwork and includes tools to address the special needs required to build content for real time.

Visualization and Web

Digital content creation tools are used in a number of fields including fine arts, architecture, design, education and scientific research.

Some of these fields require 3D computer graphics to produce highly realistic images for the evaluation of projects or prototypes. With advances in the web's ability to present graphic and 3D information, visualization on the internet is emerging as an important tool for many companies.





Technical Creativity

A s an artist working in a new medium, you must first understand the technical aspects of your new tools before you can reach your full creative potential. Just as a painter must learn how a particular paint mixes and dries on canvas, and a photographer must learn what film speed works best with a particular lens, a 3D artist must learn the basics of setting keyframes, working with 3D geometry and setting up materials and lights for photorealistic rendering.

To fully master computer animation, you must have a balance of artistic and technical skills. Not only must you learn how to work with shape, form, motion, color and texture, but also you must learn how the computer interprets all of these elements. While Maya will allow you to go far without understanding all the technical details, you will have greater creative freedom with more knowledge.

Getting to Know Your Computer

If you are sitting down at the computer for the first time, you may be intimidated by the many computerbased tasks you must learn such as opening applications, moving and saving files, and how to work over a network. If you work in a larger production house, you probably have technical assistance onsite to help you get through this part of the learning process. In a smaller production house, you likely have less assistance and must learn more on your own. Luckily, these skills come quickly with experience. The best way to learn is to dive in and start working.

Getting Started with Maya

There are several steps to getting started with Maya. This book is designed to give you a conceptual understanding of how Maya works, while the *Learning Maya | Foundation* book gives you projectbased experience. You can also use the reference manuals and web tutorials offered at the Autodesk web site.

While these academic tools are important, they can't replace true production hands-on experience. One good way to begin using the software is to model, render and animate a real object—an object you can study, document and accurately turn into a digital scene. Try to build and animate your favorite old toy, a household appliance or even your own face.

By using a real object, you will be able to evaluate your success against the real object. By focusing on creating something, you will be able to apply the knowledge you have gained from this process.



Transferring Traditional Skills

Artists with skills in traditional media will find the transition to 3D computer graphics easier once they get used to working on a computer. In fact, new 3D artists should take the time to learn one or more of the following traditional art forms because they can help enhance 3D skills:

Drawing and Sketching

Drawing is a technique of representing the real world by means of lines and shapes. This skill requires the ability to observe and record the three-dimensional world. This skill can also be used to create storyboards and character sketches—great tools for developing an idea before proceeding to computer graphics.

Cel Animation

Cel animators create 2D art through motion. Cel animation includes traditional techniques such as squash and stretch, anticipation, overlapping action and follow through. Many of these 2D techniques translate very well into 3D environments.

Painting

Painters learn to work with color, light, shape, form and composition. On the computer, these skills help create texture maps, position lights and compose scenes.

Cinematography

Knowledge of traditional cinematography will help artists use realworld techniques when setting up CG lights and cameras. This skill is very important when working with 3D graphics that are integrated into live-action plates.

Photography

Still photography requires an understanding of lighting and camera effects such as key lights, focal length and depth of field. Photography also teaches good composition techniques that are useful for framing scenes.

Sculpture

Sculpturing with clay, stone and metal requires an intimate understanding of shape and form. Hands-on experience in shaping complex surfaces is a great asset when working with digital surfaces in Maya.

Architecture

Architects often make good 3D artists because they are trained to think in plane, section, elevation and perspective. Building models by hand is another skill they develop that makes it much easier to work in a digital environment.

Right and Left Brain Thinking with Maya

Maya has a creative and a technical side. The creative side of Maya offers you tools that make it easy to work in a 3D world with shape and form. These tools free you up to make creative decisions on your project. The technical side of Maya offers you access to the inside workings of both your scenes and Maya itself. This access makes it possible to build your own custom tools and to speed up production where repetitive tasks appear. By having this dual nature, Maya is able to contribute to different stages of a production and to different ways of working.

Switching Sides

While working as a 3D artist, you will be required to be both technical and creative at the same time. One strength of Maya is that you can start off with a technical approach as you rig up your characters and models with controls. Once this work is complete, you can focus on the creative process using a few higher level controls that let you put aside the technical issues for a while.

Left Brain Thinking

The Technical Edge

Maya has many editors that give you access to all parts of a scene. For example, the Attribute Editor can access the mathematical values assigned to all objects, shaders and animated sequences in your scene.



Maya Embedded Language (MEL) and Python[®] are powerful scripting languages used to execute commands and build custom user interface elements. This is the ideal tool for technical leads who need to create tools that support production workflows used by their teams.



Maya lets you group objects together to build complex hierarchies. These groups help you organize your models while offering methods of animating complex objects. Maya is built on a complex interconnection of objects known as the Dependency Graph. This establishes the connections between objects and can be viewed and manipulated for incredible control. Understand the Dependency Graph and you understand the technical side of Maya.

Mathematics, Scripting and Programming

Mathematics is used by Maya in a number of ways: objects in Maya exist in a 3D coordinate system, colors are stored as RGB values, and animation is created as values that are mapped against time. A Maya scene is basically a database of numbers that is interpreted by the software into geometry, color and texture. In some cases, you may need to do some math outside of Maya to make sure the right numbers are plugged in. Also you may want to set up a mathematical equation or expression to create more complex motion in your scene.

Maya is built on MEL (Maya Embedded Language), a scripting language that you can use to build custom tools and workflows. This language is fairly easy to learn and more technically minded artists might want to explore its use in their work. Maya also offers the opportunity to use the Python scripting language as an alternative to MEL. If you want the tool integrated into Maya, you can also program plugins using the Maya API. To develop these skills, a foundation in C++ programming is an asset. However, you can get quite far by using existing scripts and source code as inspiration.

Right Brain Thinking

The Creative Edge

Many tools in Maya use Manipulator Handles to offer visual clues as you edit an object. By using the manipulator, you are able to make your decisions visually without relying on the actual numbers stored in Maya. Maya includes fully shaded and textured views so that what you see in your interactive scene resembles what your final rendering will look like.





Animation information is presented in visual graphs that help you visualize motion. This makes all the numbers easier to understand. You can then easily edit this graph in the same way you would edit a curve in 3D.

Creative Awareness

One of the goals of creating artwork in a 3D graphics application such as Maya is to mimic the real world. This means that the more you are aware of the world around you, the easier it will be to recreate it on the computer.

As you come into contact with people, places and objects, take a closer look and imagine that you have to model, animate and render all of the details that you see. Details such as how a person swings his or her arms while walking, or how light enters a room, offer great reference for the 3D artist to incorporate into their work. Any seasoned animator will tell you the importance of observing the world around you.

You should continue this kind of awareness when you go to the movies. In many ways, your animations will have roots more in movies than in real life. While watching movies, observe camera angles, set lighting, the staging and framing of actors, and performances. An understanding of how people, places, color, shape and form are captured on film can help you become a better animator.



The Animation Pipeline

A number of different stages lead up to a final animated 3D sequence. When computers were first used for 3D graphics, these stages were broken down into modeling, animating and rendering. These stages have since been expanded with the introduction of character animation, effects and more sophisticated camera and lighting tools.

Each stage of 3D animation is a full area of study on its own. It is useful to be familiar with all the stages, even if you find yourself focusing on only one later on. Knowing how the stages in the animation pipeline work together will help you make decisions that benefit everyone down the line.

Modeling, Animating and Rendering

The animation pipeline can be summarized in seven stages: modeling; characters; animation; materials and textures; lights and cameras; effects; and rendering and compositing. These general stages describe the main tasks required to create an animation.

On a project, you will often work on different parts of the pipeline at the same time. It is a good idea to have the teams work closely, using storyboards and sketches to tie elements together. If you work in a larger office, you may focus on one of these areas, although having an understanding of several areas is beneficial.



1. Modeling

This is the stage where you build geometry to represent objects and characters. This geometry describes the position and shape of your models and can be manipulated in the 3D workspace of Maya.



2. Characters

Characters are models that use special controls such as skeleton joints and inverse kinematics for animation. These controls make it possible to create the complex mechanics required by characters.



5. Lights and Cameras As you would on a movie set, you must set up lights and cameras to illuminate and frame objects. You can then animate both the lights and the camera to further minic Hollywood effects.



3. Animation

Once a model has been setup for animation, you can begin to animate it. By changing its position or shape over time, you bring it to life. The timing can then be tweaked to create very specific motion.



6. Effects There are many effects such as fire, fields of grass and glowing lights that can't be easily represented using models and textures. Tools such as particles and Maya Paint Effects can be used to add effects.

4. Materials and Textures

In order for geometry to be rendered, it must be given material attributes that define how it will be shaded by light. Texture can also be added to bring detail and visual richness to the surfaces.



7. Rendering and Compositing Once all the scene's parts are ready, you can render a single image or a sequence of images. You can also render objects separately, then bring them back together in 2D using a composition system.

The Animation Pipeline

Animating in Maya

Looking at the animation pipeline from the perspective of a Maya user, several stages use animation as their foundation—such as modeling, characters and effects.

Since almost any attribute in Maya can be animated, you can begin preparing for the animation process at any time.

After setting up and animating a scene, you can render and composite the 3D objects and bring them into a 2D bitmap world. The rendering and compositing stages seem to stand on their own at the end of the pipeline. However, you can apply test renderings throughout the animation process and undertake compositing earlier on.

Production Pipelines

The way in which you approach the animation pipeline will depend on the environment you create in. From a single artist on his or her own to an artist in a large corporation, the approach to using 3D graphics may differ. Here are some general descriptions of the production pipelines you can expect to encounter.

Single Artist

As a lone artist, you will be in charge of all aspects of the production process. You will, therefore, work in a more linear fashion. As technical lead for yourself, you may want to set up a consistent control strategy for your characters and scenes so that when you are animating you can think more creatively.

Small Production House

In a smaller production house, the focus is on cutting production time and making the most of limited resources. You will be called upon to play a few roles, although some specialization will occur. Custom tools may be put into place to streamline production.

Large Production House

In a large production house, specialization is more likely. You will focus on either modeling, texturing, lighting, animating, effects or rendering. Technical leads will take care of custom tools and character rigging. Maya will also be part of a larger production tool kit and MEL scripts and plugins will be required for data transfer to proprietary tools.

Gaming Company

A game company can work like either a small or large production house. Here the focus is on modeling with polygons, setting up texture UVs, painting textures and animating. The exact workflow for your models and scenes will depend on the game engine and which custom tools are available for exporting.

School/Student

If you are at school and working on a production, you can either work alone, which may limit the complexity of your animation, or you can work with your fellow students to create a production house scenario. Here you would choose an area of expertise and specialize in that area with your classmates' support. The first approach offers a more general view of the pipeline while the second approach gives you production-level experience in a particular area.



Technical Leads

In production houses, technical directors (TDs) and computer graphics (CG) supervisors offer their teams support with scripts, expressions, plugins, and character rigging. Technical leads set up controls that allow animators to focus on creating motion.

In building up a character, the technical lead might also build high-level controls that create a particular kind of motion for use by the animators. For example, if many different animators are working on a bird character, the technical lead might want to make sure the wing beat is always animated the same way. Therefore, a single control can be created that drives all the components of the wing beat. The high-level control makes sure all of the wings beat the same way. Management of the production workflow may also involve creating custom tools. Since many production houses use in-house software, MEL scripts might also be used to pipe Maya scenes out to a custom file format.

Animators

While the setup of scenes and characters is an important part of the process, the animation of these elements is where the art is created. Animators must tell a story using motion as the main tool.

A well set up scene gives an animator space to focus on setting keys on the various high-level controls built by the technical lead. With non-linear animation, a whole library of motion can be saved and used in different parts of a project. Such a library provides an animator with a sort of animation palette.

Well built controls and skilled animators are the ideal combination for creating art through animation.



Ufingers	
Ritate X	0
Robert 7	0
Hitsle Z	0
Pitger Sprowl	0.4
Index Cult	9.0
Middle Curt	4.4
Hing Curl	2.8
Finity Dut	0
Thurst Curt	0

High-level Controls For example, custom attributes make it easier for an animator to control a character's hand.



Trax Editor and Visor

The non-linear workflow of Maya is an ideal tool for animating a scene. High-level clips and poses can be mixed and blended in the Trax Editor. Motion can be quickly laid out, then edited with simple click+drag actions.



Time and Space

With 3D computer animation, artists work in a digital world where space, color, texture, time, shape and form are tools for creating images and sequences of images.

All of these physical realities must be translated into a computer language based on numbers. In fact, Maya scenes and images are really just databases of numbers that are interpreted by Maya software and presented on the computer screen in a more visual and artist-friendly manner.

While artists do not have to know how the numbers are interpreted by the computer, they do need to understand some of the ways in which space, color and time are quantified and recorded. Learning how the computer interprets digital information—such as 3D coordinates, frames per second or the RGB information stored in a bitmap image—can help artists understand how this information relates to their own perception of time and space.



3D Space

very day, you come into contact with three-dimensional objects and spaces. You have learned how to recognize and work with three dimensions in your daily routine and have an intuitive feel for how it works. If you have ever drawn a sketch, built a model or sculpted a model, you also have a creative feel for how shape and form can be described in 3D.

Three-dimensional objects can be measured and quantified. If you have ever measured the length, width and height of an object, you have analyzed its three dimensions. You can also determine an object's position by measuring it in relation to another object or to a point in space. In Maya, you can explore three-dimensional objects and recreate them on screen as rendered images complete with lights and shadows.

XYZ Coordinate Space

In Maya, 3D space is measured using three axes that are defined as the X-axis, the Y-axis and the Z-axis. If you imagine looking into a movie screen, the width would be the X-axis, the height would be the Y-axis and the depth would be the Z-axis. In Maya, these axes are presented with X and Z on the ground and Y as the height.

You can find any point in this 3D world by defining a coordinate for each of the axes. To help you visualize these coordinates, a grid with axis indicators shows you their orientation.



Two Dimensions

When you measure the width and height of an object, you are analyzing two of its dimensions. The X and Y axes can be used to find points on an object, such as the center of the wheel or the position of the headlight in this twodimensional space.



Three Dimensions When you measure the length, width and height of an object, you must consider a third dimension as defined by the Z-axis when defining points in space.

Origin

Points in a 3D coordinate system are measured against an origin point. This point is assigned a value of 0, 0, 0.

Axis indicator

To help you visualize the three axes, each is given a corresponding RGB color. X-red Y-green

Transformations

When an object is moved, rotated or scaled, the X, Y and Z axes are used for reference. An object is moved along, rotated around, or scaled along the chosen axis line. Values for these transformations



To create a ground surface to reference your work in XYZ, Maya includes a grid that maps out an area 24 x 24 units. The X and Z axes are on the ground and form the lines of the grid. The Y-axis is the height.

By default, Maya is Y-up where the Y-axis represents the height. Some 3D packages, especially CAD applications, might use Z as the height. If you import a model from one of these packages, you have to either re-orient the model or set up Maya as a Z-up world.

Perspective Space

When you visualize objects in the real world, you do not usually think about axis lines and 3D coordinates. Instead, you see the world in perspective where lines vanish to the horizon and objects get smaller as they get further away. A Perspective view allows you to visualize a 3D space in a way similar to how you view the world through either your eyes or the lens of a camera.

Most artists have learned to sketch a 3D scene in perspective or use drafting techniques to create more accurate perspective drawings. With Maya, the 3D Perspective view is automatically calculated for you, based on a camera position and a view angle that you set.

Orthographic Projections

While a Perspective view can help you compose a shot, it is not always the ideal method for modeling and animating objects. Therefore, an Orthographic view lets you analyze your scene using parallel projections of only two axes at a time. Using these views, you can more accurately determine how an object is positioned.

Most 3D animators find themselves using perspective views to compose a shot while Orthographic views offer a place to view the scene in a more analytical manner. Both views are crucial to working properly in 3D.

World Space and Local Space

When you build objects in 3D, it is possible to parent one object to another. This creates a hierarchy where the parent object determines the position of the group in world space. The child objects inherit this positioning and combine this with their own local space position. This parent-child relationship is used during the animation of an object where keyframes can be set on both the child and the parent.



bar and the wheels move with it.



Top view







Perspective view



Side view

The Complete Picture

The different points of view afforded by Orthographic and Perspective views let you build and evaluate your models.

The Camera

Perspective views are generated by cameras that simulate real-world camera attributes. It is possible to

Curve-on-Surface

Curves can be drawn in UV

space. Later edits will be in 2D

Perspective Camera

UV Coordinate Space

One of the object types you will build in Maya is surfaces. While surfaces are positioned in 3D space using X, Y, Z coordinates, they also have their own coordinate system that is specific to the topology of the surface. Instead of using X, Y, Z axes, this system uses U, V and N, where U and V represent the two axes that lie on the surface and N is the "surface normal" axis that points out from the front of the surface.

When you create a curve, it has a U direction that lets you measure points along the curve. When a surface is created, it has a U and a V direction that define the surface parameterization. You can draw and manipulate curves in this 2D surface space. The placement of textures can also take place in UV space.

UV Coordinates

The origin of the UV system lies at one of the surface corners. U runs along one axis and V along the other.



Normal

The surface Normal always points out from the front of the surface. You can see the Normal lines pointing out from each intersection on the UV grid.

Moving Curves

When you select and move a curve in UV space. you can only move along the two axes of the surface grid. Curve control points can also be edited in UV space. 17



Time

n the world of 3D animation, time is the fourth dimension. An object will appear animated if it either moves, rotates or changes shape from one point in time to another. Therefore, learning how time works is crucial to the animation process.

Both live-action and animation use either film or video to capture motion. Both media formats use a series of still images that appear animated when played back as a sequence.

