

# CREATING A 3D ANIMATED SEQUENCE

## "RAPOLA PROJECT"

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CREATING A 3D  
ANIMATED SEQUENCE  
THE “RAPOLA PROJECT”

authors :

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dedicated to

my parents and my sister

Ιορδάνη, Μαρία και Αναστασία

*Αθανάσιος*

my parents, my sisters and my grandparents

Γεώργιος, Φωτεινή, Γεωργία,

Ειρήνη, Δημήτριος και Γεωργία

*Δημήτριος*

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# INTRODUCTION

3D Graphics is a (usually) 2D representation of a 3d world. It is the technique in which an artist creates models in a pseudo 3D environment and applies to them various changes; effectively making a model look like an airplane or a human. Furthermore, the models can be animated through time and they can be presented by different viewing angles with ease, thus allowing the artist to create an animation sequence of his 3D world.

The goal of this document is to provide know how to someone that wants to explore the world of 3D graphics, by creating an environment of his/her own. The reader will be introduced to the whole development cycle of a project, based on sound theory, the wealth of knowledge of the 3D community and finally our own experiences.

This document was created along with our real projects as a guide for anyone who would like to create a presentation, an animated sequence or a series of slides, with the purpose of storytelling. The 'Rapola project' as we call our projects, consists of two animated sequences of a historical site.

Beyond the impressive nature of 3D graphics and their bond with special effects, one must not forget that this is just one more tool for the artists. Despite the complicated technical side of this tool, 3D graphics is finally recognized by the majority as a true form of art. 3D theory is the alphabet that one has to know and the modelling, texturing and animating tools that 3D packets offer are the mere words of this language. For someone to create art using 3D graphics, it is necessary to advance much further than the concepts that are described in this document. We can just provide an introduction.

Since we explore 3D graphics as a means to create an animated sequence, a lot of the concepts that we will encounter are loaned from the filmmaking world.

## Tell a story

We should not forget that as every form of art, the important factor is the essence of our story. May it be a presentation of a historical site or a product commercial, what is important is the message that we want to convey to the viewers. 3D graphics, as impressive as they can be, should not take the leading part. This means that we should not force our viewer to observe the detail in of our models but rather let him





## Introduction

subconsciously feel the pace of the sequence and forget that he is just looking at a bunch of polygons that are neatly arranged.

The viewer should be concerned about what the meaning of the story is and not wondering how the image was created.

## Applications

3D graphics' potentials are practically endless, but someone can expect to find some of the best 3D graphics in:

- Special effects used primarily in cinema and commercials
- Architectural / GIS designs for presentation purposes
- Engineering designs for simulation/manufacturing (CAD/CAM)
- Full length features with hand drawing / 3D graphics combination
- Full length features comprised only by 3D graphics
- 3D animated sequences as part of documentaries
- 3D real time interactive applications (simulators, games, VRML)
- 3D animated broadcast cartoons
- Broadcast TV IDs of stations, shows etc
- Virtual studios with live newscasters for shows/news
- Multimedia presentations, for business, education and forensics
- Breath-taking corporate animations for trade / exhibition shows
- Printed media, illustrations

## Development

The development cycle of a 3D project is an iterative procedure, the individual phases are discrete but there will always be some need to go back and add or change something, maybe even start all over again.

A lot of options are going to be presented along the developing process. If we make early decisions we will probably find ourselves restricted by our choices, on the other hand we can not be unprepared. We must know what the dilemmas that we will face are; and what will be the criteria of our choices.

## The story

The story that will be presented should have an ultimate goal. If it is presented as a series of events it will be monotone and the audience will eventually lose interest. Even a series of spectacular events will not be as compelling as a story that gives the audience a goal, something to





## Introduction

anticipate. There is no need for any Hollywood action scripts, any story can be presented in an intriguing way, as long as it defines a clear (or partially mysterious) structure, a final destination.

In short, always keep the viewers brain functional, feed their imagination and challenge their perception, evoke emotional responses. In the end, you will have passed your message.

Since we are dealing with graphics, our main purpose of storytelling will be to show the events. An ideal animation is the one that makes complete sense to the viewer without a single word of narration, dialog or text. On the other hand, 3D animation is an expensive resource. We must think carefully what is important to animate and what can be implied by some other means, like dialog or text on a piece of paper etc.

Furthermore, the characters should not just narrate a story between them because the viewer must know it, but they should have a realistic dialog, like an every day average discussion or they can reveal new information to each other. This way the viewer is not only being informed but can also 'read' the reaction of the characters.

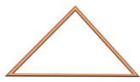




# PART I : Theme

The first question that somebody will make for an animated sequence is 'what is it about?'; even if there is no specific theme in the presentation, if for example is just a technology demo, the viewers still will try to understand what the models in the picture they are looking at are. This is our starting point.





## Chapter 1

# Material collection

## The presentation's goal

What is the goal of the presentation? This is perhaps the most important question and one of the firsts that have to be answered early on. Since 3D graphics have a broad range of applications, the answers can vary widely.

Is it an architectural model that the clients want to 'explore' and perhaps revise their options for the actual structure? Is it a product commercial? Is there an intensive scenario? It is immediately apparent that the above animated sequences have completely different goals and furthermore, they will have a completely different look and 'feel'.

Another consideration is the target audience. Of course every artist would like his work to be watched by as many people as possible, but still the target audience is a different concept. It defines the group of people that their opinion and reaction will define the success of the project.

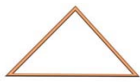
This target audience may consist of only one person, like the candidate buyer of a building; it can be a small team, for example a producer, a director and a special effects editor; it can be a large group, if for example the animation sequence is a cinematic in a video game; it may be a vary large group if the sequence is a full length feature; last, but certainly not least, it can be a huge group if the sequence is for a product advertisement.

Different target audiences and different goals can of course share a few common objectives and have a common approach in the way of their implementation. Still these characteristics must be defined clearly to everyone participating in the project, since every aspect of the development process is affected by them.

These characteristics will give some hints for questions like how many polygons should be used. Should the lighting be clear and flat, or dramatic and intriguing? Will the camera move in clear geometric paths, or it will have an irregular movement pattern, like an exploration? The objects will look new and untouched or they must look more natural, like age has touched them?

This list can be extended for as long as someone wants it to, the point is not to try to answer all these questions, if we clearly define the goal of the presentation, these questions will be almost automatically be answered upon development.





## The theme

Of course, the first consideration of any 3D artist is what it is going to be presented. Is it an archaeological site? Is it an aircraft? What we will be showing in the presentation? It may seem straightforward, but what it is going to be presented is not always a trivial question.

For example, if it is an archaeological site, we know that we will show the area. But do we want to show the architectural structure or perhaps focus in the site's purpose? If the former is true then it will probably be necessary to create extremely accurate models, but if the latter is true then perhaps the project's weight should be shifted towards character animation.

This is why the sequence's goal must be considered as much as what is the theme; and this is why it proceeds in this document.

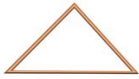
Still, no matter what we 'would like' to achieve; the theme is the factor that will define most of the development's artistic and technical considerations. Let's examine some of the possibilities.

First we need to examine how close to reality the presentation will (have to) be. For example, if it is a commercial, then the model of the product will most probably have to be an extremely accurate duplicate of the real product. Even if the object is not real, the artist may still have to meet some objective criteria. No one has ever seen a dragon, but most people have a clear image of what a dragon should look like. On the other hand, if the script defines contact with a group of aliens, then the audience will accept every model the artist will create.

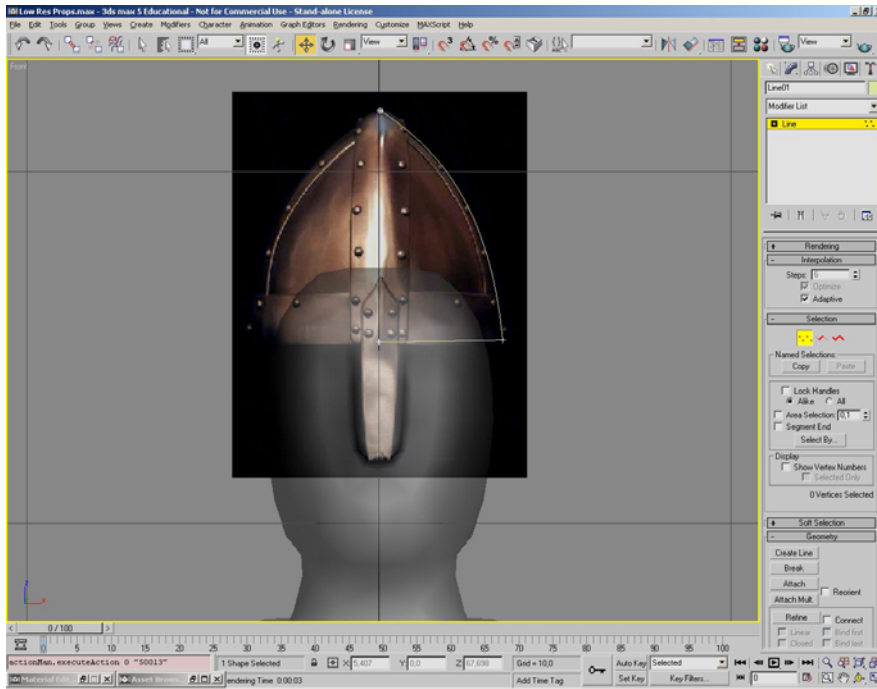
So these are some artistic considerations that we will have to make, but what are the technical ones? Well, 3D graphics' creation is vastly influenced by what it is going to be presented. If the model is real and has to be accurate, then it may be necessary to facilitate sophisticated digitizing methods. Even if accuracy is not a primary objective, photographic references are always helpful. Finally if the object is imaginary, then at least some draft sketches will have to be painted, materials that the artist may use as a clear guide or just as concept art.