Film and video images are often referred to as frames and most animation is measured using **frames** as the main unit of time. The **relationship** between these frames and real time differs depending on whether you are working with video, film or other digital media.

Frames per Second

Frames can be played back at different speeds that are measured in frames per second (fps). This is known as the **frame rate** and it is used to set the timing of an animation. The frame rate is required to output animation to film or video and to synchronize that animation with sound and live-action footage.

In Maya, you can set your frame rate by selecting Window > Settings/Preferences > Preferences and selecting the Settings category.

15 fps Film (24 fps) PAL (25 fps) NTSC (30 fps) Show (48 fps) PAL Field (50 fps) NTSC Field (60 fps) milliseconds seconds minutes hours 2 fps 3 fps By default, the Maya software frame rate is 24 fps. If you have a background in animation, confirm your time units to ensure you set keys properly.

Because seconds are the base unit of time, it is possible to set keys at 24 fps, then change your frame rate to 30 fps. This will scale the timing of your animation to match the timing as measured in seconds.

Playback

When you preview your animations, you will often use interactive playback. You can set the Playback Speed by selecting Window > Settings/Preferences > Preferences and selecting the Timeline category. The default Playback Speed is Play Every Frame. At this speed, Maya will play every frame in your scene one after another. The actual playback speed will depend on your workstation's ability to process the animated elements in your scene. Setting your Playback Speed to Real-time asks Maya to maintain your chosen frame rate as accurately as possible. This means that Maya may skip frames in order to maintain the frame rate. Note that if you are synchronizing to sound, your Playback Speed should be set to Real-time, but if you are previewing dynamic simulations, it should be set to Play Every Frame.



Time Code

Time code is a frame numbering system that assigns a number to each frame of video that indicates hours, minutes, seconds and frames. This is what gets burned onto video tape. This gives you an accurate representation of time for synchronization. You can set up time code display in Maya from the Preferences window.

0 20	40	60	80	100	120	140
10:00;00:0	1					
1.00	1.00			00:00:0	00:01	

Fields

The concept of Fields is important if you output your animation to video. To make video play back smoothly, Fields are used in place of frames. Each Field uses alternating rows of pixels—called scanlines—that are interlaced during playback. Fields are timed at 60 fps for NTSC, with each Field containing only half the number of scanlines as a typical frame.

In Maya, you can render directly to Fields that have the 60 fps (50 fps PAL) timing or you can output a 30 fps (25 fps PAL) sequence and use a compositing system to convert it to Fields. For fastmoving objects, rendering directly to Fields offers smoother playback since each Field displays half-frame intervals.



Field 1 Odd Field 1 Even

Field 2 Odd Field 2 Even

THE ART OF MAYA

Double Time

At a frame rate of 24 fps, a 6 minute animation would require 8640 frames (24 fps x 360 sec). Animators working with either cel animation or stop-motion sometimes use double time, where only every second frame is created, then repeated twice. Double animations don't play back as smoothly as the full frame rate, but they save you in rendering time. Students, especially, might consider this option when confronted with a tight deadline. You can set up double time by setting **By Frame** to **2** in Maya **Render Settings** window, under the **Common Settings** tab.

3:2 Pulldown

When an animation created for film at 24 fps is transferred to NTSC video, a 3:2 pulldown can be used in place of re-rendering at 30 fps. This technique spreads every four frames into five frames by remixing the fields of the first, second and third frames to match the film's frame rate. A 3:2 pullup takes NTSC back to film. Both these techniques can be accomplished in a compositing package such as Autodesk® Combustion® or Autodesk® Toxik® software. PAL video does not generally require a pulldown because PAL's frame rate (25 fps) matches film more closely.

How Objects Are Animated Using Keyframes

Keyframe animation is created by capturing values for attributes such as translation or rotation at key points in time. An animation curve is then drawn between the keys that defines or interpolates where the object attribute would be at all the in-between frames.

Animation curves can be viewed as a graph where time is mapped to one axis and the animated attribute is mapped to the other. In Maya, virtually every attribute can be animated in this manner. The way in which you set keys and control the in-between motion determines the quality of an animation. As scenes become more complex, you will learn to create control attributes that can drive the motion of different parts of your scene to help simplify the process of setting keys.

Setting Keys

When you know that your object or character needs to be at a certain place at a certain time, you set a key. With characters, you can create poses out of a number of keys set for different parts of the character.

Mapping Against Time

Two keyframes are mapped against time, then an animation curve interpolates the motion between the keys. The shape of the curve determines the quality of the motion.







One Frame at a Time

When you render an animation, images are created for every frame. The accurate playback of these frames will be based on the Time Units you choose in the Preferences.







In-between

The position of objects in-between the two keyframes is determined by the shape of the animation curve.









You animate objects in Maya based on a single point called the pivot point. The pivot for the whole scooter would lie on the ground, while the pivot

Pivot Points

for a wheel would lie on the ground, while the pivot for a wheel would be at its center. The position of the pivot sets the center of the axes for rotating or scaling objects in your scene.



Bitmap Space

A bitmap is a representation of an image, consisting of rows and columns of pixels, that is stored color information. Each pixel (picture element) contains a color value for a number of channels – red, green and blue. When you view these channels together at a high enough resolution, all of the different colors form a complete image. These images can then be output to video, film or printed on paper.

Bitmap images play a number of roles in an animation system such as Maya. When Maya renders a scene, the geometry, lights and materials are calculated from the camera's point of view and a bitmap image or a series of images results. Further manipulation of the image in two dimensions is then possible using compositing or paint packages. Bitmap images are also used as texture maps to help add color and detail to the surfaces in scenes.



Bitmap Sources Bitmap images are common in computer graphics and can be created and manipulated in paint, compositing and 3D rendering packages.

Bitmap Channels Each pixel is made up of at least three color values – red, green and blue. These channels combine to create the visible color.

Pixels

the bitmap image.

Up close, you can clearly see

the grid of pixels that make up

Full Resolution As pixels are presented at a higher resolution, the grid is no longer visible and you get a clearer view of the final image.

Image and Display Resolution

Maya uses the term **Image resolution** to refer to the total pixel size of the bitmap image. **Display resolution** refers to how many pixels you will find in one inch on the screen. This resolution is measured in pixels per inch (ppi) or dots per inch (dpi). Monitors have a display resolution of about 72 dpi, although your graphics card may offer several settings which will alter this value.

As an animator, you will focus on producing images with a particular Image resolution such as 640 x 480 pixels for video or one of a variety of resolutions for film. The default Display resolution for these images is 72 dpi. If you are taking an image to print, you will need to consider a Display resolution of around 300 dpi. This value may be higher or lower depending on your printing needs. Below, you can see how different resolutions look when printed. You can see how the 300 dpi image provides a higher quality image on the printed page.



2" x 2" @ 72 dpi (144 x 144 pixels)



2" x 2" @ 150 dpi (300 x 300 pixels)



2" x 2" @ 300 dpi (600 x 600 pixels)

Aliasing and Anti-aliasing

The bitmap image grid can create a staircase-like or jagged effect within an image where lines run diagonally against the pixel grid. To create realistic bitmap images, you must soften these jagged edges using an effect called anti-aliasing.

Anti-aliasing modifies the color of pixels at the edges between objects to blur the line between the object and its background. This results in a softer look. Anti-aliasing is most important when you are working with lower display resolutions (72 dpi). Higher display resolutions (300 dpi) used for printing, hide jagged edges better.

Anti-aliasing is important when you render your scenes. You can set an anti-aliasing value in the Render Settings window. An accurate calculation of anti-aliasing increases rendering time, but yields better results. Later, when you learn more about rendering, the issue of antialiasing will be explored in more detail, including the issue of antialiasing an animated sequence.

No Anti-aliasing

Without anti-aliasing, a bitmap image will display jagged edges where one object meets another and on the interior of a surface where a texture map can appear jagged without proper anti-aliasina settinas.

With Anti-aliasing

An anti-aliased image removes the staircase-like effect by creating in-between pixels that soften the edge. This gives results that more closely resemble a real photograph that has been scanned into the computer as a bitmap.

Other Channels

In a typical bitmap, the first three channels contain color information. You can also create other channels that offer useful information about the image. Maya is able to render images with mask and depth channels for use in compositing packages. These channels can be used when you want to layer several images together seamlessly, including live-action plates created outside Maya.



Mask Channel

A mask (or alpha) channel, defines where an image needs to be solid or transparent. This channel can be used to layer images for compositing or to texture map attributes such as transparency or bump. White is opaque and black is empty.

Depth Channel

A depth channel can provide actual 3D information about an image. Depth channels are very useful in a compositing package where you can combine layers or add effects such as fog or depth of field. White is close to camera and black is far.



Over the years, many different image formats have been created. You can choose one of these in Maya Render Settings window. The Maya Software default format is called IFF and it handles RGB, mask, and depth channels. Maya also has several movie formats that contain sequences of bitmap frames.

In the Rendering chapter of this book, image formats are discussed in more detail.

Non-square Pixels

While most bitmap images use square pixels, digital video uses pixels that are slightly taller than they are wide. Therefore, an image that uses non-square pixels will appear squashed on a computer monitor that uses square pixels.

On a video monitor, the image would appear with its pixels stretched to their proper aspect ratio. If you are rendering to digital video, you must take the pixel aspect ratio into account.





Computer Monitor Display

Video Monitor Display

Bitmap File Textures

Bitmaps can be used to texture objects in Maya. They can be used to add color, bump, transparency and other effects on a surface. The RGB and the alpha (mask) channels can all be used to texture the object.

Bitmaps used as textures can add detail to geometry without requiring any extra modeling. These bitmaps are ideally saved as Maya IFF files and work best with image resolutions that use base-2 such as 256 x 256, 512 x 512, or 1024 x 1024. This is because these sizes fit best with Maya bitmapping algorithm used to filter textures.

When objects are rendered, textures are affected by the lighting and shading on the object, then output as another composed bitmap image. In an animation, each frame would be rendered as a different bitmap that creates motion when played back at the right frame rate. These images can also be output to video or to film.





Bitmap Textures

Geometry

Final Bitmap Image

Alias PIX (als) AVI (avi) Cineon (cin) DDS (dds) EPS (eps) GIF (gil) JPEG (pg) Maya IFF (if Maya16 IFF (#) PSD (psd) PSD Layered (psd) PNG (png) Quantel (yuv) RLA (rla) SGI (sgi) SGI16 (tg) Softmage (pic) Targa (Iga) Tilf (SI) Tim16 (kir) Windows Bitmap (bmp) Sony Playstation [tim] XPM (spm)





Exploring Maya

Before exploring modeling and animation concepts, it is a good idea to become familiar with the Autodesk Maya user interface. The user interface is where 3D artists display and organize scenes, save and open files, and transform and animate objects. While developing these skills, 3D artists learn just how they can make Maya do what they want it to.

Maya has a very clean user interface where many of the elements share generic editor windows. At first, this may make it difficult to distinguish different parts of a scene but with experience, 3D artists learn the power of this paradigm. The generic way in which Maya presents information makes it very easy to transfer skills from one area of Maya to another. This lets 3D artists focus on learning the underlying concepts of Maya software instead of always relearning how the user interface works.



The Workspace

reating an animation in Maya involves the manipulation of many ✓graphic elements such as curves, surfaces, colors and textures. Information about these elements is stored in Maya as numeric values that can be viewed in a number of different ways. In the workspace of Maya, you can choose how you want to view a scene and access different tools to alter its 3D information. Maya offers several ways of accessing and altering your scene, giving you the flexibility to build workflows that best suit the way you work.

User Interface Elements

When you first launch Maya, the workspace is presented to you with a number of user interface (UI) elements. Each is designed to help you work with your models, access tools and edit object attributes. Initially, you should learn the locations of the UI elements so you can easily find them while you work.



Many UI panels can be set up as floating windows in case you just need them temporarily. Menus can also be broken off from menu bars in case you need to focus on the menu's contents.

Menu Sets

The first six menus are always available in Maya; the remaining menus change depending on which menu set you choose. This helps focus your work on related tools.

Tool Box

The Tool Box is where you find some of Maya's most common tools. From top to bottom, they are: Select, Lasso, Paint Selection, Move, Rotate, Scale, Universal Manipulator, Soft Modification, Show Manipulators and the last tool you used.

Quick Layout Buttons

The Quick Layout Buttons offer you quick access to Maya's predefined panel lavouts.

Time Slider

The Time Slider shows you the time range as defined by the range slider, the current time and the keys on selected objects or characters. You can also use it to "scrub" through an animation

Range Slider

This bar lets you set up the start and end time of the scene's animation and a playback range, if you want to focus on a smaller portion of the Time Line

Menus

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Menus contain tools and actions for creating and editing objects and setting up scenes. There is a main menu at the top of the Maya window and individual menus for the panels and option windows.

Status Bar

The Status Bar contains shortcuts for a number of menu items, as well as tools for setting up object selection and snapping. A Quick Selection field is also available that can be set up for numeric input.

KYYY&44

The workspace can be

evaluating your scenes

multiple panels that offer dif-

ferent ways of creating and

Panels

divided into

Shelf

The Shelf is available for you to set up customized tool sets that can be quickly accessed with a single click. You can set up shelves to support different workflows. Press Shift+Ctrl+Alt when selecting a menu item to add it to the Shelf.

IN COLUMN

View Compass

The View Compass is a navigation tool that allows you to quickly switch between the perspective and orthographic views.

Channel Box

The Channel Box lets you edit and key values for selected objects.

Layers

ini ei

Maya has two types of layers. Display Layers are used to manage a scene, while Render Layers are used to set up render passes for compositing. In each case, there is a default laver where objects are initially placed upon creation.

Playback Controls

The Playback controls let you move around time and preview your animations as defined by the Time Slider range

Characters

The Character Menu lets you define one or more characters, then prepare them for being animated.

Help Line

The Help Line gives a short description of tools and menu items as you scroll over them in the UI. This bar also prompts you with the steps required to complete a certain tool workflow.

Command Line

*** 14 |e 4

* [5

This bar has an area to the left for inputting simple MEL commands and an area to the right for feedback. You will use these areas if you choose to become familiar with the MEL scripting language.

The Workspace

Simplifying the User Interface

All of the UI tools that are available when Maya is first launched can be turned off or on as needed. In fact, you can turn them all off and focus on one single view panel if this is how you like to work. In this case, you would use interface techniques such as the hotbox, hotkeys or the right mouse button to access tools and options.



This is a single shaded view panel with the hotbox being used to access tools. Most likely, you will configure the workspace somewhere between this minimal setup and the default setup.

Hotkeys

Hotkeys will give you quick access to many of the tools found in Maya. To set up hotkeys, select **Window > Settings/Preferences > Hotkey Editor**. The Hotkey Editor lets you set up either a single key or a key and a modifier key such as Ctrl, Shift or Alt,

to access any tool in

It is also possible

Maya that is listed

in the Editor.

to build custom

commands using a MEL (Maya Embedded

Language) script.

own workflow.

This feature allows

you to set up the UI to

completely reflect your



The Hotkey Editor gives you access to all of the tools in Maya.

Mouse Buttons

Each of the three buttons on your mouse plays a slightly different role when manipulating objects in the workspace. Listed here are some of the generic uses of the mouse buttons. When used with modifiers such as the Alt key, they also aid in viewing your scene.

The Hotbox

The hotbox gives you access to all of the menu items and tools right at your cursor position. When you press and hold down the space bar on your keyboard, after a short delay, the hotbox appears. The hotbox is fully customizable and lets you focus on the tools you feel are most important to your workflow. The Hotbox controls let you turn off the main menus and the panel menus in the workspace. When the menus and panels are off, you can focus entirely on using the hotbox.



Marking Menus

Marking menus are accessed by selecting a hotkey and clicking with your left mouse button. The menu appears in a radial form so that all your options are simply a stroke away. Once you learn the location of the menu options, you can quickly stroke in the direction of an option without having to see the menu itself. Because the menu is radial, it is very easy to remember the location of each menu option. It will only take a short time for you to master this way of accessing tools.

You can set up your own marking menus by building them in **Window > Settings/Preferences > Marking Menu Editor**, then assigning the new marking menu to a hotkey.



First Use

When you first use a marking menu, press the hotkey, click and hold it with the mouse while you view the options, then drag to the desired location in the menu.





Expert Use

As you become an expert, you can quickly press the hotkey and click+drag to the desired location in the menu. The menu doesn't appear and your selection quickly flashes by.

Left Mouse Button

This button is used to select tools and objects and access visible manipulators.

Middle Mouse Button

This button is used to edit objects without the manipulator. This button is also used to click+drag. If your mouse has a wheel, it can be used to scroll into windows.

Right Mouse Button

This button is used to invoke context-sensitive menus and marking menus such as the one shown here.





Viewing 3D Scenes

hen building a scene in Maya, you work in V three-dimensional space. Orthographic and Perspective view cameras offer several ways of looking at the objects in your scene as you work. There are also different display options that change the way objects in your scene are shaded.

Default Views

In Maya, the default views are set as Perspective, top, front and side.

The Perspective view is a representation of your object in 3D space, allowing you to move along the X, Y and Z axes. The top, front and side views are referred to as Orthographic views and allow you to move in two dimensions at a time.

Extra Views

Orthographic views

180 in the Channel Box.

To create new orthographic views,

select Panels > Orthographic >

New. Make a back view panel by

creating a new front view and change

Translate Z to -100 and Rotate Y to

In addition to the default views, you can create your own cameras. To add a new 2D view, select Panels > Orthographic > New > and select Front, Side or Top. To add a new 3D view, select Panels > Perspective > New.



Camera views

To create a new camera, select Panels > Perspective > New. You can also select Create > Camera from the menu which offers some unique camera options.





Default Perspective View





New Perspective View





Viewing 3D Scenes

Default Top View



Default Front View

View Tools

By pressing the Alt key along with different mouse button combinations, you can navigate around the objects in your scene.

While the Tumble Tool is only used to rotate a 3D Perspective view, you can track and dolly in many other views including the Orthographic, Hypergraph, Hypershade, Visor and Render View.



Default Side View

Press the Alt key plus the left mouse button to rotate the camera around a 3D Perspective view.

Track

oğ€ Press the Alt key plus the middle mouse button to pan from left to right and up and down.

Dollv

Press the Alt key plus the right mouse button to dolly in and out of your scene. Using the mouse wheel also has the same effect. Note that a dolly is different from a zoom. Dollying moves vour camera closer to or farther from your subject. Zoom is accomplished by changing the focal length of a lens.



Shading

The Shading menu in Maya offers several options for displaying objects in a scene. Shading can be different for each view panel, allowing geometry to be shown at different levels of complexity.

The more detailed a scene becomes, the greater the need to simplify the objects in it. Although Maya is very good at processing complex levels of geometry, it is a good idea to view your objects in a less complex shading mode until you are ready to render or make adjustments to those objects.

There are several shading display options to choose from. The default shading in Maya is Wireframe. Other display options include: Bounding Box, Points, Flat Shade, Smooth Shade, Hardware Lighting, Wireframe on Shaded and X-Ray.

Show Menu

The Show Menu allows you to show and hide different elements of a scene. You can show all or none or specific items such as NURBS curves, lights or cameras.

The Show Menu is accessible from all views and can hide items in one view while displaying them in another.



The Show Menu allows you to edit a NURBS curve in the Side view with NURBS surfaces turned off while viewing the Perspective view panel with NURBS surfaces visible.

Isolate Select

State.

The Isolate Select option allows you to hide surfaces at both the object and component level, on a per-panel basis. To hide the Control Vertices (CVs) of an object, choose the CVs you want to modify and select Show > Isolate Select > View Selected. This will hide all unselected CVs.

Another advantage of using Isolate Select is that it affects hardware rendering only, allowing hidden objects to be viewed during software rendering.



Using Isolate Select allows you to hide CVs on a NURBS surface.



Bounding Box Bounding Box displays objects as boxes. This is useful when working with complex scenes.



Flat Shade **Smooth Shade** Flat Shade displays all or Smooth Shade displays only the selected objects all or only the selected with lower resolution. objects, as smooth surfaceted display. faces with surface color and shading properties.



Hardware Lighting Hardware Lighting displays smooth-shaded surfaces with textures and lighting.



Wireframe shading is

the default shading

Wireframe

Points Points shading displays objects as a group of points that represent the quality in Maya. shape of the object.



Hardware Texturing Hardware Texturing displays smooth-shaded surfaces with textures.



High Quality Renderina

High Quality Rendering displays surfaces with more accurate texturing. bump mapping, transparency and lighting.

Hardware Fog Hardware Fog displays surfaces with a userdefined fog. This is useful to simulate a

Shade Options

In addition to the default shading mode, there are two shading options for viewing your models: Wireframe on Shaded and X-Ray modes. Both of

Viewing your model in Wireframe on Shaded mode will allow you to easily view surface isoparms for all objects in your view panel without viewing through the object.

Viewing your model in X-Ray mode will allow you to view through your model using a semi-transparent shading. This is useful when you want to see a surface that is behind other surfaces or inside objects such as skeletons within a character.



X-Ray X-Ray shading displays objects with a semitransparent surface.



Wireframe on Shaded Wireframe on Shaded displays a wireframe on a



scene fog.

these options can be used at the same time.



Objects and Components

You can transform objects in Maya by selecting objects and their components. Selection masks allow you the flexibility to select only the items you want in a scene. These masks are grouped into three categories: Hierarchy, Object type, and Component type selections.

Object Types

Rendering

Curves

Turning off the curve

selection means you can not select the curves in the scene.

Scene objects such as lights, cameras and texture placement nodes are rendering object types.

Scene objects are items such as cameras, curves, surfaces, dynamics, joints, handles and deformers. Objects created in Maya are made up of two parts: a Transform node and a Shape node. The Transform node contains basic information about an object's position, orientation and scale in space. The Shape node defines what the object looks like.



A simple hierarchy where middleFingerGroup is the parent of middleFinger and middleFingerNail.

Hierarchies

A hierarchy consists of at least two nodes arranged in a parent-child relationship. Working with hierarchies can help keep your modeling and animations organized. You can use the Outliner or Hypergraph windows to see your hierarchies.

> Skeleton Joints Skeleton joints are used to help control characters.

Handles

IK handles are applied to joint chains for animation control.

圅

Deformations Deformers such as cluster flexors and lattices modify the shape of an object.

Objects and Components



Surfaces

Selecting by surfaces

allows you to select the surface geometry of an object.

Dynamic objects such as particles can be separately selected by toggling the Dynamics button on.

Component Types

In order to change the shape of an object in Maya, you need to modify component type information.

There are a variety of component types such as points, isoparms, faces, hulls, pivot points and handles. These components can be used to interactively modify and reshape the appearance of an object.

Points

Points such as CVs and polygonal vertices are used to modify the shape of an object.

Param Points Param points are points that lie directly on a curve or surface.

Lines such as isoparms

and trim edges define

the shape of an object.

Lines





Faces Faces are patches created by intersecting lines.

connect CVs. They can

be used to select and

transform rows of CVs

Pivot points determine

transformations occur.

the location around which

Hulls are guides that

at once.

Pivot Points

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exploring maya





Hierarchy

Object Component

Selection Masks

Selection masks allow you to select the specific items you want to work on. There are three main groups of selection masks: Hierarchy, Object and Component.

Hierarchy mode allows you to select nodes at different levels. In this mode, you can select the Root, Leaf and Template nodes.

Object mode allows you to select scene elements at the Transform node level. These include objects such as surfaces, curves and joints.

Component type selections are selections made to objects at the Shape node level, such as isoparms and CVs.

Selection Priority

Objects and Components are selected in order of priority based on an assumed production workflow. For example, if you want to select both joints and surfaces, Maya anticipates that you want to select joints first. To select more than one object with different priorities, select the first object and Shift+click on the object of different priority.

Hierarchies

When working with a group of objects that are arranged in a hierarchy, you may want to specifically work at the Root node or Leaf node level.

If you choose to work at the Root node level of a group (also known as the top node in a hierarchy) you can toggle on the **Select by Hierarchy: Root** mask. In this selection mode, you can click on any object in the hierarchy and only the top node of the object picked will be selected.

If you want to work at the Leaf node level, toggle on the **Select by Hierarchy: Leaf** mask. In this mode, only the leaf nodes or children of a hierarchy will be selected.



Hierarchy

Selecting by hierarchy allows you to select objects at either the Root, Leaf or Template node level. Unlike Object and Component selection masks, you are not able to turn on more than one mask at a time.



Object

Object selection masks allow you to make selections based on the object types you specify. Left-clicking on the arrow to the left of the pick masks displays a menu allowing you to turn all objects on or off.



Component

Component selection masks offer a variety of pick masks to choose from. Right-clicking on a mask displays more selection options.



Preferences

You can change the order in which Objects and Components are selected by choosing **Window** > Settings/Preferences > Preferences and choosing the Selection category.





Toggling on the **Select by Hierarchy: Root** mask allows you to select any Leaf node in a hierarchy to automatically select the Root node.



Clicking the right mouse button over an object will bring up a marking menu that allows you to choose from both Object and Component selection types, while remaining in Component mode. The menu

choices are specific to the object selected or the object beneath the marking menu.



Quick Select

Using Quick Select, you can type in the name of an object in the text field and it will become selected in your scene.

When there are several objects in a scene with a common name, you can type in the name preceeded and/or followed by an asterisk (*) and all objects containing that name will be selected.











Dependency Graph

Everything in Maya is represented by a node with attributes that can be connected to other node attributes. This node-based architecture allows connections to be made between virtually everything in Maya. Node attributes determine such things as the shape, position, construction history and shading of an object. With this architecture, you can create inter-object dependencies, shading group dependencies, and make your own node connections.

Nodes with Attributes that are Connected

The Dependency Graph is a collection of nodes which are connected. These connections allow information to move from one node to another and can be viewed in a diagrammatic fashion through the Hypergraph and Hypershade windows.



Right Mouse Button

Clicking the right mouse button over a selected object will give you access to an object's input and output connections.



Animation Curve

When an animation is produced in Maya, node dependencies are created between the animation curves and the object being animated.

Node Dependencies

In the diagram below you can see the nodes that are dependent on each other to make up a chess piece. Each node plays a part in creating the final rendered object. Here you see that: the Shader node is dependent on the Shape node to render the material, the Shape node is dependent on the Revolve node for the chess piece surface and the Revolve node is dependent on the Curve node to make the revolve.





Shading Group Dependencies

When a material is created in Maya, a network of node dependencies is built. This network is referred to as a Shading Network.

The Hypershade window allows you to make and break connections between shading group nodes. The Hypershade displays thumbnail images representing each node. The diagrams below both show the same shading group dependency in the Hypershade and Hypergraph windows.



Hypershade

Using the Hypershade, you can make materials and textures and view the node dependencies used to create them.



Hypergraph

The Hypergraph window can also be used to view and create shading group dependencies. However, it does not have swatches as the Hypershade does.

Viewing Dependencies

Dependencies are relationships created between nodes that are connected. There are many ways to view and edit dependencies in Maya including the Hypergraph, Attribute Editor and Channel Box.

By selecting a node and clicking the Up and Downstream Connections button in the Hypergraph window, you can view node dependencies on a selected node. This window visually displays the connection between nodes, with arrows showing the direction of their dependency to one another.

The Attribute Editor is made up of several tabs allowing you to view related nodes of a dependency group. In the Attribute Editor, you can edit the attributes that affect these nodes.

In the Channel Box, the selected node is shown with a listing of any keyable attributes that belong to it. Depending on the node selected, it will also show input, output or shape nodes. If you select more than one node with the same keyable attributes, you can modify them at the same time using the Channel Box.



Making Connections

Connections made in Maya represent the flow of information from one node to another. You can make your own connections between nodes as well as break connections using the Connection Editor.

The Connection Editor offers a list of node attributes that can be connected to other node attributes. For example, you can map the scale of one object to influence the rotation of another. This creates a connection between the two nodes where every time you scale one, the other automatically rotates.

The Connection Editor can extend the possibilities of your production by automating tasks done through the connection of nodes.



Connection Editor

The Connection Editor allows you to make connections between nodes attributes.



Hypergraph

In the Hypergraph, you can view the result of connections made in the Connection Editor.

Construction History

When an object is built in Maya, Input nodes can be viewed in the Dependency Graph containing information on how the object was created. These Input nodes allow you to edit an object based on the geometry used to build it. For example, if you were to create a curve and use the Revolve Tool to make a surface from it, the curve used to create the surface would hold information as to how the surface was created. Using construction history, you can go back to the original curve and alter the shape of the object.





Construction History Deleted



Transformations

Transformations are changes made to an object's position, orientation and scale in space. The Transform node holds all of this information and the Transformation Tools such as the Move, Scale and Rotate Tools are used to transform an object along the X, Y and Z axes.

Manipulators

Manipulators are used to move, scale and rotate objects in orthographic and 3D space. Each of the manipulators use red, green and blue colored handles. These match the colors of the X, Y, Z locator at the bottom left corner of the view, making it easier to distinguish the direction of the transformation. These handles are designed to constrain the transformation to one, two or three axes at a time, allowing for complete control.





Move Tool The Move Tool has a handle for each X, Y and Z axis and a center handle to move relative to the view.

Rotate Tool The Rotate Tool has a ring for the X, Y and Z axes. One ring moves relative to the view, and a virtual sphere rotates in all directions.

Scale Tool With the Scale Tool, you can scale non-proportionally in X, Y or Z. You can also scale proportionally by selecting the center handle.

Setting Pivot Points for Transformations

Objects are transformed around their pivot point location. This is important to be aware of because the position of your pivot point affects the outcome of your transformation. To change the location of your pivot point, select a Transform manipulator and press the **Insert** key on a PC or the **Home** key on a Mac. Move your pivot point to the desired location and press the **Insert** or **Home** key again to set the pivot point.



Object is rotating around a properly positioned pivot point.



Move/Rotate/Scale Tool

This tool incorporates the Move, Rotate, and Scale manipulators into one tool. Select Modify > Transformation Tools > Move/Rotate/Scale tool to use this tool.

QWERTY Hotkeys

To work quickly and efficiently in Maya, the QWERTY hotkeys offer a fast way to access the transformation tools. To select the tool you want, simply press its corresponding key on the keyboard: Select (q), Move (w), Rotate (e), Scale (r), Show Manipulators (t). In addition to these tools. Maya offers access to the last tool you used by pressing the y key.



Use the QWERTY shortcut keys on your keyboard to select and transform the objects in your scene.

Reset Transformations

Once you have manipulated an object, you may not be satisfied with its new transformation. To reset your object to its original position, select **Modify** > **Reset Transformations.**

Freeze Transformations

Select Modify > Freeze

Transformations to keep your object's current position, rotation and scale as its default position. This means that your object will now have values of 0 for its Translate and Rotate attributes and a value of 1 for its Scale attributes.

Iransformations

Scale Tool

The Scale Tool allows you to change the size of an object both proportionally and non-proportionally. The default coordinate system for scaling is local. Double-clicking on the Scale Tool icon will open the **Scale Tool Settings** window, where you can modify the tool's default behavior.



Move Tool

The Move Tool enables you to move objects through 3D space using one of four coordinate systems: **Object**, **Local**, **World** and **Normal**. The default system is **World**, but you can change this in the **Move Tool Settings** window by double-clicking the Move Tool icon.

Each object has its own coordinate space with the origin located at the object's pivot point. When the object is rotated, the object's axes are also rotated.

Local space uses the pivot point of the parent or root node in a hierarchy as the location for its axes. Thus, all objects are moved in relation to their parent.

World space is the coordinate system for the scene. When objects are moved, they are moved relative to the origin of the scene.

Normal space exists at the component level and all coordinates are relative to the surface you are working on. The axes are U, V and N, where U and V represent the axes that lie on the surface and N the axis that points out from the surface, known as the surface normal.



Use the Rotate Tool to rotate an object around any of the three axes. The Rotate Tool Settings window offers three rotate modes: Local, Global and Gimbal.

А п	ame Rotate	Tool		
Tool Defaults				
+ Rotate Options				
Rotate Mode 4	C Local	C Global	C Gimbal	



Local

Local is the default setting. It allows you to rotate an object in Object space. Note that in this mode, the axes rotate with the object.



Global

Selecting Global mode means the object will rotate within world space. In this mode, the manipulator rings never change direction.



Local



Object



Normal

2D Transformations

When transforming an object using the Move Tool in the top, front and side views, you are constrained to move only in two dimensions. When using the Rotate and Scale Tools in an Orthographic view, you can transform an object in both two and three dimensions.



Universal Manipulator

The Universal Manipulator is similar to the Move/ Rotate/ScaleTool, but it lets you transform objects



with greater precision. When you click on its manipulator handles, a numerical input field appears for you to enter a precise value by which you can transform an object.

axis at a time.

Gimbal In Gimbal mode you can rotate your object in only one



Animation

When 3D artists animate, they paint with motion instead of color. As an object moves, rotates or changes shape over time, it is being animated. This motion can be at a constant speed or it can accelerate or decelerate. At times, this motion will attempt to mimic real-world events such as an object falling off a table, while at other times, it will take the form of an actor telling an audience a story.

Models that are animated must be set up with mechanical properties that define how they work. To have a door open and close or a drawer slide in and out, 3D artists must understand the mechanics of their models so they can animate them.

There are a number of tools for creating motion in Maya software. In some cases, 3D artists will animate all the parts of an object separately. In others cases, they use higher level controls to help streamline their workflow. Situations can even be set up where the animation of one object controls that of another.



Animation Techniques

When you animate, you bring to life otherwise static and motionless objects. You take aspects of the object such as its position, size, shape and color and change these over time. If these changes are set up properly, you create motion that instills character and life in the object.

In Maya, there are a number of ways to animate an object. Using a bouncing ball as a common example, it is possible to explore the different animation techniques available in Maya. In a real project, you will most often combine several of these techniques to achieve the best results.

Setting Keys

Setting keys or keyframing, is the most fundamental technique for animating in 3D on a computer. This technique involves recording attribute values as keys for one or more objects at particular points in time. As you set multiple keys, you can play back the scene to see your object animated.

Setting keys gives you a great deal of control over timing. When you animate using keys, you generate animation curves that plot the key values against time. These curves are great tools for analyzing and editing the motion of an object. Other animation techniques are usually combined with some keyframing. Most animation you do in Maya will involve some form of setting keys.

Keying Attributes

By setting keys on attributes at different times, you define the motion of an object.

For example, Translate X is keyed at the beginning and end of the bounce.

Translate Y is keyed with an up and down motion that is fast near the ground and slow near the peak of the bounce.



Secondary Motion Rotate Z defines the rolling of the ball; scaling of the ball is used to indicate its impact with the ground.

Path Animation

Path animation involves attaching the object to a curve where points on the path are used to determine where the object will be at particular points in time. It is easy to understand the way an object moves around in 3D space through a path, since its curve clearly depicts where the object is going.

Method 1

A curve is used to represent the path of the bouncing ball. This method lets you describe the path of the bounce by shaping the curve, but timing the bounce requires the setting of several motion path keys to lock down the motion.