For example photographs may be used directly into the 3D application to act as a visual aid for the artist to create models.





# Chapter 1 : Material Collection







# Chapter 2 Preparation

Once the theme and goal of the presentation are set, artists participating in the project will know what the sequence's overall feeling will be. But what exactly will be shown? Is there a script that clearly defines each scene and shot?

We know what we are going to present, but we are still a few steps away from touching our 3D application. First there must be a clear picture of how the presentation is going to be implemented. What are the scenes? Are there any specific shots we need? What should be the length of the presentation? Will there be a soundtrack synchronized with the picture? Will the editing be based on the pace of the music?

## Storyboards

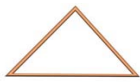
The most common method for defining in detail the idea of the project is with storyboards. Storyboards are simple sketches packed neatly in a form that may be accompanied with some text, resembling a comic book.

Storyboards define with simple pictures the general idea of the project, giving a guide to everyone participating in the project about how the presentation is going to be implemented. This is also a good place to identify difficult portions of the project that will need some extra care.

Many artists underestimate the importance of storyboards; and it is true that they are not a necessity. Still someone must have a way to organize his thoughts and this way must be usable by the rest of the team. The bigger the team the more a good organization plan will pay off. This is why it is very common that a hand drawing artist will be hired just for the creation of the storyboards and the concept art. There is also the option of creating the storyboards using the 3D packet; this is usually slower than drawing them with pen and paper, but in some cases it may be preferable.

Even if this is not an option and if you can't draw very well, storyboards can only help and no matter how childish they might look, they still serve their purpose. As a matter of fact, storyboards must be kept simple and have only the absolutely necessary detail. This is true not just because investing in an almost photorealistic storyboard is a waste of resources, but it can make artists feel restricted, in a way that their work will have to look exactly as the storyboard. Artists must be





given the freedom to present new ideas and this applies even if there is only one person participating in the project.

### Budgeting

Of course economical restrictions apply to every project, but when we are referring to budgeting in 3D graphics, we are speaking more about time budgeting. Once the storyboards are made, the team can start identifying details regarding its implementation, like: what are the objects that will be modelled, what are the textures that are going to be used on the surfaces, perhaps some of the models are going to be animated, what kinds of lighting methods will be used, what is the level of detail that each scene requires.

Usually there is a deadline, regarding the delivery of the project, but even if this is not a defined date, it will certainly be a timeline; someday the project must be completed! The time period can be divided into segments that can generally comprise object modelling, texturing, animating and finally scene composition and rendering. As we already said, the development cycle has these separate phases, but still there will be a lot of overlapping and revising between them.

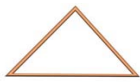
Almost no other phase can't start unless modelling has started, but someone may choose to model low resolution models and complete the rest of the phases with those, then finally model the high resolution actual models and start the rendering process with them. Or after the animation phase starts, it usually becomes apparent that the models need several revisions. Moreover the modelling process can not be completed without some basic texturing applied to the models.

In the last paragraph has become apparent that time budgeting a 3D project is not a trivial task. The storyboards will give a first idea for the balance between the individual faces. If there are a lot of different locations and models then the modelling and texturing processes will take longer. If there is a lot of animation and especially dialog, then the animation process will be much longer. Finally, if there are any visual effects like explosions or water reflections, there are going to be a lot of test renders for tweaking and the final render will take longer too.

Preparing for the project can easily be underestimated, since artists want to start working with the actual models and get feedback as soon as possible. This is desirable to a certain degree. But we must remember that there must be a balance between preparing our work and actually working with the 3D application.

When the project is beginning then this balance will be heavily shifted towards the preparation part. Until the point that at least all phases will have advanced to some degree, preparation will still have a





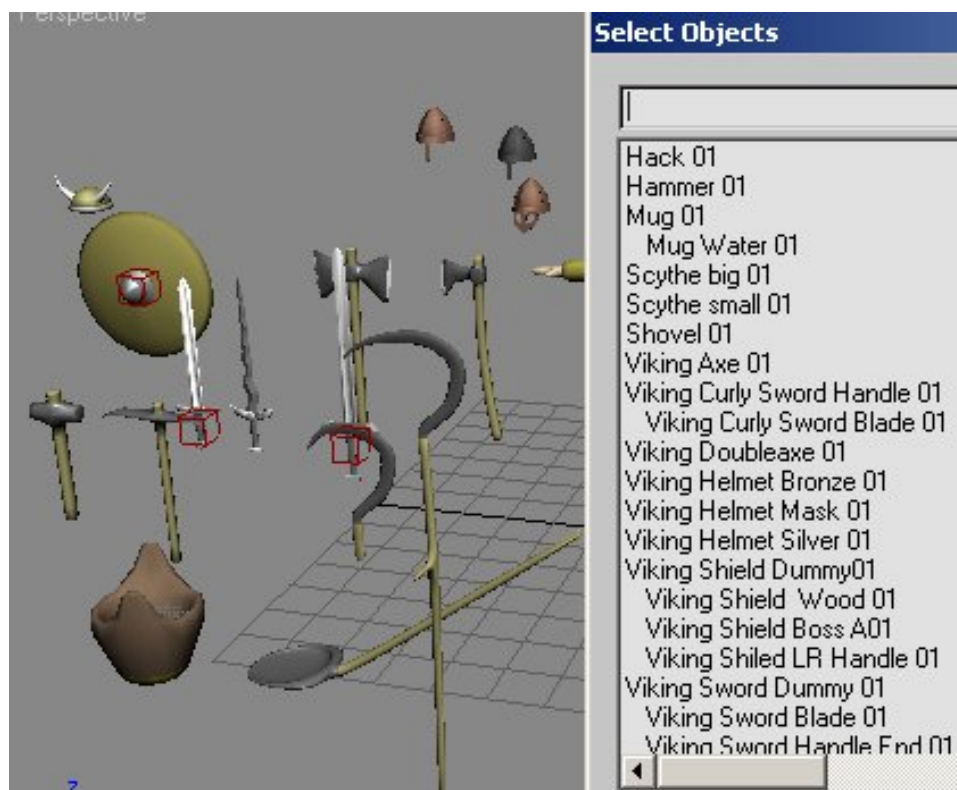
## Chapter 2 : Preparation

major role in our 3D work. When most details will have been clarified, then preparation time for each day will be minimized to a couple of minutes.

### Naming Schemes

Naming scheme is a set of rules that the user follows in the naming of the objects in a project, in a way that makes them more accessible. 3D applications by default name their objects when they are first created according to their type, for example box01, sphere35 and so on. A more descriptive name though would be more appropriate.

Following a naming scheme is a necessity for all projects that the development team is comprised by more than one single person. But even if this is the case, a naming scheme helps in organization of large scenes with dozens of objects, especially if the objects interact with each other in some way.



Naming schemes must have been set before any work starts in the 3D program and must be followed religiously. This guarantees that anyone needs only to know the naming scheme to be able to find his way into a scene that someone else has created.

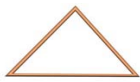




# PART II: The concepts

3D graphics are undoubtedly a complicated area of study. Still, the basic concepts that are enclosing the overwhelmingly wealthy world of 3D graphics are actually quite straightforward. These concepts are the foundation of 3D theory and although some artists choose to avoid them, they compose the corner-stone of every single 3D graphics tool, so sound knowledge and understanding of them is a necessity.



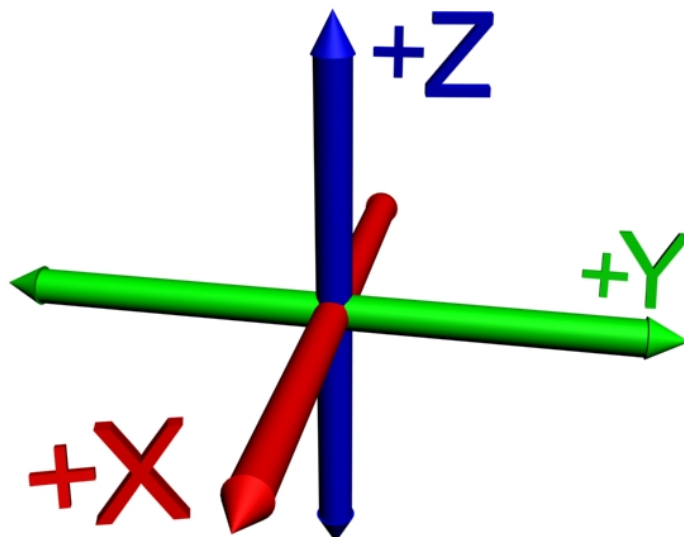


## Chapter 3 3D Basics

3D objects live in a 3D space, which can be vast and someone must have a way to navigate through it. 3D programs share a common and universally accepted way to represent 3D space, the use of a Cartesian coordinate system, which is a way to represent space as a set of (infinite) points. Note though, that not all programs agree to the orientation of the coordinate systems they use.