Method 2

Here, a curve is used to replace the X and Z translation of the ball while the Y translation, rotation and scaling are keyed normally. This method is ideal if you want to animate the ball bouncing along a curved path, which might suit a cartoon-style bounce.



Hierarchical Animation

You set many of your keys on the Transform nodes of your object. By grouping an object to itself, you can set up different nodes with their own pivot points and orientation, then key them on their own. This added complexity isn't really required for a bouncing ball, but can be very useful for more complex objects where you want different levels of animation.



Animation Curves

By setting keys, you map the attribute's value to time. The keyframes are then connected by an animation curve that helps define the attribute inbetween the keys. The Maya Graph Editor shows you the speed of the motion and lets you reshape the curve.



When building a hierarchy for motion path animations, it is always helpful to reserve a node for the motion path.



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Set Driven Key

Set Driven Key allows you to control or "drive," the value of one attribute with another attribute. The relationship between the two attributes is defined by an animation curve. The driving attribute can be used to drive multiple attributes. For example, the rotation of an elbow joint could drive a bulging bicep muscle and the wrinkling of a sleeve.

Custom attributes can be added to a control node. then connected to other attributes in the scene using Set Driven Key. This creates centralized controls.



Drivers

Set Driven Key lets you use one attribute to drive other attributes. Here, the Translate X of the ball drives the Translate Y and roll of the ball. As the ball moves forward, the bouncing action takes place. The resulting animation curves map the keyed attributes to Translate X instead of time.

Expressions

Another way of animating object attributes is through expressions. Expressions can be mathematical equations, conditional statements or MEL commands that define the value of a given attribute. Expressions are evaluated on every frame. You can animate using an expression when you have a mathematical relationship that you want to achieve. In the case below, the absolute value of a sine wave creates the bounce of the ball.



ball4.translateT = 5"abs/sin(time*3)); ball4.rotateZ = -(time *420)

Bounce Expression

A sine wave placed on time creates the bouncing motion. An absolute value function keeps the motion in positive Y and the forward motion is driven directly by time. Other multipliers are used to control the size of the bounce and the phase of the motion. Expressions are evaluated at every frame of the animation.

Non-linear Animation

Non-linear animation uses animation clips that contain keyframed motion. These clips can be cycled and blended with other clips in the Maya Trax Editor. For a bouncing ball, a single bounce clip could be cycled, then blended with a clip of the ball rolling. These clips can be moved, scaled, cycled and blended. You can also add and subtract clips from the Trax Editor to quickly explore different animation options.



Dynamic Simulation

To animate a ball that is bouncing off a series of objects or against a non-flat terrain, a dynamics simulation is required for the most realistic results. The ball can be turned into a rigid body that is propelled forward using dynamic attributes. Forces such as gravity or wind can then be applied to the ball to bring it to the ground.

Objects in the scene can also be turned into rigid bodies so the ball will collide with them. If they are passive, they will not be affected by the collision. If they are Active Rigid Bodies, they will move as the ball hits them. In the end, the simulation can be baked to turn the motion into keys.

Initial Velocity

When an object is set up for dynamics, it can have attributes such as initial velocity and initial spin that give it a starting motion.

- 6 ⁶ 6 6 6 6 6 6

Active Rigid Bodies

An active object is affected by forces and by collisions with other Active Rigid Bodies. Active objects will animate during a simulation.

Fields

Objects can be subjected to fields such as gravity, wind or turbulence.

Passive Rigid Bodies

Passive objects are used as collision objects by active objects, but they do not react to either forces or collisions.



Setting Keys

For an object to be animated, it must change over time. For example, a car might move forward or a light might blink on and off. To animate these changes in Maya, you need to set keys for the car's Translate X attribute or for the light's intensity. Keys are used to mark attribute values at specific times. Then, animation curves are used to determine the value in-between the keys.

As a 3D artist, setting keys is one of your most important techniques. This animation technique can be easily applied to your objects and the results can be easily edited. Once you are familiar with this technique, you will soon find that you spend less time setting keys and more time editing the motion.

Keying Attributes

When you set keys, you key values for one or more of an object's attributes at specific frames in time. These keyframes set the values, while tangents set at each key determine the interpolation in-between the keys. This interpolation results in an animation curve that can be edited in the Graph Editor. This editing feature helps you control the quality of your motion.







In Maya, virtually every attribute is keyable.

As you learn more about the different nodes available in Maya, you will begin to discover

models. For example, if you keep an object's

Construction History, you can set keys on the Input node's history. You can also set

materials, cameras and other node types.

unique possibilities for animating your

keys on attributes belonging to lights,

Step 1: Keyframes

Keys are set for at least two points in time. You can set keys for one or more attributes at the same time. The keys are then stored as animation curves.

Step 2: Animation Curve Shape

In the Graph Editor, you can view and edit the animation curves. At each key, there are tangents set that define the shape of the curve.

Step 3: Playback

Next Key Play ——

Keying Attributes

When you play back an animation, the object uses the keys and the values defined by the animation curve to create the resulting motion.

< Backward | Forward >

Last Frame Next Frame —

The Time Slider

Timing is one of the most important components when creating an animation. You must ensure your key poses are timed properly and that the in-between motion achieves the desired results. The Time Slider lets you play back or "scrub" your animation to evaluate this timing. You can also edit the timing of the keys.



Click+drag in the Time Slider to quickly preview the motion. You can drag with your middle mouse button to change time without updating object values.

You can import a sound file into Maya, then load it into the Time Slider using the right mouse button. The audio waves will be visible to help you synchronize your keys. The animation's Range and the Playback Range can be set separately. This makes it possible to preview subsections of a larger animation by updating the Range Slider.

Setting Keys



How To Set Keys

There are a number of ways to set keys in Maya. Each one offers a different way of recording time and value information. In some cases, you may want to set keys for a number of objects and in others, you may want to set keys for a single attribute. The results are always the same, as animation curves are created for any attribute for which you set a keyframe. The only difference lies in choosing a workflow that meets your needs.



Channel Box

The Channel Box always displays the keyable attributes of a selected object. The Channel Box also lets you highlight one or more channels and then select Channels > Key Selected to set keys for the highlighted attributes on all the selected objects.

What is Keyed?

Generally, you set keys on attributes belonging to selected objects. You can further control which attributes are keyed using the Set Key options where you can work based on keyable attributes, the manipulator handles or the pop-up Character Menu (where you only key character-specific attributes).

Keyable Attributes

By default, the Set Key command sets keys for all keyable attributes of a given object or character set. Attributes can be set as either keyable or non-keyable from Window > General Editors > Channel control. The keyable attributes are visible in the Channel Box and can be keyed with the Animate > Set Key command. Animated attributes that are non-keyable retain the keys set while keyable.

Manipulator

Keys can also be set using your manipulator as a reference. In the Set Key options, you can choose to either use the manipulator or the manipulator handles as the keyable attribute. Therefore, keys would be set depending on which manipulator you are working with. This allows you to focus your keyframing on the attributes you are currently editing.

Character Menu

If a character has been selected from the Character menu found under the playback controls, only that node will be keyed with Set Key. The use of this menu assumes you have chosen a characterfocused workflow when setting keys. You can set the character to None to set keys on other objects in the scene.



driver

Selected Character

Set Key

The Animate > Set Key tool is designed to create keys for all the keyable attributes that exist on selected objects or characters. If a character is selected from the character pop-up then it is keyed. Otherwise the selected object is keyed.

...0 🐼



Attribute Editor

When viewing attributes in the Attribute Editor, you can click the right mouse button over individual attributes and choose Set Key. Since this window shows both keyable and non-keyable attributes, you can use this method if you need to key an attribute that does not appear in the Channel Box

Viewing and Editing Keys

To view and edit keys, you can focus on the animation curve's shape or its timing. Select Window > Animation Editors > Graph Editor to access the animation curves and define their shape and timing. Select Window > Animation Editors > Dope Sheet to focus on timing. In both windows, you can set the attribute value, edit tangents and cut, copy and paste keys.

In the Graph Editor, you can edit the weighting of the tangents. This feature provides you more control over in-between motion. This is in addition to the various in and out tangents that you can set in both windows using the menus. As you become more proficient with the Graph Editor curves, you will begin to appreciate the Dope Sheet where you can easily make more general edits.





Graph Editor

This window offers a view of the animation curves themselves. This makes it possible to view the in-between motion and edit curve tangents. You can also move keys around and edit their values.

Dope Sheet

The Dope Sheet focuses on keys. You can select keys hierarchically and edit them using this window. For example, you can use the Dope Sheet Summary to edit keys for all the selected objects.

Hotkeys

A fast and easy method for setting keys is through hotkeys. Hitting the S key will set a keyframe for all keyable attributes on the selected object or character set. Pressing Shift w, Shift e or Shift r, will set keys for just the translation, rotation or scale of an object.

iel Key	×
Enter list of tim	es:
5 10 15	
OK	Cancel

Prompt

One of the Set Key options is to use a prompt window to let you set the keys for multiple points in time. For example, you could set a key for frames 5, 10 and 15 all at once using this window. The same attribute value would be keyed for each of these times.



Auto Kev

Auto Key lets you key automatically as you edit objects in your 3D views. Auto Key will set keys whenever the value of an animated attribute is changed. Make sure to turn this option off when you have finished using it.



Modeling

Modeling is the process of creating shape and form on screen. Models in

Maya can be hard objects with sharp edges or organic objects with a softer look. Using one of several geometry types, 3D artists can build surfaces,

then push and pull points to change their shape.

Modeling on the computer can be a challenge at first because the goal is to mimic 3D objects on a 2D screen. In this chapter, 3D artists will learn how to use manipulators and different view panels to navigate this virtual world so they can focus on sculpting and building their models.

While building good looking models is important, 3D artists must also be aware of how the model will be used down the line. Models might need to bend or twist or simply move around your scene. Also, the way surfaces are texture mapped will depend on how they were



Geometry

The mathematics of geometry is used by the computer to determine what you see on the screen. The Maya user interface gives you tools to edit geometry without having to understand the math behind it.

In order to build complex scenes, you need to understand how to manipulate geometry and how the geometry will be animated and texture mapped down the line. A good looking model is only complete when it satisfies the needs of all aspects of the animation process.



Points, Curves and Surfaces

Points, curves and surfaces are the basic geometric elements that you will use to create and manipulate 3D objects on the computer.

The creation of surfaces from points and curves is the essence of modeling in Maya. Sometimes, you start with an existing surface and manipulate its points to define shape and form. Other times, you start with carefully constructed lines or curves that are then used to build a surface. Either way, you will work to give a physical presence to these basic geometric elements.

Building a Scene

Above is a wireframe view of a street scene. Complex scenes can be redrawn more quickly when viewed without hardware shading or texturing.



Points

Points are defined in three dimensions using X,Y and Z coordinates. In Maya, control points are used to help define the shape of object types such as curves (CVs), surfaces (vertices, edit points) and lattice deformers (lattice points). Points are also very useful as references for snapping.

- Objects

One surface is often not enough to fully define an object in 3D. When a series of surfaces is positioned in relation to each other, you begin to get more complex models. These models require grouping to bring together the parts into a selectable hierarchy that can work as a single object, while not denying you access to the individual parts.

Geometry Types

One of the first decisions you have to make when you start a project is how you are going to build your models. There are four types of geometry: polygons, NURBS, Subdivision and Bezier surfaces.

You can use any geometry type to create either simple or complex models. You can use one geometry type as a starting point for another or you can build models that combine geometry types. In general, if you are building organic shapes, you will probably use NURBS or Subdivision Surfaces. They will give you smooth surfaces and have the fewest control points, making edits to the surface easier. Since NURBS are limited to a four-sided patch, there are limitations to the types of organic shapes you can make from a single surface. This is where it is beneficial to use Subdivision Surfaces because they can represent many more types of shapes with a single surface. If you are building non-organic shapes, such as a desk or wall, it is easier to use polygons because they easily make shapes like corners or edges. If you are building a surface that combines hard edges with an organic shape, Subdivision Surfaces work well. In this chapter, you will learn more about your options so you can decide on the geometry that best suits the way you want to work.



NURBS

NURBS geometry is spline-based. The geometry is derived from curves and surfaces approximated from the surface's control vertices (points) locations. NURBS allow you to start with curves that are then used to generate surfaces. This workflow offers precise results that can be easily controlled. All NURBS surfaces are four-sided patches, although this shape can be altered using the Trim Tool.

Polygons

Polygons are shapes defined by vertices that create three, four or n-sided shapes. Polygonal objects are made up of many polygons. Polygons can appear flat when rendered or the Normals across adjacent faces can be interpolated to appear smooth.

Subdivision Surfaces

To create objects with Subdivision Surfaces, you need some understanding of both NURBS and polygonal modeling. Subdivision Surfaces are mostly built using a polygon mesh as a base and then refined. The advantage of using this geometry type is that detail is added only where needed. It creates smooth surfaces like NURBS but does not have the limitations of being four-sided patches.

Scene Hierarchy View

Within the Hypergraph window, you can view the objects in the scene and any relationships between them. An object will have a Transform and a Shape node. The Transform node contains information such as translation, rotation and scale. The Shape node contains information such as History, Tessellation, Render Stats and Object Display. When vou select an object, the Channel Box will display information for both the Transform and Shape nodes. If you are using the Attribute Editor, the Transform and Shape nodes will be represented by different tabs.



Shape node

Tessellation

The Maya renderer requires polygonal objects in order to be able to execute rendering calculations. Therefore, NURBS and Subdivision Surfaces are broken down into triangles or tessellated, during the rendering process. The advantage of letting the renderer tessellate a spline-based model is that you can set the quality of your tessellation to match the size and scale of your object in a scene.





Even though the boot is a NURBS surface, it will be tessellated into triangles when it is rendered. This is true for all surface types that are rendered in Maya.



Modeling Techniques

Aboosing the geometry type that best suits your model will depend ✓on several factors, such as: how the model is going to be used, how complex the model has to be, whether the model will be animated and deformed and what kind of texture maps will be used. If you are unsure of what type of geometry to work with, it is possible to begin with NURBS because it can be converted to polygons or Subdivision Surfaces later. Polygons, however, cannot be converted to NURBS, but can be converted to Subdivision Surfaces.

Starting with Primitives

One of the most common ways to create a model is to begin with a primitive shape. This simple shape is then molded or expanded to add more detail. This technique using polygons is frequently used for developing environments and characters for interactive games. NURBS primitives, such as spheres and cylinders, are commonly used to begin organic modeling of objects such as body parts. A polygon cube is a good place to start a Subdivision model by simply converting it to a Subdivision Surface and then beginning to extrude.



Primitives









The model on the left was created from a NURBS primitive sphere that had several spans and sections in both directions to have sufficient detail. The Artisan Sculpt Surfaces Tool was used to create the main shape, which was then tweaked with CV manipulation. The model above began as a polygon cube. It was then scaled, had faces extruded and was finally converted to a Subdivision Surface.

Network of Curves

For more precise surfaces, a network of curves can be used to control the shape and parameterization of the surface. Surfaces can be created from curves, trim edges or isoparms. For industrial types of modeling, creating a network of curves is essential for smooth and precise surfaces. There are several tools within Maya to create a network, such as: Snap to curves and Point Snapping, intersecting and projecting curves, Animated Snapshots, curve rebuilding and surface curve duplication.



The thumb was created using a profile curve for the base of the thumb and attached to a motion path. The curve was scaled and deformed at the end of the path to the shape of a thumbnail. Finally, an Animated Snapshot was performed to create the curves to use for a Loft.

Symmetry

Most objects in life, whether they are organic or industrial, have symmetry. Modeling only half the object and mirroring it offers an efficient method for completing the entire object. This technique is widely used for industrial design, but can also be used for organic shapes such as heads and bodies. A helpful tip for viewing a mirrored copy update interactively while you work on one half, is to use an Instance duplication with a negative scaling instead of a regular copy.



The human head is one surface and not mirrored. Instead, it was created using the Artisan Paint Tool with the Reflection feature that sculpts on both halves at the same time. The alien head was modeled as one half and mirrored as a -1 scale in the X-axis.

Patch Surface Modeling

This method of modeling requires more planning than the others. This method creates a surface out of many smaller NURBS surfaces that have surface continuity and, typically, the same number and positioning of isoparms.

The planning stage of patch modeling involves deciding where the cutlines are to be positioned and what the parameterization of the surfaces will be. The Stitch and Rebuild Surface Tools are used extensively to create surfaces with this method.



Organic Modeling

When the surfacing tools are not sufficient to create the shape you are looking for, direct control point manipulation sometimes is the only solution. Artisan is an excellent tool for creating broad shapes but it can be difficult to use in tight areas where you may need to manipulate only a few CVs or vertices at a time. Manipulating on such a fine level is an art in itself that demands patience and skill.

Selecting the points for manipulation can be the first challenge because it is easy to accidentally select points on the back of the model. Artisan Paint Selection Tool can be handy for selecting or deselecting points since it works on the surface under the brush and does not affect points on the back surface. Also, being able to hide unselected CVs lets you focus on the surface without the clutter, making it easier to change your selection. On NURBS models, when hulls are on they offer good visual clues as to where the CVs are in space. After the selected CVs have been modified, use the keyboard arrows to pick-walk to the next row.



The left model displays only those CVs that are being modified. By pressing F, the view is focused to center on whatever is selected, making tumbling the camera easier for evaluation of the affected surfaces. The model on the right uses the Paint Selection Tool to select front surface vertices, avoiding wrong selections on the opposite side of the model.

Rotoscoping

If the model needs to have exact proportions or is being developed from a sketch, you can import reference images as backdrops and rotoscope (or trace) them. Maya Image Planes are objects in the scene that can display images or textures. Each Image Plane is attached to a specific camera and provides a background or environment for scenes seen through that camera.