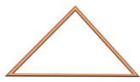
### Cartesian Coordinate system

In a 3D Cartesian coordinate system, the smallest area that can possibly be occupied is called a point (P), which is referred to by three real numbers (coordinates), indicating the positions of the perpendicular projections from the point to three fixed, perpendicular and graduated lines, called the axes (X, Y and Z) which intersect at the origin. Often the x-axis is imagined to be horizontal and pointing roughly toward the viewer, the y-axis is also horizontal and pointing to the right, and the z-axis is vertical, pointing up. 3D models are constructed with respect to some coordinate system.



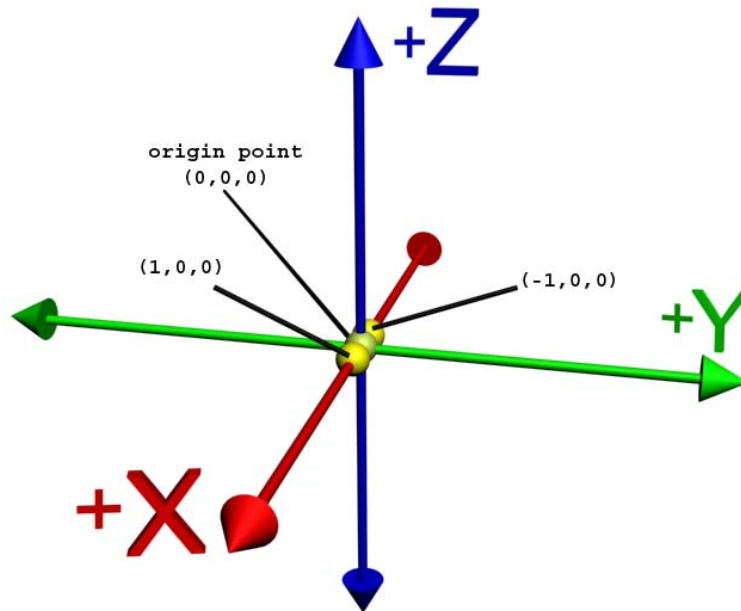
One example of a coordinate system is the longitude/latitude or polar coordinate system, which is used to specify locations on earth. A navigator on a ship or airplane uses this system to specify where the





craft is and where it's headed. All computer graphic programs use the Cartesian coordinate system.

The point of intersection between the three axes XYZ has coordinates  $(0,0,0)$  and is called the origin point. The next point in the X axis has coordinates  $(1,0,0)$  and the previous one has  $(-1,0,0)$ . All axis use the same scale in their numeration.



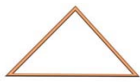
NOTE: The famous French philosopher and mathematician, René Descartes, invented the Cartesian coordinate system in 1637. With this discovery, Descartes joined the two disciplines of algebra and geometry into a unified system, allowing equations to be applied to geometric objects. This was a great breakthrough that enabled many later developments, including computer graphics.

### Axes

An axis is an imaginary line in cyberspace that defines a direction. There are three standard axes in 3D programs, which are referred to as X, Y and Z. The “width” axis, X, runs horizontally. The “height” axis, Z, is vertical, going from top to bottom and bottom top. The Y-axis is related to “depth”. It travels from the front to the back of cyberspace and vice-versa.

If you center the X, Y and Z axes within 3D space, the coordinate at the intersection of all three axes is the origin point,  $0,0,0$ . If you draw a dot at the point immediately adjacent to the origin along the “right” side of the X-axis, the point would be identified as  $-1,0,0$ . The next point in the same direction would be  $-2,0,0$  and so fourth. On the other hand, if





you move toward the “left” side of the X-axis, the numbers would be negative: 1,0,0 followed by 2,0,0 and so on.

The same holds true for the Z-axis as well, with numbers going positive when travelling “up” the Z-axis, and negative when going “down”. Therefore drawing the point immediately “above” the origin would yield 0,1,0 and the one below it would be 0,-1,0.

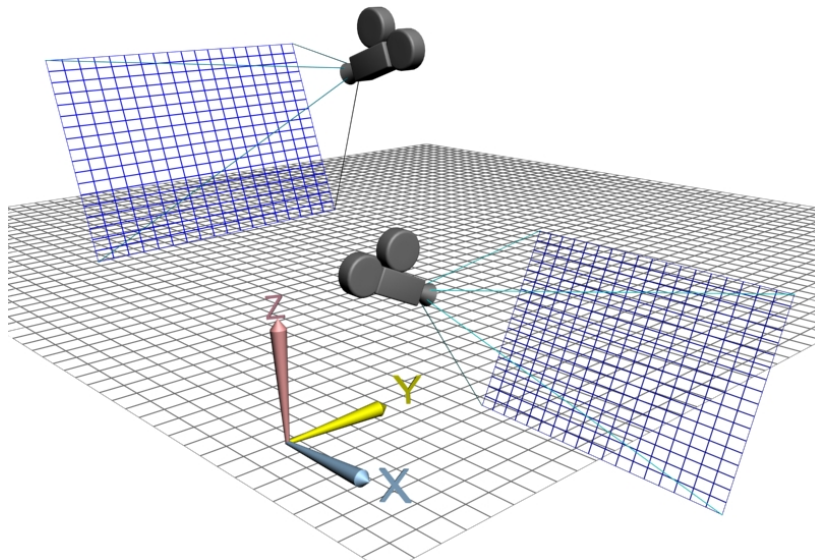
## Coordinate systems

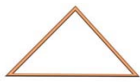
Different coordinate systems can co-exist in the scene. The user can choose which is the most appropriate for each operation.

### World coordinate system

The world coordinate system is the principal coordinate system of a 3d workspace, which is independent of viewport and display. It is also known as the global coordinate system or the scene universe. Individual objects are each defined in their own local coordinate systems. Light sources and the viewer or cameras are positioned in this system, and animation moves the objects within it.

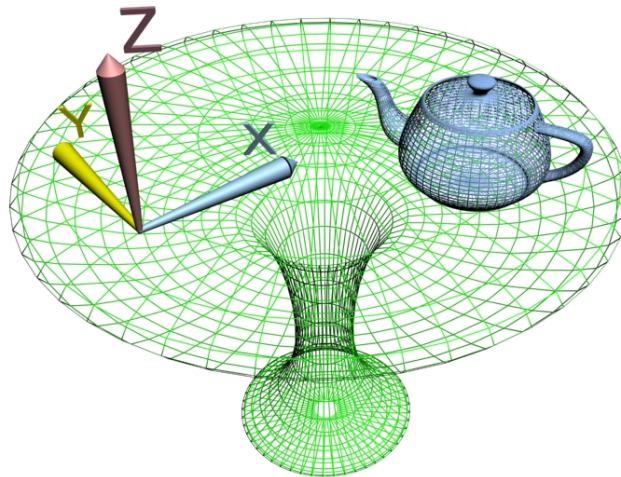
- X runs in a positive direction towards the viewer.
- Z runs in a positive direction upward.
- Y runs in a positive direction to the right.





### Parent coordinate system

The Parent Coordinate System requires an object to be hierarchically linked to another object in the parent/child relationship. In Parent Coordinate System, the child always uses the parent's Local coordinate system. If the object is not linked to a specific object, it's a child of the world, and the parent coordinate system is the same as the world coordinate system.

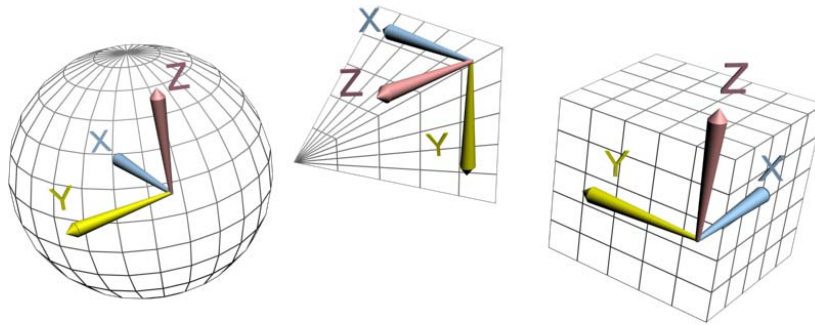
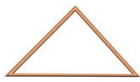


### Local coordinate system

The local coordinate system is the coordinate system in which an object is initially defined. The local coordinate system usually stays with the object and is independent of the world coordinate system in which the object is placed with other objects to form a scene. An object is usually placed and oriented within its local coordinate system in some geometrically and computationally convenient way. For example, the center of a sphere is usually located at the origin of its local system, while a cube may have its edges aligned with the principal axes of its local coordinate system, with one of its vertices at the origin. The user can reposition the pivot point at any time, though.



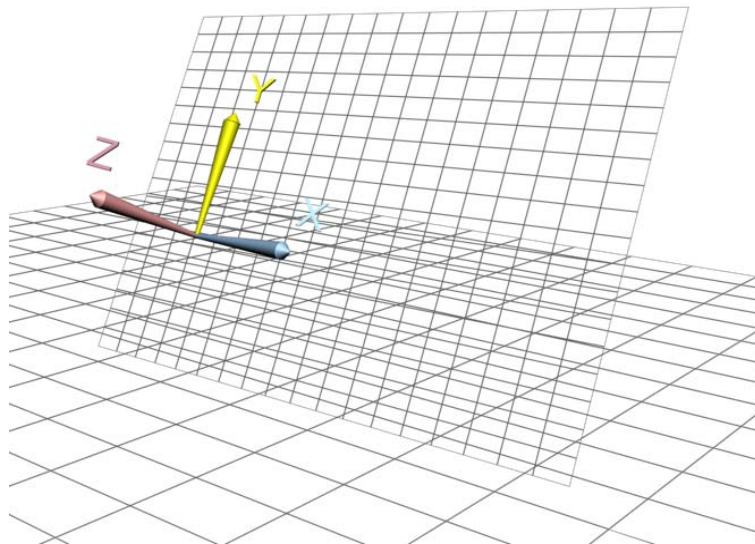




The data defining the object in the local system becomes an important part of the object database. Complex objects made-up of more than one primitive object may require a hierarchy of local coordinate systems, for example constructive solid geometry models.

### Grid coordinate system

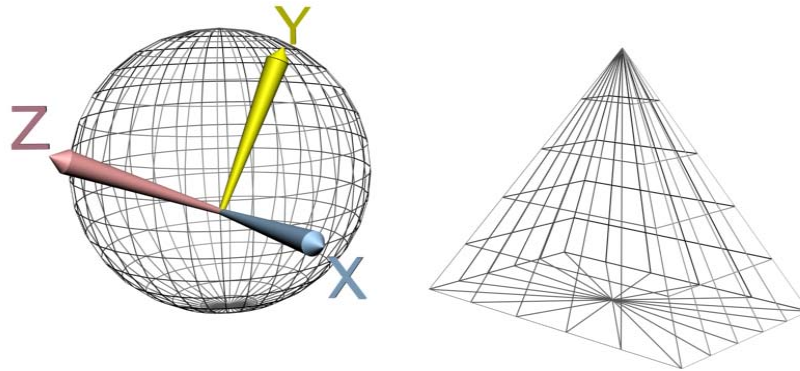
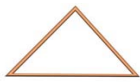
3D applications provide special helper objects, called grids. Grids exist to help users define specific arbitrary coordinate systems.



### Pick coordinate system

The user can define at each moment the coordinate system which he considers the most adequate for the task he is undertaking. In the Pick Coordinate system you can use the coordinate system of another object in the scene as the current coordinate system.

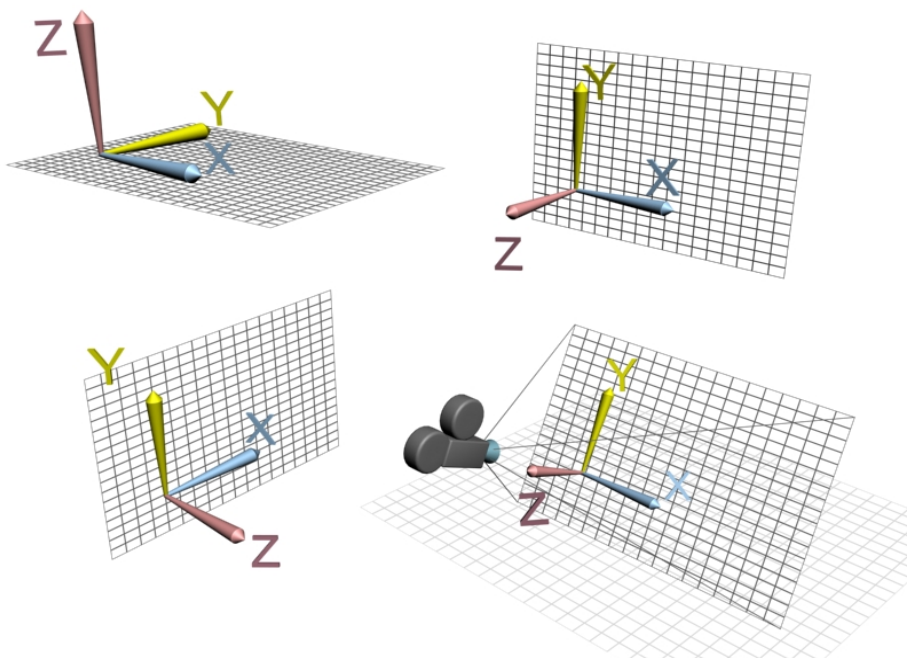


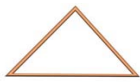


## View coordinate system

A display coordinate system oriented relative to the camera or viewer. It is usually a left-handed system; X, Y, and Z axes are the same in all viewports. When you move an object using this coordinate system, you are moving it relative to the space of the viewport. The camera can be located anywhere in the world coordinate system, aimed in any direction, and given a reference “up” direction, thus determining the geometric relationship between the world and view coordinate systems.

- X always points right.
- Y always points up.
- Z always points straight out of the screen toward you.

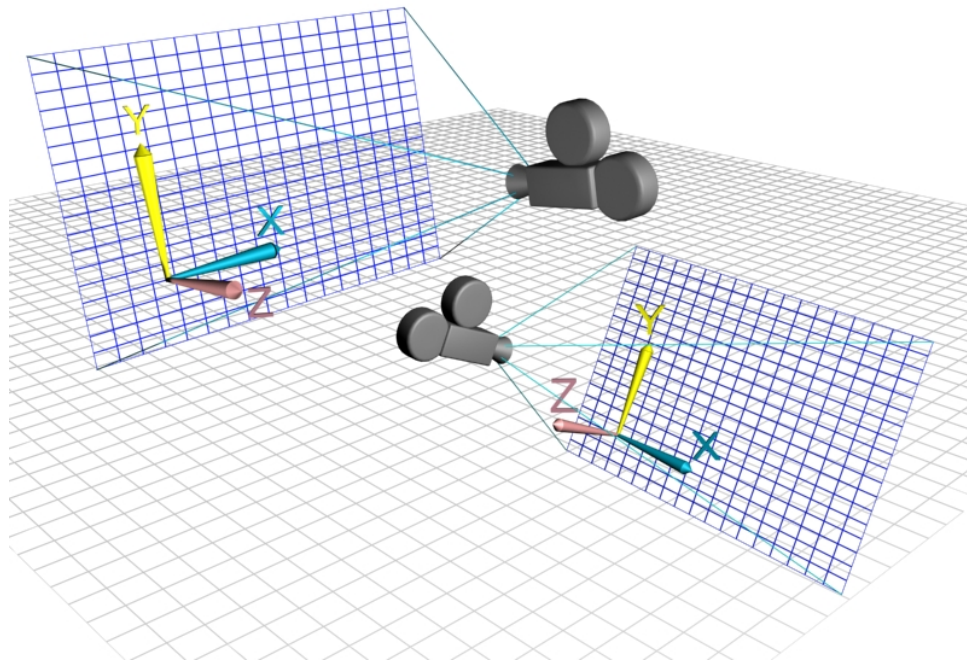


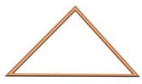


### Screen coordinate system

Screen Coordinate System is exactly the same as View for orthographic viewports. However, for non-orthographic viewports the positive z axis points out of the screen toward the viewer. Screen Coordinate System allows you to move objects in space based on your line of sight in non-orthographic viewports.

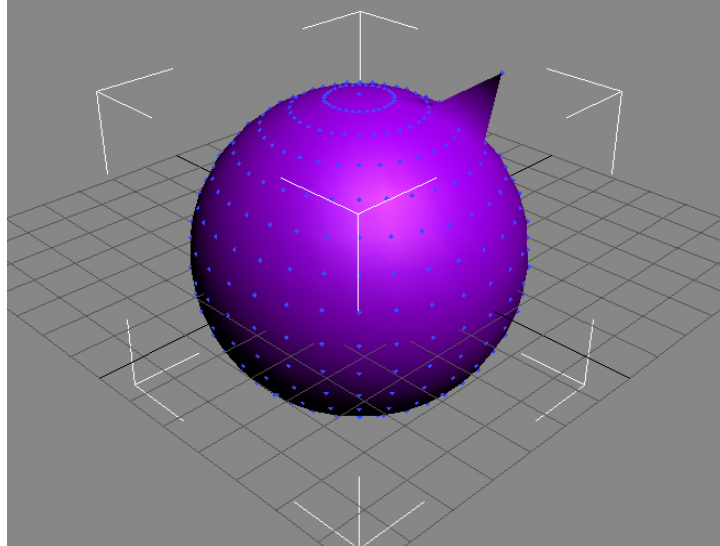
- X is horizontal, running in a positive direction toward the right.
- Y is vertical, running in a positive direction upward.
- Z is depth, running in a positive direction toward you.