> An Image Plane is used as a guide to model a hand. Image Planes can use single image files, a numbered sequence of image files or a movie.



NURBS Surfaces

The foundation of a NURBS surface is the NURBS curve. To create NURBS surfaces efficiently, you must be proficient in creating good curves. The same principles behind NURBS curves are applied to NURBS surfaces since the two are related. There is an obvious difference: a NURBS curve has only one direction, while the NURBS surface has two directions. The two directions on a NURBS surface have an origin and together they define the Normals of the surface, which determine the front and back of the surface. Being aware of these surface properties will help when using certain modeling and rendering operations, such as attaching surfaces or texture placement.

Anatomy of a NURBS Surface

The components of the NURBS surface are very similar to those of the NURBS curve, except the edit points are not moveable. NURBS surfaces have CVs, hulls and spans which define the shape of a four-sided surface. NURBS models, whether they are organic or industrial in nature, are generally made up of several adjoining foursided patches. As with the NURBS curve, it is desirable to define surfaces with the fewest evenly spaced isoparms or CVs. As earlier stated, the quality and type of curve will affect the characteristics of the surface. However, the surface parameterization can be modified after creation by duplicating the surface curves at the desired locations and re-lofting.

Hulls

The hull comprises straight lines that connect CVs. When you select a hull, you are actually selecting all of its associated CVs. The hull offers a better visual cue for the distribution of CVs in a crowded area.

Isoparms

Isoparms are lines that represent cross-sections in the U and V directions. Isoparms can be inserted, removed, used to make curves and snapped to. If you select an isoparm that's not a span or section, it displays as yellow dots. If you select an isoparm that is a span or section, it displays as a solid, yellow line. This distinction is important for some modeling actions.

Control Vertices They do not exist on the actual surface but are used to manipulate the shape of the surface.

Surface Point

You can select a Surface point that represents a measurement of U and V. The values at this point are dependent on the parameterization of the surface.

Surface Patch

A NURBS surface patch is defined by an enclosed span square. Several patches can be selected and duplicated to create individual NURBS surfaces.



NURBS Marking Menu

Surface Origin

Turning on this display option highlights the first U and V isoparms (red and green) and labels them U and V. It also draws a line indicating the surface Normal direction (blue).

Spans

A span or segment is the space between isoparms at edit points. When creating surfaces using Revolve, Primitives, Loft or rebuilding, you can specify the number of segments or spans.

NURBS Surfaces

Building Surfaces

Birail Surface

Primitives

The majority of the surfacing tools begin with creating curves defining the surface. In some cases, the curves are used to create simple surfaces that are then rebuilt and modified by CV manipulation. Other times, the curves are used to create much more complex surfaces that would be difficult to attain otherwise. To help you understand

Profile Curve 1

Rail 1

Profile Curve 2

the operation of the tools, view the Help Line as you scroll through the menus.

The Birail Tool creates a surface by using two or more profile curves that sweep along two rails. The profile curves must intersect the rail curves to create a surface. Profile and rail curves can be isoparms, Curves-on-Surface, trim boundaries,

or boundary curves of an existing surface. The advantage of this tool over the Loft is

greater control with the addition of rails.

NURBS primitives are common geometric

objects such as spheres, cubes and cylinders. Primitives are often used as the foundation for other shapes.

Loft: Select curve(s), isoparm(s) or trim edge(s)

Rail 2

Profile Curve 3



Fillet Blend Surface

The Fillet Tool creates a seamless blend between two surfaces. The three types are: Circular Fillet, Freeform Fillet and Fillet Blend. These terms are discussed later in this chapter.





Loft Surface

A Loft Surface is created when a surface is applied to a series of profile curves that define a frame. There must be at least two curves or surface isoparms and ideally the same parameterization for each curve, to achieve a clean surface. If the curves have the same curve degree and parameterization, the Loft Surface will have the same number of spans in the U direction.





Deformed Half Sphere

Trim Surface

To create a trimmed surface, a closed Curve-on-Surface is required. There are various ways of creating these curves which will be discussed later in this chapter.



Extrude Surface

The Extrude Tool creates a surface by sweeping a cross-sectional profile curve along a path curve. The profile curve can be an open or closed curve, a surface isoparm, a Curve-on-Surface or a trim boundary. The extruded surface on this model creates a lip for the scooter surfaces and gives the illusion of depth.



Revolve Surface

The Revolve Tool creates a surface defined by a profile curve that revolves around a defined axis. The use of construction history is very useful to tweak the shape after the revolve operation. The front fender began as a revolved surface that was then scaled, deformed and finally trimmed. The tire and rims are simple revolves.





Polygon Modeling

Polygons can be defined as a number of connected points that create a shape or face. Points are connected by edges that surround the resulting face. A face can exist as triangles, quadrangles (quads) or n-gons. Joined together, they create a polygon mesh. A polygon mesh can be created using the Primitives that come with Maya, but a more complex shape results from using the Maya polygon editing operations. A polygon mesh can also be created by a conversion from NURBS, Subdivision Surfaces, Paint FX, Displacement or Fluids.

Polygon Components

Each polygon mesh consists of components that are modifiable to help create and edit the mesh. These main components are vertices, edges, faces and UVs. There are polygon editing operations in Maya that allow you to edit these components. You will need to select the individual components that you wish to modify, by toggling on **Convert component selection** (Preferences > Modeling > Polygons). Maya will automatically switch to the right component type for any given edit operation and perform the operation as instructed.



Use the right mouse button over the model to access a marking menu that will allow you to change selection modes interactively. This method allows you to select multiple component types.



Polygon Objects

All of these objects were created from polygons. Some models (like the scooter and the gallery) were created with a specific polygon count target in mind. This means that these models do not exceed a certain number of polygon faces. While these restrictions apply to game content, models created for softwarerendered output often do not fall under these restrictions.

Polygon Creation

To create a polygon shape, select **Mesh** > **Create Polygon Tool**. After placing a point, use the middle mouse button to alter its position.





You can continue to place points until the desired shape is achieved. Press Enter to finish.

Non-planar Polygons

When working with quads and n-gons, you should be aware that if a vertex lies off the plane from the other vertices, it creates a non-planar face. To avoid this when creating or appending polygons, you can toggle on Mesh > Create Polygon Tool > Options > Keep new faces planar. If this situation occurs as a result of a modeling operation, then either triangulate the non-planar faces or use the cleanup operation to tessellate faces with four or more sides. While non-planar faces can be rendered in Maya, they may cause problems if you are creating a polygon mesh for export to a game engine.



The first shape has only three sides and by nature is planar. The second and third shapes have four sides each, but appear to be planar.



The third shape has the fourth vertex on a different plane than the other vertices of its face. The third face is considered non-planar.

Polygon Primitives

Maya includes several polygon primitives that can give you a starting point for your model. The majority of these primitives are closed shapes and all primitives are created with a default set of UV information. These primitives have construction history which can be modified at any time.

Modeling a Head

Extruding Faces

under Edit Mesh > Extrude

directly to the division points.

Joining Objects

shells as well.

Splitting Polygons

Using some of the more common polygon modeling tools, the steps for creating a polygonal head are illustrated below.



A default cube was created and then smoothed by selecting Mesh > Smooth. The two rear bottom faces were then extruded to create the neck and the front lower edges were moved down to create the chin.



The lower faces of the front were split for the nose and the middle edges were moved up to create the eyebrow area. The nose and eyes were created by splitting faces in the appropriate areas and then moving vertices to get the desired shape



The mouth was created by splitting the faces in the mouth area and then moving vertices.



The eyes and neck were further refined and then the edges of the model were smoothed in the proper areas.

You can further refine your shape by extruding the face of a polygon. This extrusion operation inserts faces at the edges of the face to be extruded and allows the selected face or faces to be moved, scaled or rotated from their original position. If you are extruding multiple faces and want them to maintain a cohesive shape, toggle on Edit Mesh > Keep Faces Together. This only inserts faces at the edges on the border of the selected faces. Otherwise,

faces will be inserted at every edge. This tool can be found

The Split Polygon Tool allows you to divide a polygonal

face. You can also use the tool to insert vertices on an

edge. To assist you, the tool has options that allow you

to set how many Snapping Magnets you want and the

Snapping Tolerance for the magnets. By setting Snapping

Magnets to 3, the edge being split will have three equally

Sometimes you will create the individual parts of a model and then want to join them together. For objects to be

must be combined to create a single object and must have

objects will create a single object with construction history

their Normals pointing in the same direction. Combining

relating back to the original objects. The separate pieces

of the new object are called shells. Shells are pieces of an

object that are not connected to the rest of the object by

shared edges. Objects that are combined with opposing Normals will give an unexpected result when their edges are merged. This is because their edges run in different

directions. This is true for appending polygons between

The border edges of the left arm and left torso

Merge operation is applied. The arm and torso

now share common edges and the holes in the

left side of the torso and left arm are closed.

opening are selected and the Edit Mesh >

joined, they must match certain criteria. The objects

spaced division points. Increasing the Snapping Tolerance increases the influence of the magnets. With a Snapping Tolerance of 0, the vertex can be added anywhere on the edge. A tolerance of 100 will force the vertex to snap



Face four is selected. This is the face that will be extruded.



After the extrude is complete, new faces were added at the edges of the extruded face.



is to divide a face in half. This is done with a tolerance of 100.



The torso and arms are selected and ready to be combined. Mesh > Combine to do this.



The same steps as before are applied. But, the result is different because the edge direction of the two shells are opposite each other. Maya was able to merge the front edge of the right arm and the rear edge of the torso, but could not continue and stopped merging edges.



However, the face can be split any way you want as long as the last vertex ends up on an edge.



The three objects have been combined into one object. However, there are three separate shells



Here you can see the problem. The left arm and torso have their Normals pointing out, while the right arm's Normals are pointing in. You could solve this by selecting a face on the right arm, select Normals > Reverse > Options. Toggle on All faces in the shell and Reserve user normals and then press Reverse Normals. The right arm's Normals now follow the rest of the object and the edges can be merged properly.







Deformations

In the real world, some objects are hard and some are soft. The surfaces on the soft objects can be bent and folded into different shapes. This kind of surface deformation can be set up and animated in Autodesk[®] Maya[®].

Pushing and pulling the control points on a surface deforms its shape.

Yet to sculpt every surface point-by-point can be time consuming. Maya offers deformation tools that give 3D artists a higher level of control. A deformer applied to one or more objects can be used to achieve bending and twisting

by editing a few control points or attributes.

Deformers can also be used as modeling tools because they are great



Deforming Objects

any objects in our 3D world are able to change their shape -Many objects in our op world are taken to a rubber ball squashes and stretches as it hits the ground, and human skin bends as the elbow rotates. To achieve these kinds of effects in Maya, surfaces have to be able to have their shape animated. This means animating the positions of control points instead of simply translating and rotating the whole object.

Types of Deformation

In Maya, there are a number of ways to change or deform the shape of an object. These deformers can be used to help you model surfaces or animate organic forms. While there are a set of tools in Maya called deformers, there are other tools that change the shape of objects. By becoming familiar with all of these techniques, you can best decide which one can be used in your work.



A face with no deformations.



The same face after using surface deformation to reshape the nose, add smile, round out the cheeks, widen the chin, and make folds for eyelids.

Deformers

Maya has a category of tools called deformers that either perform a specific type of surface deformation such as twist or bend or make the process of deforming a surface easier in some way. For example, a lattice is a cage-like manipulator made of a small number of lattice points. Each lattice point controls several control points in a specified region of the surface. Moving one lattice point can affect many control points on the surface that would be difficult to select and move individually.

CV and Vertex Edits

The most rudimentary method of deforming a curve or geometry is to select component level control points and translate, rotate or scale them. This is useful when you need to move a surface point to a specific location

deformations

Simulated Deformations

Maya has features for simulating properties of cloth ing and soft, dynamic moving materials like curtains, flames and flags. A soft body is a geometry object whose control points are controlled by particles and dynamic fields such as turbulence and gravity.

Skeleton Chains

A skeleton chain consists of joint nodes that are connected visually by bone icons. Skeleton chains are a continuous hierarchy of joint nodes that are parented to each other. You can group or bind geometry (skin) to these joint hierarchies. You can then animate the joints (usually by rotating them) and the geometry will be animated. Binding geometry to a skeleton causes the geometry to be deformed as the skeleton is animated. For example, you could rotate a neck joint and the geometry around the neck joint would rotate as well.

Deformer Sets

When a deformer is created, certain control points of the surface will be affected by it. The control points that are affected by a given deformer are said to be part of that deformer's membership. Maya keeps track of which control points are members of which deformers by using sets. It is possible to add or remove control points from a deformer's set membership by selecting **Edit Deformers > Edit Membership Tool.**



A non-deformed sphere with its CVs displayed.



Alternatively, an explicit list of the CVs belonging to this set membership can be viewed and edited by selecting Window > Relationship Editors > Deformer Sets.



To select the lattice, click on Edit Deformers > Edit Membership Tool. This highlights the CVs on the sphere that are affected by the lattice. The yellow CVs are part of the lattice's membership.

Deformer Order

One of the many powerful and flexible features of deformers is the ability to layer multiple deformers together. For example, you could apply Bend, Lattice, Blend Shape, Skeleton and Cluster deformers on the same object and all will interact to produce the final deformation. However, the order in which Maya evaluates these deformers does affect the final shape. Fortunately, you have control over the order in which the deformers are evaluated.



Here, a Squash deformer is added first, then a Bend deformer. Notice that the how the deformation looks.



When the order of deformation is reversed so

the deformation.

that the Bend deformer is evaluated before the

Squash deformer, the result is a different look to

Augusta de la companya de la company





The same sphere with a lattice deformer applied. The top rows of lattice points have been moved up to deform the sphere.



A row of CVs is removed from the lattice's membership with the Edit Membership Tool. Now the deformer has no effect on those CVs.



To access the List of History Operations window, place the cursor over the object and use the right mouse button and select Inputs > All Inputs. This window displays a list of Input nodes connected to the text object. Click+drag the middle mouse button on the list of items to the left to change the order Maya evaluates these Input nodes.

Artisan Sculpt Surfaces Tool

Maya Artisan provides you with a set of brushes to sculpt detailed organic models, for simple NURBS surfaces, subdivision surfaces and polygon meshes. You can push, pull, smooth or erase deformations on your model and even add a texture map to further displace it.



Select Edit NURBS/Subdiv Surfaces > Sculpt Geometry Tool to use the Artisan Sculpt Surfaces Tool. This is an easy way to paint deformation onto a surface interactively.



The model after the Sculpt Geometry Tool has been applied. This second image uses a more detailed surface, allowing subtle definition and wrinkles to be added.



Deformers

Lattices, clusters, wires, sculpts and wraps are deformers that can manipulate a large number of points using simpler objects and, therefore, offer a mechanism to animate points in a more controlled and predictable manner. Lattice, cluster, wire, sculpt and wrap deformers are used in both the modeling and animation process, with the focus being more heavily on animation. These deformers are located under the Deform menu and each offers a unique solution for deforming surfaces.

When any deformer is used as a modeling tool, you can use a Delete History operation to bake in the deformations. If you are not satisfied with the resulting deformation, you can simply delete the deformer and the surface will snap back to its original shape.

Lattice Deformer

A lattice deformer surrounds a deformable object with a cage-like box that you can manipulate to change the object's shape. Operations such as translation, rotation or scaling can be applied to the lattice object or to the components to deform the underlying surface. The lattice can encompass the entire object or any number of control points. Even a lattice can be deformed since it is also a deformable object.

When a lattice is created, there are actually two lattices created: an influence lattice and a base lattice, the latter of which is invisible by default. When the influence lattice is edited, the resulting deformed surface is generated by calculating differences between the lattice points of the influence lattice and the base lattice.





Pushing Through a Lattice If you push an object through a lattice, you get the cartoon effect of an object being pushed through a keyhole.

Wire Deformer

Wire deformers are like the armatures used by sculptors to shape objects. With a wire deformer, you use one or more NURBS curves to change the shape of objects.

In character setup, wire deformers can be useful for setting up lip and eyebrow deformations. Wire deformers can also be useful for shaping objects during modeling. To create further wrinkling effects, you can also use the Wrinkle deformer.





Lattice Deformer You can specify the lattice's structure in terms of S, T and U divisions. The greater the number of

divisions, the greater the lattice point resolution.

🖬 ffd3Base

Soft Modification Tool

The Soft Modification Tool lets you push and pull geometry as a sculptor would pull and push on a sculpture. The amount of deformation is greatest at the center of the push/pull, and gradually falls off farther away from the center.

🛃 ffd3Lattice

The Soft Modification Tool is located in the Toolbox. The corresponding action is **Create Deformers > Soft Modification**.



History

Every time you use the Soft Modification Tool, a softMod node is created, allowing you to go back to previous nodes and make changes. These nodes can also be animated just like any other deformers.

Deformers

Flexors

Flexors are special deformers designed for use with rigid skinning. They provide various types of deformation effects that improve and enhance the effects provided by rigid skinning. There are three types of flexors that can be attached to a skeleton: lattice, sculpt and joint flexors. Once they are applied, the joint is usually rotated to see the effect of the flexor and further adjustments can be made. Set Driven Key is an ideal tool to set up a relationship between the flexor and its affecting joint.

jointFlexor12	
Creasing	1.3
Rounding	1.4
Length In	-4.2
Length Out	1.4
Width Left	0
Width Right	0

Wrap Deformer

The function of a Wrap deformer is similar to that of a lattice deformer, with some slight differences. The most obvious being that a Wrap deformer can be made from a NURBS or polygon mesh and be any shape. Just like the lattice, the wrap also creates a base shape and any difference in position, orientation or shape between the base shape and the wrap influence object results in a deformation of the surface. This technique uses an influence object with fewer points than the object you are deforming. The primary visibility is turned off for the wrap deformer, so it does not render.