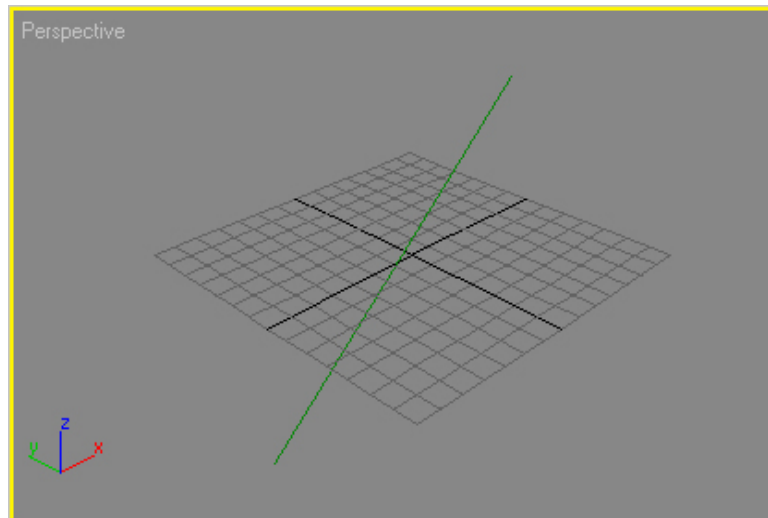
## Vertices - Points

A vertex is a point where a number of lines come together and connect to each other. The plural of vertex is vertices.



## Lines

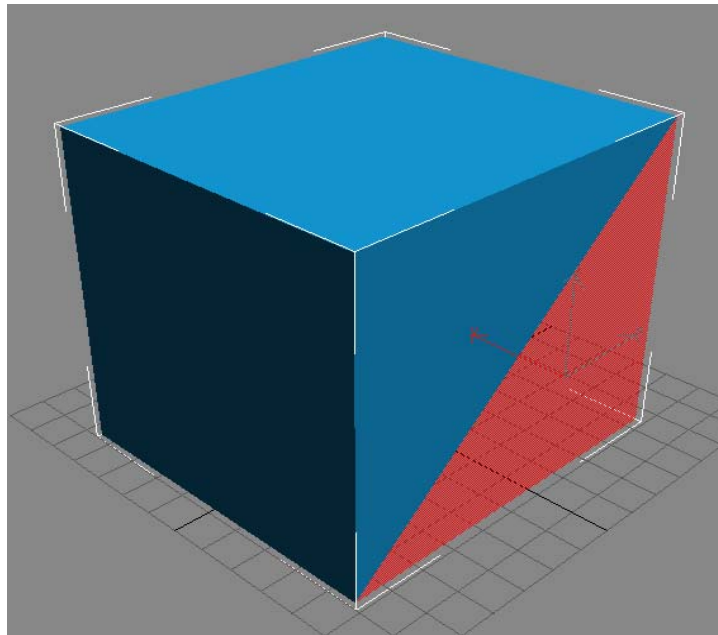
A line is formed when a connection is made between two points. If that line is extended to additional points, it is a polyline. If the line is further extended to the starting point – enclosing the shape – it forms a polygon.





### Faces

The area enclosed by the edges of the polygon, the “inside”, is called face. A face is the smallest possible mesh object: a triangle formed by three vertices. Faces provide the renderable surface of an object. While a vertex can exist as an isolated point in space, a face cannot exist without vertices.

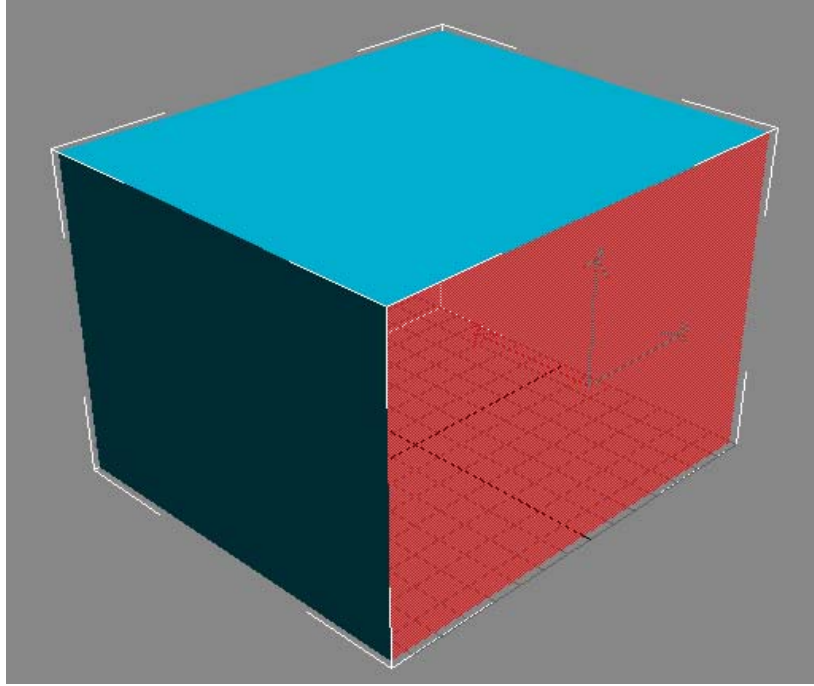
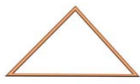


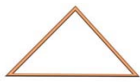
### Polygons

Polygons are series of vertices that define a plane in 3D space. Most 3D engines use polygons to construct the surfaces of their objects. A polygon can be made up of one or more triangles, like a quad is made of two triangles, a pentagon is made of three triangles, etc.

Some rendering engines support multiple polygon types, but triangles are the most common. Some people use the term polygon to specify a quad, others use it when talking about triangles. Polygons are also called polys, or sometimes n-gons.







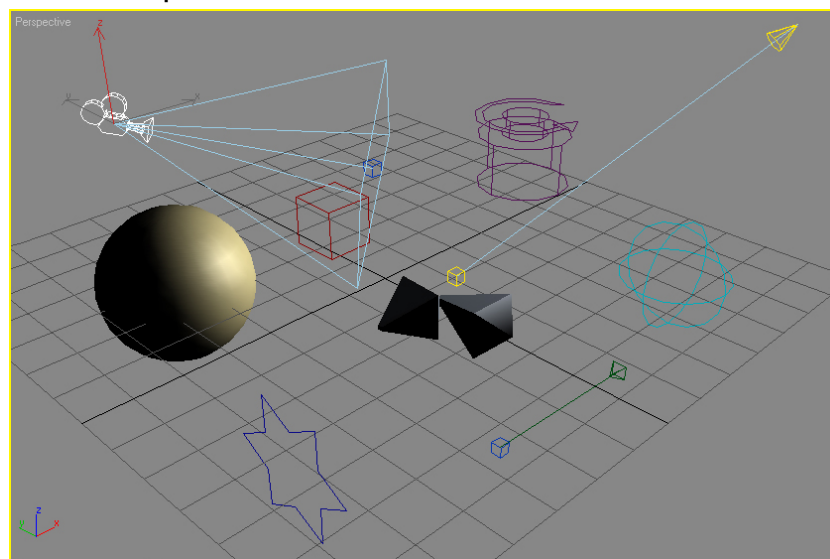
# Chapter 4 Overview

We have gradually moved from points in 3D space to polygons. These are the foundations of 3D graphics. Based on them, we can advance to more abstract concepts, like objects and 3D models.

This chapter will make a very short visit to most of the concepts regarding the work cycle in a 3D application.

## Objects

Most 3D applications are object-oriented. This means that every item that lives in our scenes is considered to be an object. Objects can be 3D models, but there are also other types of objects, like 2D shapes, or items that have a specific function and do not render in the image.

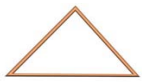


## 3D Models

A 3D model can be defined as a set of faces that are regarded by the application as a unit. This means that if we apply a move transformation to the object, all its faces will move together and this way the object's shape will remain intact.

Beyond of just being a set of grouped faces, applications treat a 3D model as a totality, allowing the user to perform complex tasks on them, like assigning textures or animate them.

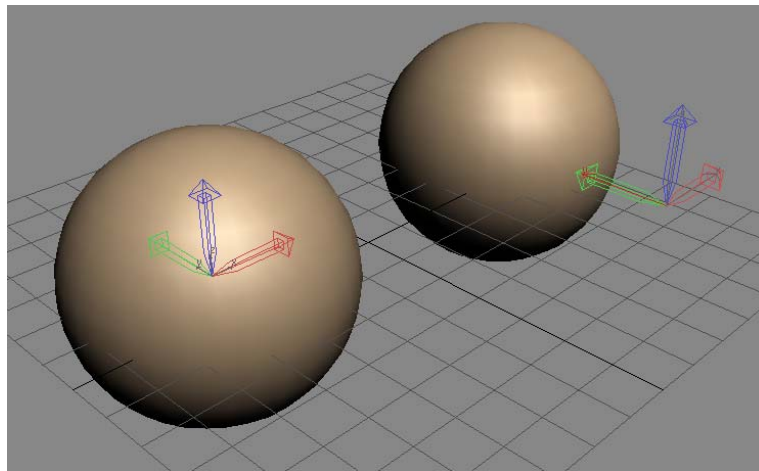




## Pivot Point

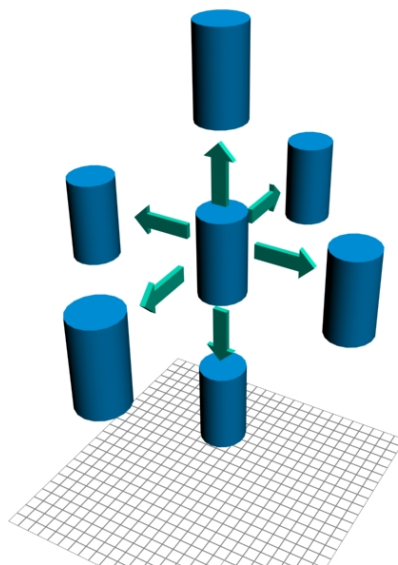
All objects have a pivot point, it is independent from the object's shape; and can reside within the object or out and far of it. The pivot point defines the center of the object's coordinate system and its direction. Every object has exactly one pivot point; but the user can change it at any time.

We can think the pivot point as the point from which we 'grab' the object to transform it. It is the point around which we can rotate the object. But if we move the object then the pivot point's position is irrelevant, the result will always be the same.

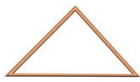


## Transforms

There are three basic operations:  
**move**, does not depend on the pivot point

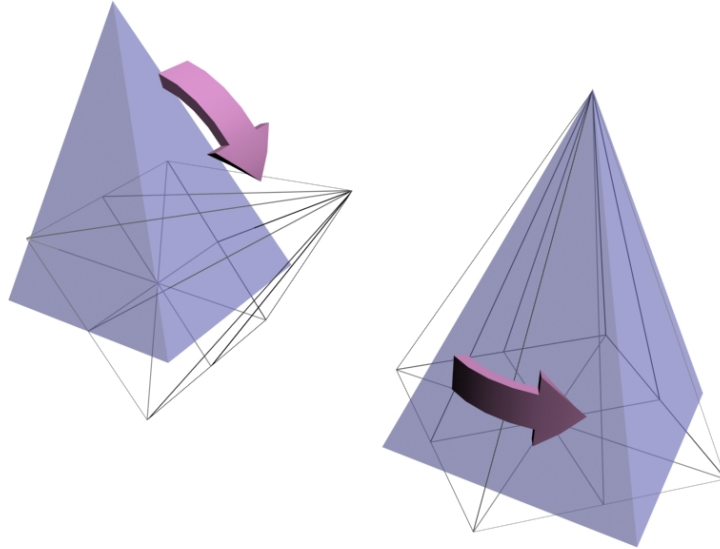




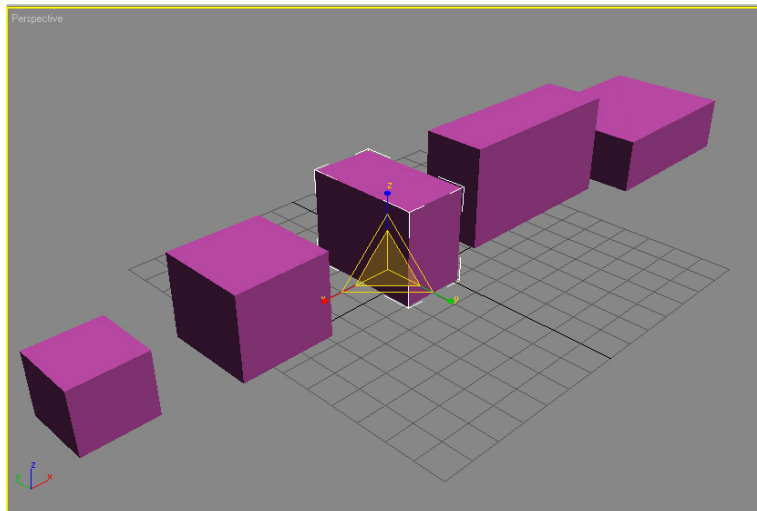


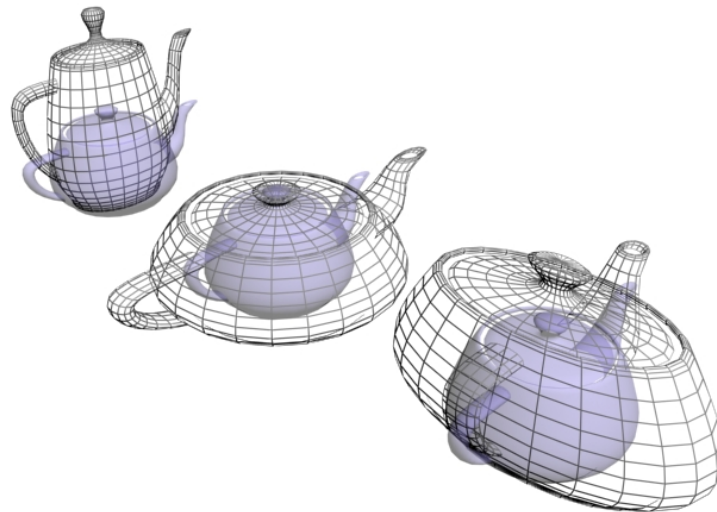
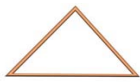
# Chapter 4 : Overview

**rotate**, depends entirely on the pivot point



**scale**, depends largely on the pivot point

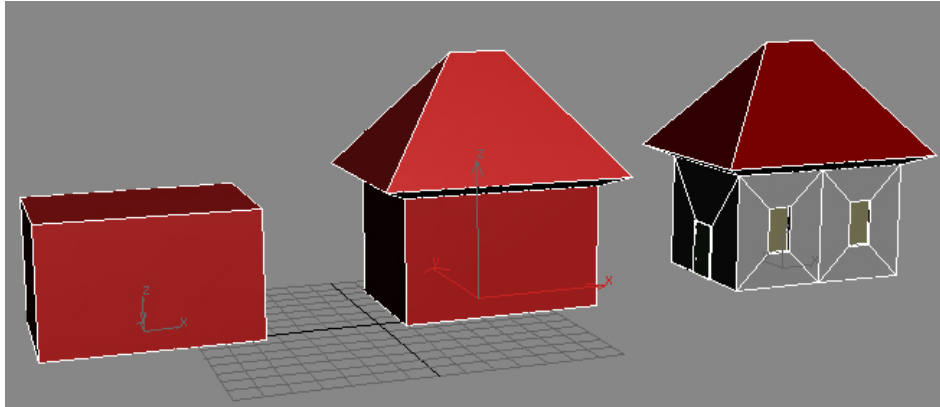




The scale transform can change the object uniformly or it can distort it, if it is used on one or two axes.

## Modelling

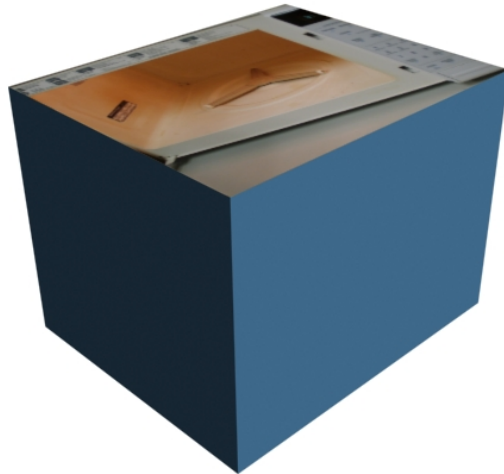
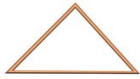
Modelling refers to the process of generating 3D models and the manipulation of their shape to bring them to their final form.



## Texture Mapping

When the models are generated, they have a simple colour assigned in their surfaces. No matter how detailed and accurate, the model will not look realistic. What we do is assigning in their surfaces attributes to make them look more real and more detailed than they really are. This process is called texture mapping.





## Viewpoints

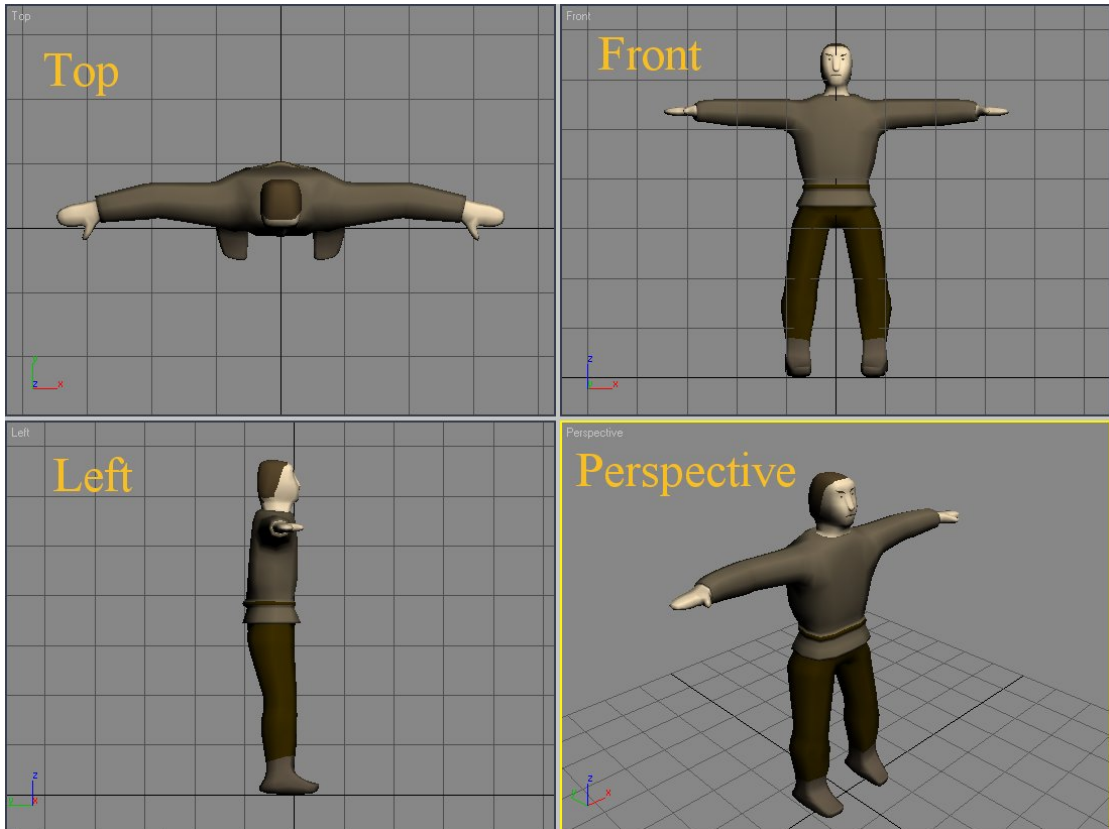
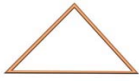
The point from where we are looking  
The direction towards we are facing