Flow Path Object

deformer

The Flow Path Object function creates a lattice around the object that has been animated on a motion path. This technique allows the object to deform to the

shape of the curve. There are two options: around the object or around the path curve. They both achieve the same look unless you decide to add deformations to the lattice.



Clusters

Using clusters solves some fundamental problems for keyframing control points. These points can only have their position in space animated because they don't have a Transform node. Clusters are deformers that create a set out of any number of control points from one or more multiple surfaces and provide them with a Transform node. Once a cluster has been created, you have the ability to keyframe its scale and rotation based on the cluster's Transform node's pivot point. You can also group clusters into a skeleton hierarchy.





Six CVs around the top eyelid are clustered and weighted. The pivot point for the cluster is then placed at the center of the eye so the surface deforms around the eyeball. Without a cluster and pivot point, the eyelid would move straight through the eyeball.

After creating a cluster, you can assign a percentage to the CVs to control the amount the points will move via the Edit Deformers > Paint **Cluster Weights Tool.** For example, if a control point is weighted 1.0, it will move 100 percent of the transformation. A value of 0.5 will only transform 50 percent. The top row of CVs for the eyelid are weighted 0.5 and the bottom 1.0. This allows for nicer tucking when the eye is open. Otherwise, the top of the eyelid would recess too far into the head with a value of 1.0.



created with the weighting at the default value of 1.0. The adjacent image shows the same cluster, but with the CVs weighted in a tapering effect. The selected CVs are shown in the Component Editor with their assigned weight.

Sculpt Deformer



Sculpt deformers are useful for creating any kind of rounded deformation effect. For example, in setting a character for animation, you could use sculpt deformers to control a character's cheeks or to bulge a bicep. When you create a Sculpt deformer, select components to only affect that region of the model.





The Sculpt Tool can be very useful for simple bulging effects, but it also allows for much more complex deformations. For example, you can use a NURBS surface that deforms to create a more organic feel, or you could use a texture map where you can paint the deformer influence.



Character Animation

One of the most challenging and rewarding forms of computer graphics is character animation. Here, 3D artists combine the transformation of a digital skeleton with the deformation of a skinned surface to set up a character that walks, talks and moves around in 3D space.

Of course, a character doesn't have to be a human or an animal. Any object that is animated with expression and tries to speak to the audience through its actions is considered a character. In fact, the same techniques used to animate a dog might be used to animate a dancing bottle, a tiger or a tree.

Autodesk Maya allows you to combine all the controls found on different parts of a character into one or more character sets. This makes it easier to pose characters and work with them in the Maya non-linear Trax animation system. These techniques



3D Characters

A3D character is a digital actor. Whether your character is a tin can that bounces with personality, or a photorealistic human being, the animator will need to control it easily and interactively. The specific requirements of the character's motion will dictate the complexity of the character's controls. Maya offers many tools for the creation of these digital performers.

A Typical Character

The character's mechanics must be convincing to an audience and the skin and clothing must also move and bend properly. Maya includes a number of tools that help you manage the parts that make up a typical character. This process of preparing character controls is called rigging and is used to let the animator focus on the process of animating. A fully rigged character can be quite complex as it brings together skeleton joints, surfaces, deformers, expressions, Set Driven Key, constraints, IK, BlendShapes, etc.

Skeleton Joints

Joints are used to create a framework for a character's hierarchy. The rotation of the skeleton joints defines the motion of the character. You can use inverse kinematics for even more control.

Character Controls

Using animation techniques such as Set Driven Key and expressions, you can set up attributes for controlling different parts of a character. For example, a hand joint could have attributes used to control the different finger joints.

Constraints

It is possible to constrain the kinematic controls of a skeleton to objects in your scene or even simple locators. You can then animate the constraint weights to make a character pick something up or grab hold of a fixed object.

Selection Handles

Selection handles give you quick access to parts of a character's hierarchy that are to be animated. This makes it easier to work with a character after it has been rigged up for animation.

Character Resolution

A fully rigged 3D character includes many bound surfaces and deformers that can slow down the interactive manipulation and playback of the scene. Therefore, a low resolution character that has surfaces parented to the skeleton makes it possible to work interactively while animating. You can then switch to the fully rigged character for rendering. A low resolution version of a character also makes it possible to begin animating before the entire character is fully developed.

Facial Animation

To animate facial features, you can use deformers such as BlendShape to create facial poses that can be used for talking and for showing emotion.

Kinematics

To control your skeleton joints, you can choose from forward or inverse kinematics. Forward kinematics allows you to set the joint rotations directly. IK allows you to position IK handles, which rotates the joints.

Bound Surfaces

Surfaces of a character's skin and clothing can be either parented or bound to the skeleton joints to make them move together. Binding places points from a surface into clusters that are then associated with particular joints.

Deformers

To help the surfaces bend realistically at joints, deformers such as flexors and influence objects can be used.



As you animate, you can use low resolution surfaces parented to your skeleton to achieve more interactivity while animating.

A Typical Character Animation Workflow

The development and animation of a 3D character involves a number of steps. Once you have a design, you must begin to build the character's model, lay down skeleton joints and rig the skeleton so that it is capable of an appropriate range of motion. Character controls can also be set up to assist the animation process.

While it is possible to work in a linear fashion, starting with modeling and ending with rendering, most productions require some form of concurrent work to be done. An animator might need to begin laying down motion while the model is still being finished. At the same time, character deformations and texture maps may each be assigned to different parts of a team. For this reason, you may use your low resolution character to begin animating and blocking out scenes while the higher resolution character is refined and set up for deformations and rendering.

Motion Capture

As an alternative to setting keys, you can use motion capture to simulate real-life motion on a character. Generally, motion capture involves recording joint positions and rotations from an actor that are then applied to a skeleton. Motion capture works well with non-linear animation where motion capture clips can be blended together.

Note that you can import mocap data from Autodesk[®] MotionBuilder[™] software via the FBX[®] file format.





Motion capture offers realistic motion performances that can be imported as animation curves and applied to digital characters.



The animation from the low resolution character is applied to a fully rigged skeleton with

bound surfaces and deformers.

Rendering

The character is rendered in its final setting. You might also render the character on its own, then use a compositing package to integrate it with the background.

Character Design

In support of the story, the character is designed using sketches, storyboards and in some cases, clay models. These visual aids give the 3D artist a clear understanding of the character and the character's range of motion and emotion.



Skeleton Rigging Using sketches or the model as a guide, joints are drawn and kinematics and character controls are set up



A fully rigged model that uses low resolution surfaces parented to the skeleton can be used for initial animation studies

Binding Skeleton

skeleton and joint rotations

tested. Deformers are used

to enhance the final look.



On a typical character, you will have many attributes on many different nodes that need to be keyed. A character set allows you to collect those attributes in one place and build up a character definition. When this character is highlighted in the

O None art_student art student art_student_face 🕨 🔿 legs 🏒 O arms ' Character Sets. O mainBody O head_neck

pop-up Character menu, that character set is active whether or not it is selected. This feature makes it possible to easily set and edit keys for that character since it is always active. Character sets are also necessary to animate using non-linear animation through the Trax Editor since Trax clips can only be created for a character set.

Select Character > Create Character Set to start a character, then select Character > Set Current Character Set > Character Set Editor to add and subtract attributes from the set. The Character menu found near the Time Slider can also be used to highlight a character.



Character Sets

This set is the root of a character setup. You can have attributes assigned to the character or you can assign sub-characters to it. If you select this set and set keys, you also key the sub-characters.

Sub-Character Sets

These sets help break down a character into smaller parts in case you want to focus on one area. These sets can be set up to control specific body parts such as arms, legs and facial features.

Keyable Attributes

For each character and sub-character set, you can choose which keyable attributes need to be brought together to effectively animate the different parts of the character.

🕶 legs ..0 🐼



Animating Characters

o animate a character, you must deal with a large number of attributes that are scattered around the many joints, IK handles and Transform nodes that make up the character. A number of tools can help you consolidate these attributes and make it easier to set keys on your character.

Character Sets

Character Sets offer you high-level control over your character. These sets let you collect attributes from different parts of a Character and edit and set keys on them in a single place. Keys set on Character Sets are transferred to the associated attributes.

Character Sets are given special treatment when they are highlighted on the Character menu. A highlighted character is keyed by the Set KeyTool (S key), even if its parts are not selected in the workspace. Highlighted characters also show up in the Graph Editor without having to be selected.

neckJoint2.rotateZ

neckJoint2.rotateY

neckJoint2.rotateX

neckJoint3.rotateZ

neckJoint3.rotateY

neckJoint3.rotateX

• at s

O am

O mainBody

O head_neci

Character Pop-up Menu

This pop-up menu found next to the timeline in the

lower right of the workspace lets you quickly select

and edit characters and sub-characters. The char-

acter set highlighted here is the active character.

pint1.rotateZ

nint1 rotate\



Sub-characters

Sub-characters can be created for different parts of a character to give you more control. These breakdowns should mimic areas that you want to animate as a group.





Relationship Editor

If you select Character > Set Current Character Set > Character Set Editor or Character Set Editor from the Range Slider toolbar, you open the Relationship Editor. Highlight a Character Set on the left, then click on attributes on the right to add them to the Character Sets



Character Mapper

Use the Character Mapper to establish a relationship between a source character's nodes or attributes and its target. Then you can import and export or copy and paste, animation clips between the mapped characters in the Trax Editor.

Animating Characters

character animation



shaderit J.

Character Sets

Non-linear Animation

to the highlighted character.

add attributes to characters.

Some attributes will be part of a character or

sub-character when they are created. To add more

attributes, you can highlight them in the Channel

Box, then select Character > Add to Character

Set. You can also use the Relationship Editor to

Attributes

To animate using non-linear animation, you must have character sets set up. Only character and sub-character sets will be recognized when you create clips and poses and place them into the Trax Editor.

Constraints

Constraints allow you to control a character using other objects (such as locators). Constraints let you control parts of a character like the position of IK handles with a point constraint or the rotation of joints with an orient constraint.

The advantage of constraints is that they are flexible. If an arm or leg cannot reach its constraint, it pulls away from the constraint gently, rather than being abruptly stopped. When you see this pulling, you can quickly adjust other constraints to minimize the pulling of the first constraint.



Arm

A character's hands can be constrained using point and orient constraints. You may want to parent these to the shoulders so they move with the body. If you have any finger attributes, you may want to use the locator as a Control node



Eves

Aim constraints can be used to control a character's eyes. These would be parented to the head but could still be moved on their own to offset the gaze. It is a good idea to use a different locator for each eye to avoid having a cross-eyed look.



Elbows and Knees

A pole vector constraint can be used to control the positioning of elbows and knees. These locators help orient the IK handle's pole vector, which helps prevent the IK solution from flipping. Pole vector constraints can also be parented to parts of the body.

Animated Constraint Weights

It is possible to add more than one constraint to an object. Each of these constraints is given a weight, and the object will be constrained based on the average of the constraints' weights. Therefore, you can animate an object that switches from one constraint to another by keying the weights from 0 to 1. If you are animating the weights, make sure you don't set all the weights to 0. This would create a confusing situation for your object when working interactively.



Step 1: Character Constraints

The character's pelvis, arms and legs are constrained to locators. The arm locators are parented to the shoulder so they move with the body, while the leg and pelvis locators are in world space. This lets you move the character freely without it being locked down.



Step 2: Scooter Constraints

The arm locators are parented to the handle-bars so they rotate with the steering mechanism. The leg locators are parented to the running board and the pelvis locator to the seat. When the scooter moves, the character constraints will also move.



Step 3: Key Initial Weighting

While the character walks freely, the character constraints are keyed at 1 and the scooter constraints are keyed at 0. This puts the character constraints in control until the character sits down. You will want to add the Constraint node's weight attributes to a Character node to make sure they are keyed with the character.



Step 4: Key Final Weighting

As the character sits on the scooter, the character's constraint weights are keyed at 0 and the scooter constraint weights are keyed at 1. Now you can animate the scooter and the character will follow. You might want to animate the scooter constraint weight for the pelvis to move up and down as the scooter goes over bumps.

Control Nodes

In some cases, you will not want to add every attribute to a character. Instead, you will want specific Control nodes that have custom attributes linked using reactive animation techniques (such as Set Driven Key or direct connections), to other attributes in the scene. This creates an intermediate level of control that lets you focus on fewer attributes, while maintaining control over many attributes.









Control Nodes and Manipulators

Dynamic or custom attributes can be added to specific nodes to let you animate several other joints or attributes using one control. Some custom attributes could roll a finger while others could control an eye's pupil dilation. These attributes would later be included in a character set for automatic keyframing.



Materials and Textures

While geometry describes the shape of an object, its material describes how its surface will appear when rendered. In the real world, when light hits a surface, it reacts to the surface qualities. Some of the light is absorbed and some is reflected. A shiny object reflects light directly, while a matte object diffuses the light. While reflected light does not actually illuminate surfaces in Autodesk Maya, materials and textures can be set up to simulate the real-world reaction of surfaces to light.

To create realistic images, material qualities such as color, specularity, reflectivity, transparency and surface detail must all be set. Maya uses special connected nodes called Shading Networks to set up the material qualities of your surfaces.

Textures let 3D artists create more complex looks for their surfaces. A texture can be a set of procedures set up in Maya or a bitmap image



Shading Your Models

While geometry defines the shape of a model, shading defines how the model's surfaces react to light and details such as color, transparency and texture.

Maya uses Shading group nodes to tell the renderer which materials, textures and lights will affect the final look of a surface. Shading networks are made up of nodes that define the final look of a rendered surface. Learning the proper role of each of these nodes will ensure that you build shading networks that render successfully.

Material Qualities

Before actually looking at a more complex shading network, it is useful to consider the various material qualities that you will be trying to achieve. A basic understanding of how an object is shaded can be translated into attributes on shading network nodes in Maya.



The geometry shown as a wireframe becomes more realistic with the addition of shading networks that add color and texture.

Basic Shading

Shading shows you how the surface appears when illuminated. As light hits a surface, it defines a gradation from light to dark that makes the surface's 3D qualities apparent.

Highlights and Reflections

As a surface becomes shinier, it begins to show highlights and reflections. Specular highlights show the hotspots where the light sources are reflected, while reflections simulate light bounced from surrounding objects.



Surface Relief

Surface relief, such as bumps and scratches, helps add a realistic look to a surface. This effect can be achieved with special textures called **bump** and **Displacement Maps**.



Transparency

It is possible to see through transparent areas, such as the glass on this jar, while opaque areas, such as the label, cap and paint, remain solid. Transparent surfaces, such as glass, can also bend light. This is called refraction and can be achieved in Maya using Raytracing.

Evaluating Shading Networks

To preview shading networks and texture maps, set up a camera, then illuminate your objects with lights and render. Hardware rendering can be used to quickly preview textures and some lights, while software rendering is required to explore all shading situations. More in-depth discussion of rendering types is found in the Rendering chapter. Lighting and camera information is found in the Digital Cinematography chapter.



Hardware Rendering It offers a preview of the color of textures and up to eight lights.



Software Rendering It is capable of rendering all shading effects such as bump, specular, shadows and all lights.

The Anatomy of a Shading Network

Shading networks are built as nodes that control specific aspects of the shading effect. These networks define how various color and texture nodes work with associated lights and surfaces. The placement of textures on surfaces is also controlled by nodes within the network.

There are several ways to view shading networks in Maya. The Hypershade window lets you easily connect nodes and view the connected attributes. You can also double-click on any node to open the Attribute Editor. Along the way, you can zoom in and out in the Hypershade window to get the complete picture. You can also view shading networks in the Hypergraph window but this view does not give you swatch images.

2D Texture Placement Node

A texture is mapped in 2D space when it is mapped to the UV space of the geometry. This node is used to define the texture's positioning and orientation within the UV space.



3D Texture Placement Node This node lets you define a position in 3D space for your texture and makes it easier to texture multiple surfaces as if they were one. The icon in the modeling views can be used to interactively establish the texture's position in world space.





File Texture Node File textures are bitmap images imported into Maya that can be used for texture mapping attributes such as color, bump or transparency.



Environment Texture Node An environment texture is used to simulate reflections on the surface. This node might be shared among several shaders and have an effect on many surfaces.

Shading Group

This node is the root of the shading network. It sends information about materials and textures, lighting and geometry to the renderer. In most cases, you will not have to work directly with the Shading group node because the Material node is where you will make most of your texture connections.



Material Node

Material nodes define how the surfaces will react to light. The term **shader** is often used to describe the role played by the Material node. In general, this node will be the focus of your work as you build up all of your shading networks.



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The Connection Editor can be used when the desired attribute is not available in the pop-up menu, or when you want to make a special connection, such as the Out Color R of the one node to the Diffuse of another.

Shading Network Connections

Shading network nodes have input and output attributes. Texture mapping involves making connections between these Input and Output attributes. One way to connect them is to drag one node onto another in the Hypershade window. You are then offered a list of input attributes to map to. In this case, the Output attribute is a default attribute, such as outColor. For more complex mapping, the Connection Editor allows you to select input and output attributes directly.



When a texture node is dragged onto a Material node, you are given a popup menu of possible input attributes. This makes it easy to connect two nodes

This makes it easy to connect two nodes together. You can also drag nodes directly onto attribute names in the Attribute Editor to connect them.



Placing the cursor over the line that connects two nodes gives you information about the connected input and output attributes. You can use this information for future reference. To break the connection, select this line and delete it.