Viewing plane

It is the visible area. There can be two different kinds of viewports in 3D applications:

- orthographic view, view from a perpendicular axis
- axonometric view, arbitrary angle
  - Parallel lines will remain parallel in those views.
- perspective view, like a true lens, distorts the forms and gives clues to the viewer for the size and position of the objects in the scene.

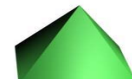
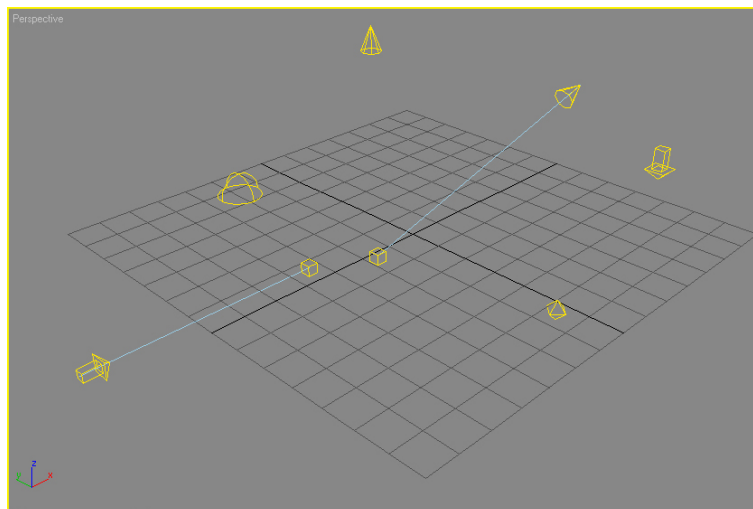


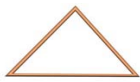


## Lighting

The user can add any amount of lights of several types:

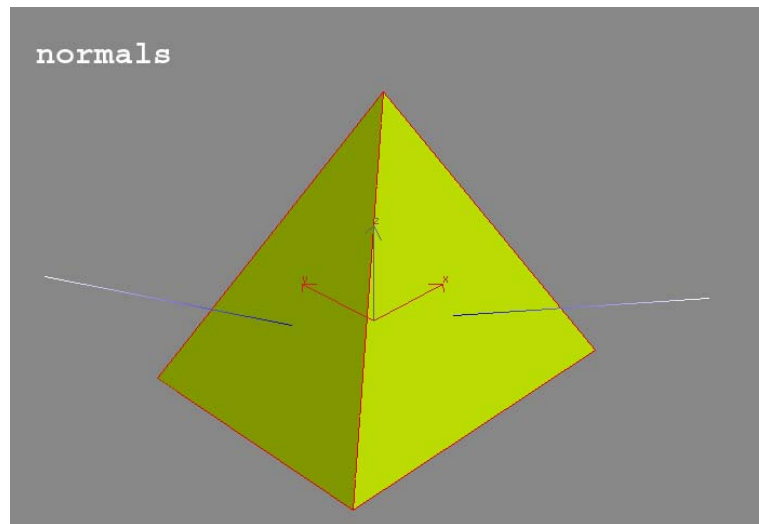
- spot lights, lighting cone (flash lights)
- direct lights, distant light sources (like the sun),
  - all the rays are parallel to each other
- omni lights, light point (bulbs), to all directions
- ambient, not a light source, value added to all pixels





### Normals

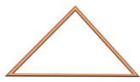
Normals are the perpendicular lines for each polygon, indicates direction which the poly is visible. (single / double sided) is being used in the lighting calculations



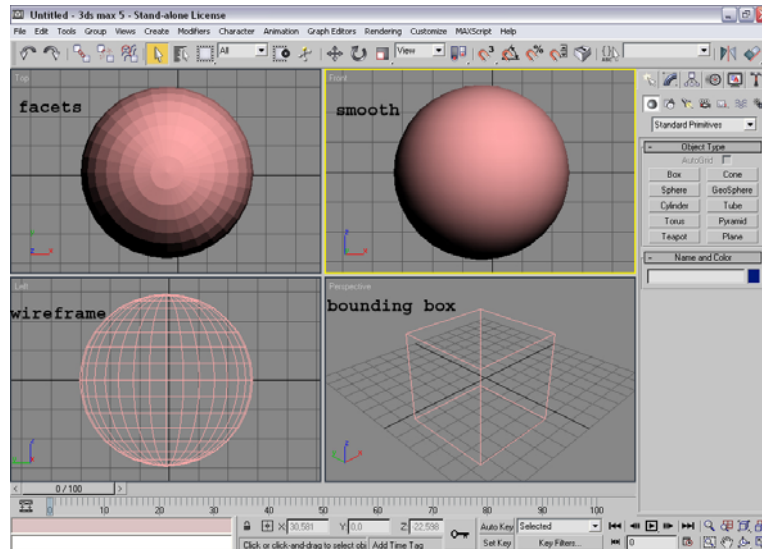
### Display / Rendering Modes

- **Bounding box:** very simple, approximation of object's location and size (only for display)
- **Wireframe:** draws lines for the polygons edges, either both sides or only the visible ones (hidden line mode)
- **Flat shaded:** polygons are being painted, the whole polygon takes one colour, a single normal in the center of the poly is being used.
- **Gouraud (smooth):** calculates the colour for each vertex and interpolates across the polygon surface.
- **Phong:** like smooth with specular highlights (bright reflections). A surface normal is being calculated for every pixel on the object's surface.





## Chapter 4 : Overview



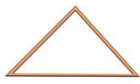
### Rendering only

- Ray tracing: imaginary ray from the viewer to the scene, it can be bounced and bent.



- Radiosity: calculates bounced light from all surfaces, colour bleeds from surfaces. Radiosity is very accurate and realistic, but extremely time consuming.

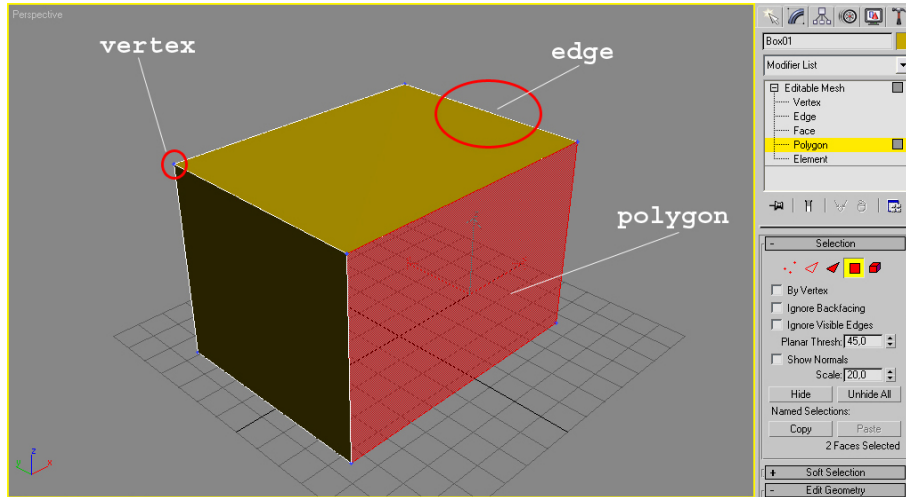




## Sub Object

Most objects are comprised of smaller building blocks, called the sub-objects. For example 3D models are comprised by vertices, line segments, polygons and more.

- object level
- sub-object level (vertices, edges, faces and polygon, element)
- modifiers may have a gizmo, a helper object that defines the region that the modifier affects.





# PART III : Modelling

3D models consist of thousands of vertices, edges and polygons. Although defining them one-by-one was at a time a viable method, it is only used today in a very different form, known as low-polygon modelling.

Most of the time, a modeller will need tools that effect a great number of sub-objects (or even whole objects) at a time. These methods provide a convenient way to apply the 3 basic transforms, move, rotate and scale, to different parts of an object, hence giving a completely different effect.