Surface Materials

Materials in the real world react to light by absorbing or reflecting it. Polished surfaces are shiny because they reflect light with strong highlights, while rough surfaces have a softer look because they disperse light. A Material node is a mathematical shading model that simulates a natural reaction to light.

The Material node contains a number of attributes that let you control how surfaces are shaded. Maya includes several material types, such as Phong, Blinn and Lambert, that each define a different shading model. The Material node acts as a focal point for shading and texturing information. It is then fed into the Shading group node where it is combined with information about lights and the geometry to be rendered.

Material Qualities

The behavior of light when it strikes a surface in real life is quite complex. Surface imperfections can distort the angle at which light rays are reflected, causing them to scatter, become trapped, or be absorbed. This type of scattered reflected light appears soft and even and is known as diffuse light. Very smooth surfaces have little or no surface imperfections, so light is not absorbed and reflected light is more coherent or focused. When this light reaches our eyes, we see bright specular highlights. These real world behaviors are simulated in Maya with the Diffuse and Specular attributes.



The Material nodes have attributes in two main sections. Common Material Attributes are found on most Material nodes, while the Specular Shading Attributes change, depending on the chosen material type.

Ambient Color

This attribute creates the effect of even illumination, without requiring a light source. In this image, the Ambient color has RGB values of 0.25, 0.25, 0.25 on all objects.

Diffuse

Diffuse determines how much light is absorbed and how much is scattered in all directions by surface imperfections. Rougher surfaces tend to have higher Diffuse values while smooth or mirror-like surfaces have Diffuse values that approach 0.

Color

Color is made up of red, green and blue attributes. The color of light and reflections will influence this base color.

Transparency

White is transparent, black is opaque and other values are semitransparent. You can also use a texture map to create the appearance of holes in a surface.







Incandescence

This attribute can be used to make a surface appear to emit light. The Incandescence attribute is not actually emitting light and has no effect on other surfaces.

Glow

This attribute, found in the Special Effects section of the Material node, can be used to add the appearance of atmospheric noise to a surface.

Specular Highlights

Specular shading attributes determine the amount of light that is reflected at a consistent angle, resulting in an intensely bright region called a specular highlight. Perfectly smooth surfaces will have very bright, tiny highlights because there are no surface imperfections to distort the reflection angle. Rougher surfaces like brushed metals will have a softer highlight.

Combined Effect

In real life, the proportions of the specular and diffuse components of the total reflected light will vary, depending on the characteristics of the surface.

Bump

This attribute lets you add surface relief by using a texture map to alter the direction of the surface Normals.



Reflectivity

This attribute controls the amount a surface reflects its environment. This environment could be a 3D texture map connected to the material's Reflected Color, or actual Raytraced reflections of objects in the scene.

Reflected Color

This attribute can be texture mapped to define a reflected environment without relying on Raytraced reflections. These texture maps are positioned in world space and can be assigned to various materials to make sure the scene's reflections are consistent.

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Material and Shader types

Several different material and shader types offer you distinct shading characteristics. The main difference between materials is how they handle specular highlights when rendered. Shaders are specialized materials that render differently and specifically for some objects.

Below are six of the most commonly used material types and five specialized shaders. Various attributes such as color, bump and specularity can be mapped with textures and will affect the appearance of the final render.

Lambert Material

This material type is the most basic and does not include any attributes for specularity. This makes it perfect for matte surfaces that do not reflect the surrounding environment. The Lambert material type can be transparent and will refract in a Raytrace rendering, but without any specularity, it won't reflect.

Blinn Material

Many artists use this material type exclusively because it offers high-quality specular highlights using attributes such as Eccentricity and Specular Roll Off. This material type can be edited to look like a Phong material, which has sharper highlights, in cases where you need better anti-aliasing of highlights during an animation. This material is good for glass and metals.

Ramp Shader

layer below.

Tin material

(top layer)

This shader gives you extra control over the way color changes with light and the view angle. You can simulate a variety of exotic materials and tweak traditional shading in subtle ways. All the color-related attributes in the Ramp Shader are controlled by ramps.

Layered Shader

qualities of the surface.



Phong Material

This material adds a sharp specular highlight to the Lambert material. The size and intensity of the highlights are controlled by the Cosine Power attribute. This material can also have reflections from either an environment map or Raytraced reflections. The Phong material is good for plastics.



Ocean Shader

anisotropic highlights.

The Ocean shader is a specialized shader with attributes defining realistic waves on large bodies of water. It is usually used through the Fluid Effects > Ocean > Create Ocean command, which automatically creates nodes required to render an ocean



Use Background Shader

The Use Background material is primarily meant for combining CG and live-action components. The material is assigned to stand-in geometry that represents surfaces and objects in the live-action plate. The material then catches shadows and reflections from objects in the scene. Many of the diagrams in this book have been rendered with a white background and a Use Background material assigned to a plane to catch shadows.



Reflection catchers Shadow catchers

To create convincing results, you must set up your lighting and position your camera to match the background image to your model. While compositing, you would remove the image plane and render with a black background. The Use Background shadows are available in the rendered mask channel.



Materials and shaders can be dragged from the Create section of the Hypershade, where you can assign them and make texture connections.



After creating a Material node, you

can change the material type quickly using the pop-up menu in the Attribute Editor. This will change the types of attributes available for shading.

PhongE Material

This material type adds a different kind of specular highlight to the Lambert. The PhongE material includes attributes such as Roughness that controls the softness of the highlight. Whiteness that controls its intensity and Highlight Size.

Shading Map Material

This material type allows you

to create custom shading on

the positioning and color of the

shading and highlights on the

lower end of the ramp.

Hair Tube Shader

width, rendering fine hairs does not require as high anti-aliasing levels.





Ramp texture



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Layered shaders render more slowly than other materials. Instead of using a Layered shader, it may be better to set up a regular Material

node that uses a Layered Texture node mapped to Color. Specular and

Diffuse maps can create the appearance of variations in the material

A Layered shader allows you to combine two or more Material nodes that each have their own qualities. Each material can be designed

separately, then connected to the Layered shader. The top layer's

transparency can be adjusted or mapped to reveal parts of the





Layered shader

White areas of the map are completely transparent, while black areas are opaque. Shown above are the two materials and a map that would result in the layered shader.



Digital Cinematography

When preparing a digital scene, lights and cameras play a very important role. Both lights and cameras make it possible to view objects in a realistic context. Artistically, they both allow 3D artists to control the look of their animation with the same creative control as a live-action cinematographer.

In some ways, the most difficult aspect of using lights and cameras in Maya is that the possibilities are endless. It is very easy to fly a camera around without a clear sense of purpose or add too many lights to a scene. The question is whether or not the creative decisions support the story being told. Therefore, it is a good idea to consider how liveaction movies make use of camera moves and lighting.



How Light Works

ight affects the way in which we see the world around us. Light defines the shape and form of objects and spaces, while at the same time, it works on an emotional level by setting mood and atmosphere. Learning to control light is an important 3D skill.

Cinematographers use light to illuminate the objects in the scene, in order to support the scene's emotional context. The quality of light in a digital shot is equally important, although the rules are different.

Real World vs. Digital Cinematography

In the real world, light bounces. Light starts from a light source, such as the sun or a lamp, and is either bounced or absorbed by all surfaces. An object appears red because the green and blue light is absorbed while the red light is reflected. A cinematographer sets up lights, then measures the light levels, which include both direct and indirect light. This information is used to adjust the exposure settings of the camera.

In Maya, surfaces are illuminated directly by lights. There is no bounced light coming from other surfaces. This is because CG lighting doesn't bounce. Here, film isn't exposed to light and camera controls don't need to be adjusted. Instead, light levels are controlled using the intensity settings of the lights themselves.

In the Real World

The film's exposure to light is controlled by the camera.

- Light is emitted from a source with a controllable intensity. Direct light is hard, while light bounced from other surfaces is softer.
- 2 Light levels are measured using a light meter to determine the proper exposure settings for the camera.
- 3 Camera controls such as F-Stop, shutter angle, exposure time and film speed are set to control how much light is exposed to the film.



To simulate a bounced light in Maya, you would need to use a secondary light such as an area light or an ambient light.

Positioning Lights

Lights can be positioned using the **Show Manipulator Tool**. Each light is displayed with an eye point that defines the position of the light source and a look at point that defines where the camera is pointing. Adjusting these points sets the translation and rotation values on the light's Transform node.

The line between the eye and look at points defines the light's direction. Spot, Area and Directional lights must have their directions set to work properly, while Ambient and point lights only require an eye point position.

You can also position a light by selecting the light, then choosing **Panels > Look Through Selected**. This lets you use the Alt key to dolly and pan the view as if it were a camera. This method often makes it more intuitive to position the light and its look at point.



Creating Lights

Lights can be created using either the Create > Lights menu or using the swatches in the Hypershade. Light attributes can be edited using the light's shape node.

On the Computer

The scene's lighting is directly controlled by the lights.

- A The renderer samples a point on a surface from the camera's point of view.
- B A list of associated lights is taken from the surface's shading group and used to determine which lights should be used in the shot.
- C The light's attributes, such as intensity, color and decay, are used to calculate the illumination on the surface.





Looking through a spot light.

Light Types

Maya has several light types, each of which illuminates a scene differently. A typical scene combines a number of different light types. You can switch between light types in the Attribute Editor.





Spot

Directional

Directional lights use parallel rays of light to illuminate a scene. Shading is very uniform without any hotspots. These rays are similar to the light of the sun, which hits the earth with parallel rays.

Spot lights emit light that radiates

from a point within a limited cone

angle. You can use this cone angle

to limit the area receiving light.



Point

Point lights emit light in all directions, radiating from a single point. This creates an effect similar to a light bulb. This light creates subtle shading effects with definite hot spots.



Area lights emit light using a twodimensional area. The area light's icon can be used to help define the light's direction and intensity. A larger area light has a stronger intensity.



Ambient

Ambient lights emit light uniformly in all directions. The Ambient Shade attribute adds positional behavior. Bump maps are not visible with ambient light alone.



Volume lights emit light in all directions for a finite distance based on a 3D geometric shape. The light shape can be a box, a sphere, a cylinder or a cone.





Light Nodes

When a light is created, it is built with two nodes. The Transform node holds all the information about the light's position and



orientation. For most light types, scaling a light will not change its shape, or the effect of its illumination, but it will allow you to change the size of the light icon to make it more visible in the workspace. The one exception is with area lights, as their intensity is affected by scaling. The Shape node holds all the information about the light's illumination. Some of the spot light attributes can be edited when using the Show Manipulator Tool by clicking on the Cycle Index icon. Each click allows access to different manipulators that control attributes such as Cone Angle or Penumbra Angle.

Spot Light Attributes

The spot light's Shape node contains attributes that control how the light will illuminate the scene. Since the spot light contains the most attributes, it is used as the example here. The other light types contain a subset of the Spot Light Attributes.

Type	SpotLight		
Color			
Intensity	65.000		
	P Bunnales B	Meled v	
	P Ent Difuse	10000	F Ent Specular
Decay Rate	No Decay *		P Enit Specular
Decay Rate Cone Angle	No Decay • 40.000		P Initipeula
Decay Rate Corre Angle Penunbra Ingle	Emit Datuer No Decay 40.000 5.000		F Initipeula

Intensity

This attribute determines how much light is emitted from the light source. As you increase the Decay and Dropoff values, you need a more intense light.

Color

You can set RGB values for the light being emitted. This will have an influence on the color of your scene.

Hotspot

The point where the light is most intense is referred to as the hotspot. You also know it as a specular highlight. The look of the highlight is a result of the intensity of the light and the shading qualities of the surface's Material node.

Dropoff

This attribute determines how much the light intensity diminishes as it gets to the outer edge of the light. This puts more emphasis on the light's hotspot.

Decay

This attribute determines how much the light intensity diminishes as the light gets further from its source. Therefore, if you choose to use Decay, you need to increase the Intensity.

Cone Angle

This attribute determines the width of the spot light's cone of influence. The areas outside the cone are not illuminated

Penumbra Angle

This attribute creates an area at the edge of the spot light where the light fades. A larger value here creates a soft look for the light.













Casting Shadows

One of the most dramatic aspects of lighting occurs in areas of no light. Shadows add drama to your scene while helping to anchor characters and props to the ground. If your character leaps into the air, you know what is happening because the shadow and character no longer touch each other.

In Maya, there are many factors that affect the look and quality of your shadows. You can choose from Depth Map and Raytraced shadows which offer different levels of quality and rendering speed. Sometimes light attributes, such as Cone Angle, will affect your shadows and must be taken into account. The more you know about how shadows are cast, the easier it will be to adjust the appropriate attributes.

Depth Map Shadows

Depth Map shadows are the more efficient of the two shadow types. A **Depth Map shadow** can be created by setting **Use Depth** Map Shadows to On in the light's Attribute Editor.

Depth Map shadows work by recording the Z-depth information from the light's point of view, then using this information to evaluate whether or not a point in your scene is in shadow. The diagram below shows how a spot light evaluates Depth Map information to generate shadows. You can see that the Depth Map is generated from the light's point of view.

Step 1

When rendering starts, a Depth Map is created that measures how far the various objects are from the light. White is used to show surface points closest to the light, while the various shades of gray show a greater distance from the light.



Stored Depth Map Value

Step 2

When a point on a surface is being shaded during the rendering process, the distance is measured between the point and the light source.





With and Without Shadows

Here are two shots of a scene. The first does not use shadows and the second one does. You can see how the scooter in the second image is much more grounded, and it is easier to read the scene's depth. While shadows do require extra work when you set up a scene, they are well worth the effort.

Step 3

This measurement is then compared to the depth information stored in the Depth Map. If the point's distance is greater than the distance stored in the Depth Map, the point is in shadow.

Step 4

If the point is in shadow, the light's illumination does not contribute to the shading.

Note: Another light, such as an ambient light, may illuminate parts of the scene where the spot light does not. That is why you can see the wood texture underneath the chair in this image.

Casting Shadows
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Raytraced Shadows

To calculate Raytraced shadows, Maya sends a ray from the camera and when this ray hits a surface, it spawns another ray toward the light. This shadow ray reports whether or not it hits any shadowcasting objects on its way to the light. If it does hit a shadow-casting object, then the original surface is in shadow.

Raytraced shadows have the disadvantage of being slower to render than Depth Map shadows. However, depending on the look you are interested in, there are several reasons why you would use Raytraced shadows in your scene. These include transparent shadows, colored transparent shadows and shadow attenuation.

If you want Raytraced shadows, but not reflections and refractions, then set **Reflections** and **Refractions** to 0 in the **Render Quality** section of the **Render Settings**.

Transparent Shadows

When casting shadows from transparent objects, Depth Map shadows do not take into account the transparent qualities of a surface, while Raytraced shadows do. This may be a deciding factor when it comes to choosing which technique you will use to cast shadows.





Depth Map Shadows When a Depth Map is generated at the start of a render, it does not take transparency into account. For this reason, the shadow generated by a Depth Map will appear solid.

Raytraced Shadows Raytraced shadows are computed during the rendering process. Therefore, the transparency of the object is taken into account. As a result, Raytraced shadows clearly represent the details of a transparent or transparency mapped object.

Colored Transparent Shadows

Another feature of Raytraced shadows is that you can create colored transparent shadows. For example, in the real world, when light passes through a stained glass window, you see the colors transmitted by the light passing through the window onto the floor. In Maya, Raytraced shadows will automatically create colored shadows when the transparency channel on a material is colored or when it is mapped with a colored texture.

Raytraced Shadows

The color of the transparency automatically casts a colored shadow.







Default Renderings Using the default settings built into a spot light, the Raytrace rendering offers a sharper shadow than the Depth Map shadows. Rendering time is longer for the Raytraced scooter.





Soft Shadows

By tweaking the Depth Map shadows attributes you can see much better results. Using Light Radius and Shadow Rays to soften the Raytraced shadows, you can see how the rendering took even longer.

Shadow Attenuation

By default, Raytraced shadows look more accurate and crisp than Depth Map shadows. This can result in an undesirable computer-generated look in most cases. To avoid this, the shadows can be softened using a combination of a non-zero **Light Radius** and **Shadow Rays** greater than 1. These controls are found in the **Raytrace Shadow Attributes** section of the light's Attribute Editor.

The biggest difference between a Raytraced soft shadow and a Depth Map shadow is that a Depth Map shadow is evenly soft around its edges. By contrast, a Raytraced shadow will dissipate or attenuate with distance from the shadow-casting object. This can be slow to render but is often used to create beautiful looking shadows in still renderings.



Depth Map Soft Shadows The light's Dmap Filter value affects the softness of a Depth Map shadow. Raytraced Soft Shadows Light Radius and Shadow Rays define the softness of a Raytraced shadow.

Shadow Limit

When working with Raytraced shadows, you should also set the **Shadow limit** attribute. For example, if you have a shadow-casting object with several transparent surfaces behind it followed by an opaque surface, you would expect to see a shadow on the opaque surface. In order to see this shadow, set the **Ray Depth Limit** on the light to a value that is the number of transparent surfaces + 1. Be sure that the **Shadow limit** in the **Raytracing Quality** section of the **Render Settings** is not set lower than this value, or you will not see your shadow.



Rendering

A 3D artist's ultimate goal is to create a sequence of images that can be synchronized with sound and played back as a movie. The creation of these images occurs in the renderer where surfaces, materials, lights and motion

are all taken into account and turned into bitmap images.

The art of rendering involves finding a balance between the visual complexity needed to tell a story and the rendering speed that determines

how many frames can be rendered in a given time. Simple models render quickly and complex models take longer.



Rendering Scenes

Rendering is where all of the work in setting up models, textures, lights, cameras and effects comes together into a final sequence of images. In very simple terms, rendering is the creation of pixels that are given different colors in order to form a complete image. A render involves a large number of complex calculations that can keep your computer busy for quite a while. The key at this stage in the animation process is to find a way of getting the best image quality and the fastest render times so that you can meet your deadlines.

Before exploring the specific details of rendering animation sequences, it is important to realize that there are two different methods to render images: software and hardware rendering. More specifically, there are three different software renderers shipping with Maya. They are Maya software, mental ray and vector.

The software renderers are considerably more complex than hardware rendering and require a great deal more knowledge and understanding to get the best results. The renderer is where all of your scene data and settings are handed off to the software and render calculations are performed that result in final bitmap images. To give you some insight into what Maya actually does with your scene data during the software render process, an overview is shown throughout this chapter.

Hardware Rendering

Hardware shading, texturing and lighting use the computer's graphics hardware to display objects on the screen. The Maya hardware renderer presents a seamlessly integrated rendering solution that leverages the ever increasing power of next-generation graphics cards to render frames. It is currently used primarily to render hardware-type particle effects and previews, which are later enhanced in a compositing application. However, this is changing as the future of rendering lies in this type of renderer, especially due to the performance advantage over the other renderers.

Maya also supports CgFX and ASHLI hardware shaders. To view these shaders, you must have a qualified graphics card. They also can only be rendered with the hardware renderer.

Software Rendering

All three software renderers use complex algorithms to combine elements, such as geometry, cameras and textures, with the physics of light to create final bitmap images. Because some aspects of light's true behavior would be prohibitively slow to calculate, most renderers let you employ shortcuts, such as ambient lights, in place of Global Illumination to make sure that rendering times support the production cycle.

Software rendering has the advantage of being more flexible than hardware rendering. Software companies can add functionality by changing algorithms in the code without being restricted by the computer's hardware. Therefore, while software rendering is not as fast as hardware rendering, the added functionality lets you achieve more sophisticated results.





Hardware Shading You can display hardware shading, texturing and lighting in any view panel using the panel's Shading menu.

Hardware Renderer

The Hardware renderer can produce broadcast-resolution images in less time than with software rendering.



Software Rendering

You can create a software rendering in the Render view window or by using Render > Batch Render. The Batch Renderer is always used to render animation and can also be launched from a Command Line.

Software Render Process

1. Geometry Filtering

To start the rendering process, Maya determines which objects in the Maya scene file will be rendered. Any objects that are hidden, templated, or do not belong to a shading group, will not be rendered.

2. Light Depth Maps

From the point of view of each shadow-casting light, Maya renders Z-depth files called Depth Maps to be used later to compute the shadows in the scene. Two Depth Maps are created because the Use Mid Dist is turned on by default in the light's Attribute Editor.

3. Tiling/Primary Visibility

By looking at the bounding boxes of the geometry, Maya can determine which objects are visible to the camera and approximately how much memory will be required to render them. Based on these estimates, the image is divided into rectangular regions called tiles. Each tile is a manageable amount of data for the renderer to process at one time. It is possible to explicitly set the maximum tile size (in pixels) from a Command Line.

4. Shading

Maya computes all of the texturing, lighting, shading Anti-aliasing, 3D motion blur, etc. for the visible surfaces in each tile.



Deep Raster Generation

When an IPR render is launched, a temporary file is created and written to disk in the iprImages directory. This deep raster file stores the image itself and all the data required to allow interactive tuning of shading and lighting attributes during an IPR render.

5. Post Processing

After the frame is rendered, Maya completes the final image by creating and automatically compositing any of the post process effects that you have specified. These effects include Depth of Field, 2D motion blur, Glow, Paint Effects, Fur, etc.





LEGEND



Tessellation

Maya uses triangles at render time to approximate NURBS surfaces, Subdivision surfaces and displacement mapped or quadrilateral polygonal objects. This process is called tessellation. Tessellation is time-consuming, so the artist sets

attributes on a per-object basis to manage the number of triangles the renderer will use. During the render process, tessellation is triggered only when needed.

Raytracing

If Raytracing is enabled in the Render Settings window, any secondary rays needed for reflections, refractions or raytraced shadows will be computed and will contribute to the shading process. The hybrid nature of the rendering architecture ensures that primary rays are not raytraced and only specified objects participate in Raytracing. This allows for a highly efficient approach to achieving added realism in a render.



Render Output

Bimage or sequence of images will need to suit the medium you are outputting it to. These image properties, such as size, format and frame padding, are set from the Render Settings Window.



Rendering Animation

An image file name consists of three components when rendering an animation: file name, frame number extension and file format extension. A combination of these three components is referred to as the file name syntax.

The file name is the base name for all images in the animation sequence. The frame number extension represents the frame in the Time Slider in which the image is rendered. The file format extension indicates your chosen file format. You can see these combined as a preview at the top of the Render Settings window.

You need to tell Maya what frames to render when rendering an animation. After a Start Frame and an End Frame are specified, Maya renders all the frames in between by default. However, if you want to render every 10th frame for test purposes, you can set the By Frame attribute to 10. In this case, Maya only renders every 10th frame, beginning with the Start Frame number.



Renderable Camera

The pop-up camera list allows you to choose which camera will be used in the Batch render. It is possible to render from more than one camera in a Batch render. This Render Settings attribute does not affect which camera is used while rendering in the Render View window within Maya.

Render Resolution

The Render Resolution refers to the dimensions of a rendered frame in pixels. The list of presets in Maya allows you to quickly select a resolution from a list of those commonly used in the industry.



Render Output

Channels

The color channels of a rendered image are made up of red, green and blue (RGB). A mask channel, or alpha channel, stores information about the coverage and opacity of the objects in your scene. This channel allows you to work with your rendered images in a compositing software application like Autodesk Combustion or Autodesk Toxik software.

A depth channel records the distance from the camera to the objects in the scene. This is often called Z-depth and you can look at it using the Z-key in FCheck.

Maya can render an image file that contains RGB color information, a mask channel, a depth channel or any combination of the three. The flags in the Render Settings window let you choose what channels will be rendered. Some image formats do not support embedded mask or depth channels; in these cases, Maya generates a separate mask or depth file and puts it in the mask or depth sub directory of your current project.

Rendering Fields

When an NTSC television displays images, it uses a technique called interlace, where electron beams horizontally scan all of the oddnumbered lines first and then fill in all of the even numbered lines (for PAL, even lines are scanned first). Each of these scans is called a field and they are half a frame apart in time. This means that instead of 30 frames per second, you actually see 60 fields per second (50 fields per second for PAL) when you watch television.

Rendering fields in Maya takes advantage of this interlace technique to achieve smoother motion on video. Instead of rendering whole frames, Maya renders each frame in two fields where the odd scan lines are rendered separately from the even scan lines at half-frame time intervals. The two fields are automatically put back together to form a whole image at the end of the frame render. The result is that the motion of an object in-between frames is captured in the render. In the final interlaced image, moving objects will look ghosted when viewed on your computer monitor because the monitor shows vou both sets of scan lines at the same time. However, when the same image is viewed on a television screen, the objects will look correct.

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Image Formats

The Maya Render Settings lets you render your images in the specific format that you need for your production pipeline. The default image format is the Maya IFF, but you can choose from a list of many standards used in computer graphics such as TIFF, GIF, JPEG, PSD, etc. Most of the formats are 8 bits per channel, but Maya also renders 10 bit Cineon and several 16 bit formats which are commonly used for film. Human eyes can perceive more colors than 8 bits can represent, so highresolution formats, such as film, sometimes require better color definition to look realistic.

Maya also lets you render directly to AVI or QuickTime movies. While this may be convenient, you might also consider rendering in one of the other formats that creates separate images, so that you have more flexibility. An application such as Autodesk Combustion allows you to create a movie from the images after any adjustments have been made.

AVI (.avi)

AVI is the Microsoft Audio Video Interleaved movie file format. Maya only renders uncompressed AVI files as these are the most common for reading into other applications.

QuickTime (.mov)

This is the file extension for Apple QuickTime movie files. Maya only renders out uncompressed QuickTime files as these are the most general for reading into other applications.

Animated scooter rendered as interlaced fields.



Interactive 3D

Through video games, visualization and the world wide web, 3D computer graphics have moved beyond the movie screen and into our everyday lives. Today, computer games consist of complex 3D characters and environments produced under aggressive production schedules. As such, game production has shifted away from the traditional animation pipeline, adapting new ideas such as game engines and blind data.

While many of the concepts covered in this book can be used by game developers to help them in their work, gaming environments have rules that are required to get graphics to play in the most efficient manner possible. Therefore, the kinds of models and textures that game developers can create are limited.



Interactive 3D

The rendering of 3D scenes into animated movies supports a narrative tradition where a story is told to an audience. The audience plays a passive role in relation to the content. In our digital world, this relationship is changing as audiences begin to demand more interaction with the content they are viewing.

The Video Game Generation

Interaction with content is most evident in video games where the main character is the viewer or "player" who makes key decisions that shape the resulting action. Players want to be immersed in new worlds where they can become the actors and the decision makers.

The ability to interact in 3D environments similar to our own, serves to further enhance the experience. For this reason, Maya includes a number of tools designed to help game developers create these 3D environments and the actors who inhabit them.



3D on the Web

While interactive 3D is most prevalent in video games, similar content is beginning to appear on the web for more mass-market consumption. E-commerce sites are beginning to use technologies such as VRML (virtual reality modeling language) to let customers preview their products in 3D.



A Different Workflow

Interactive 3D has different rules compared to film and video. Understanding these rules will help you make the best choices when deciding on such issues as geometry type, texture mapping and the animation.



Interactive



Modeling

Models built for interactive 3D are primarily polygonal models that use controlled polygon counts to suit the gaming system. Some next-generation game systems already have support for Bezier geometry, and NURBS and Subdivision surfaces may soon follow.





Animation

When playing a game, the player drives the motion of the scene. Therefore, animation is stored in small sequences that are controlled using the joystick (the player's control). For character animation, some systems support inverse kinematics (IK) and some do not.





Effects

Generally, effects are added to video games using 2D sprites that are composited on the fly. With next-generation systems, there will be support for more complex dynamics and particle effects. The limits are set by the system itself.



Rendering

Whereas an animation is rendered to a series of still frames, games use hardware rendering to present content to the player. Models and textures must be designed for real-time playback. Lighting and texturing tricks help attain faster playback.

nteractive 3D

A Short History of Gaming

Sprite-based Games

Bitmap graphics have been the driving force for video games from the beginning. These bitmaps were created as "sprites" that would be overlayed during game play in reaction to the player's moves. To preserve playability, the number of colors was limited to suit the power of the game system. To this day, games are being produced using 24 bit sprites rendered in programs such as Maya. Sprites are sometimes used in real-time games to add effects.

Real-Time 3D

Once graphics engines began supporting the display of polygons to the screen, 3D became interactive. With the creation of true 3D environments, players could now roam around a game and discover its secrets. Every year, the systems become stronger and there are fewer restrictions on the games.



1 bit B&W Pixels ~ 1980 – 1990 These games used simple bitmaps to generate the game play. Graphics could be easily created using simple pixel based paint systems.



8 bit Color Pixels ~ 1985 – 1994 Adding more colors offered

Adding more colors offered richer environments, but the limited palette meant that the sprites had to be painted by hand.



24 bit Color Pixels ~ 1993 – Present With a more complex color space, 3D programs could now be used to generate sprites. This created richer gameplay environments.



Low Polygon 3D ~ 1995 – 2000 These games offer the freedom of motion within a 3D environment, but models maintained a jagged look because of low polygon counts.



Next Generation ~ 2000 – Future The polygon counts are now becoming high enough for much smoother artwork and more stunning visual effects.

Setting the Limits

To make a game truly interactive, the game art must not interfere with the game play. Therefore, the speed at which a game can get polygons and other sprite based graphics to the screen is crucial to this interactivity.

Hardware

Games are run on both computers and game consoles. The ability of the hardware to process graphic information has a strong impa



information has a strong impact on the look of the final game. Hardware rendering

is measured in Polygons Per Second (PPS) and the higher the PPS, the more complex an interactive 3D scene can be. This PPS rate is affected by textures, animations and in-game effects, and can lower the hardware's total PPS.

Game Engine

The game engine is the software that handles the user's input, calculates animation and dynamics, and renders the graphics to the screen. The game engine is built by the game developer to create the most sophisticated game experience possible for players. When designing a game engine, a developer must decide on a production pipeline that matches the intended hardware platform.

The Rules Are Changing

In the world of interactive 3D, the term next-generation is a bit of a moving target. Systems are becoming more powerful, game engines more open and game developers more inventive. Also, systems are beginning to accept different geometry types, and hardware rendering techniques are becoming more realistic.

As mass market uses of interactive 3D rise, these techniques will begin to be incorporated into more open standards, such as Web3D, which will help make interactive 3D a more integrated part of how we work and live.





Game Creation

To create a game environment, a game developer must put together a wide range of digital content such as 3D characters, levels, motion, behavior, textures, shaders and lighting. This information is then given to game programmers, who build it into a real-time game. The coordination of all these parts is a complex undertaking that requires the game developer to work with concept artists, modelers, animators, texture artists, level designers, programmers, writers and musicians, to name a few. With the ability for near photorealistic output from next-generation systems (game consoles, graphics hardware and PCs), development teams have grown from small teams of 5 or so people, to larger teams of 30 or more.

Gaming Workflow

While a distinct workflow will vary from studio to studio, there is a basic gaming workflow. This workflow, from design document to concept art, game art, level building and game programming, is not necessarily a linear one as all of these activities can happen at the same time. Because of the number of tasks involved, establishing a workflow at the beginning of a project can mean the difference between making a dead-line and missing it.

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Design and Planning

Every game starts with a design document that lays the groundwork for the player's real time experience. Characters, environments, puzzles and music are laid out along with detailed design sketches that become the game's story-boards. The plan defines the workings of the game, while the sketches define the look and feel.



Level Building

Level building is where the various digital game art pieces are brought together to create the gaming environment. This is where many objects will be placed repetitively to make the most efficient use of game memory. The level builder is designed to work intimately with the actual programming of the game.



Game Art

Starting with the design sketches, 3D characters, props and sets are built using techniques defined by the chosen game engine. Texture maps, lighting and other game specific data are also added. Models are built for different levels of detail since props and characters in the foreground can have more detail than those in the background.

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Game Programming

This is where most 3D artists tend to be less involved. The artwork and levels are run through a game engine designed for a specific console. Ideally, the game art is built in such a way that the programming runs very smoothly.

Game Art

All the visual content created for a game, whether it be concept drawings, 3D assets or levels, can be referred to as game art. The concept drawings can be used in Maya as a reference to create 3D assets. 3D assets can consist of characters models, or items for use in the game. These 3D assets can also be rendered to create sprites. Levels often use varied amounts of these 3D assets to help create a feeling of realism in the space and for items like weapons or power-ups.

Environments

Environments, or levels, comprise the world that the player sees and interacts with. These environments can be broken down into interiors and exteriors. They can be created in Maya using polygon manipulation, procedurally with height maps or a combination of the two.



Props

Props can be items like the pictures and benches in the gallery or a key that the player must collect. Props help a game convey its realism or lack of realism. Maya toolsets allow the creation and modification of these props.

Characters

Characters help bring a game to life. A character can be the hero of the game or its evil villain. Maya character animation tools allow for the creation of animation that can breathe life into your game characters. Animation that you create can also be reused on different characters to speed up production.



Color and Texture

The skillful use of color and texture on a model can help you imply detail. You can apply color to a model and use a grayscale texture map to suggest shading. This technique can also help you save texture memory. Maya not only allows you to paint color information on a model, but also to create textures by using Paint Effects in canvas mode.

Textures

Textures are used to add detail where no geometric detail exists. Some textures will be on what is called a decal. A decal can be a singular texture map or multiple textures laid out into a square to maximize texture space.

Color per Vertex

Color information can be stored at the vertex level and is derived from prelighting geometry, painting the color on or setting color values at each vertex.

Lightmaps

Lighting information in a scene can be saved to a picture file that can be applied to the base texture as a light map so that lighting for a level does not have to be calculated at runtime.



Level of Detail

One of the ways to keep frame rates consistent in a game is to use a technique called Level of Detail (LOD). With this technique, multiple versions of a model created with varying polygon counts are switched depending on their proximity to the camera.

When the model is close to the camera, the higher detailed model will be used. As the object moves farther away, the higher detail models will be replaced by lower detail models. Maya will let you take a group of models and assign them to an LOD group. This group will switch between the models based on their distance from the camera in Maya.

LOD Visualization

When setting up the LOD group, the highdetail model is selected first, with lower detail models selected in descending order. You need to have two or more objects selected to create a level of detail group. Edit > Level Of Detail > Group will assign them to the LOD node and automatically set up distances to switch models. You can select this node and change the distances that the models will switch. For example, looking at the images to the left, the top image shows a model that is closest to the camera and consists of 1422 polygons. The second image was set up to switch at 8 units from the camera: it contains 474 polygons. The third and final model of the LOD group will switch at 20 units from the camera and consists of 220 polygons. You can also use a quad with a software render of your model mapped to it as a texture map.



Blind Data

Traditionally, data such as item spawn points, environmental conditions (slipperiness, noisy floors) and condition triggers (enemy attacks, door opens, platform moves) fell into the game programmer's domain. Today, the ability to assign this information visually also allows 3D artists and level designers to control where it's placed on a model or environment.



Painting Blind Data

Blind data can be painted onto components using the Artisan tool sets to help you see where the data is being applied. You can set multiple data types and assign colors to them. Here, the door trigger is being painted. You can see the color applied to the model.



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