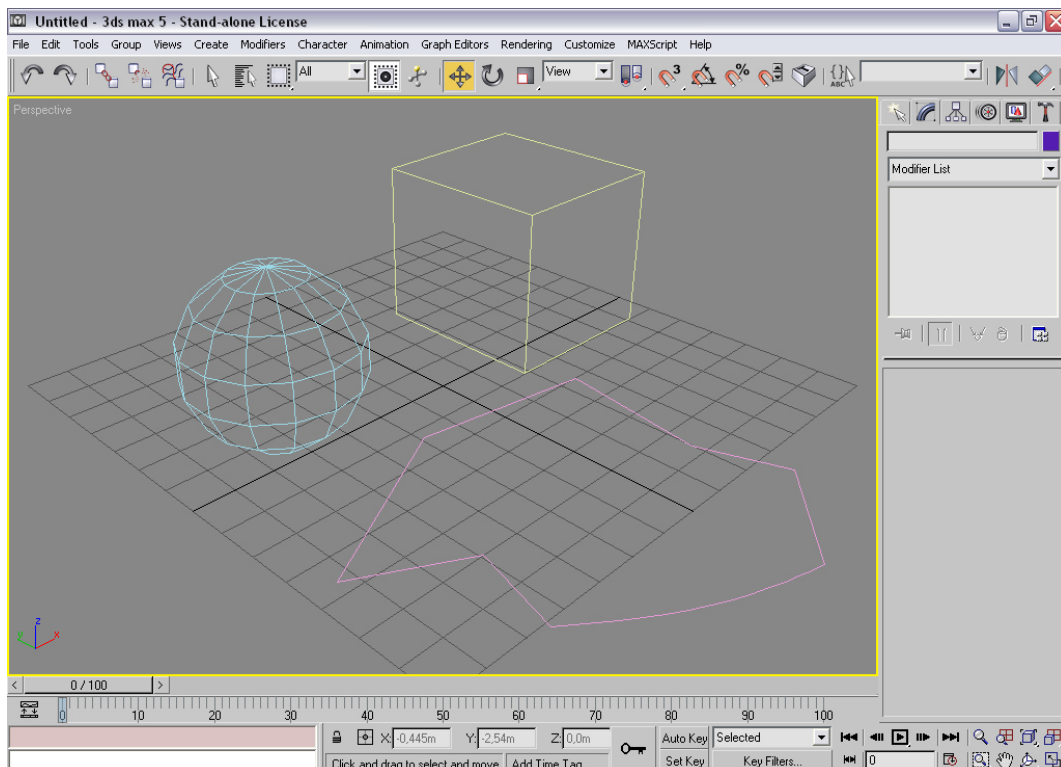
## Chapter 5

# Introduction to Modelling

Four are the basic types of modelling systems: polygonal, spline, patch, and parametric. Most packages combine these systems within their toolsets, because each has its strengths and weaknesses.

## Polygonal Modellers

Polygonal modelling is the oldest type of 3D modelling and in this type of modelling the surfaces are defined as a collection of squares or triangles (polygons). Polygonal modellers are best for objects that don't change shape, like ships, buildings, but are not good at organic shapes. Another disadvantage of this type of modellers is that you have to model your object in high polygon resolution, or else your object may appear faceted.

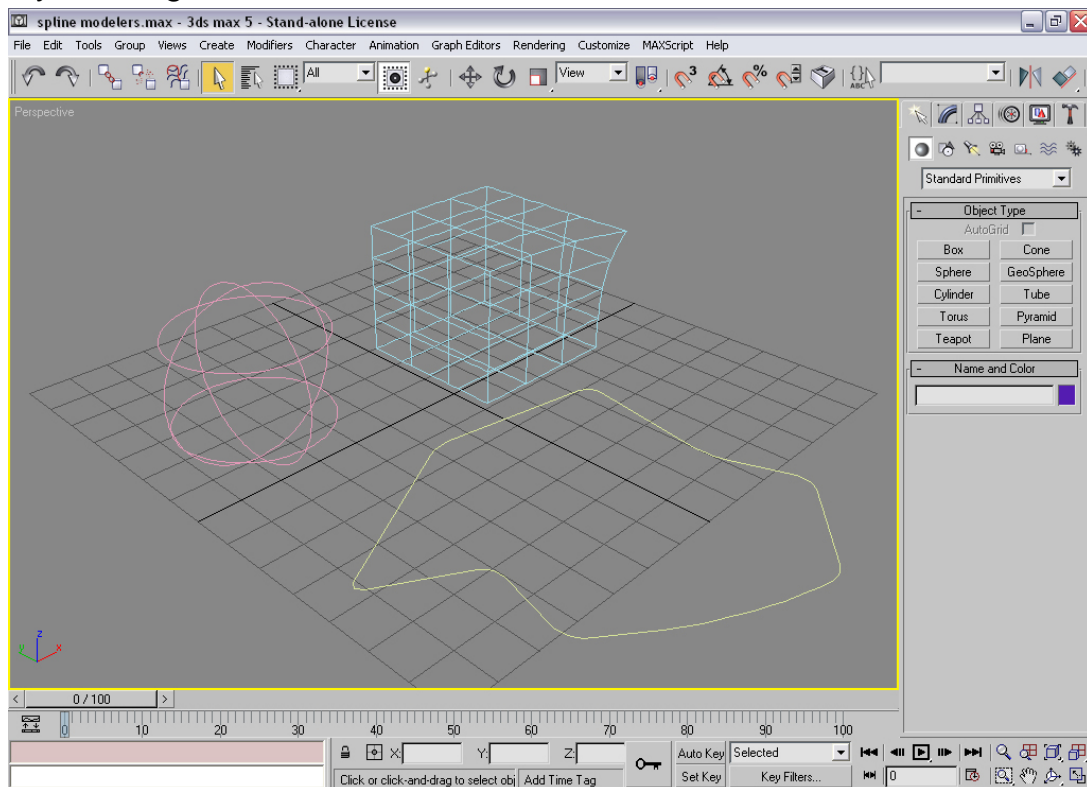


With the advent of a new polygonal modeling method, subdivision surfaces, this situation has changed.



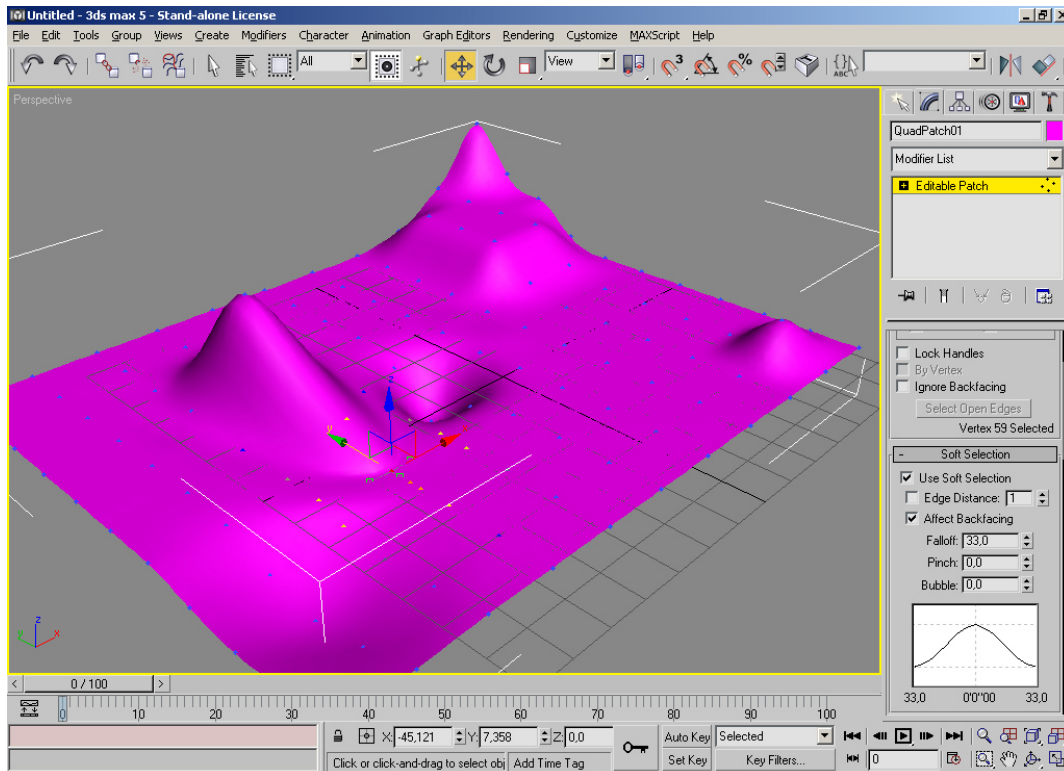
## Spline Modellers

A spline is a smooth line that is defined by control points that they are used to effect its contours. It is mathematically defined and can only be approximated in the computer screen. In general, spline based modellers produce smoother, rounder shapes than polygonal based modellers. This makes them more suitable for making organic forms and animating liquids. One of the main advantages of spline-based modelling is that it is resolution-independent, which means that (in theory) you can get as close as you want to an object and never see any faceting.



## Patch Modellers

Patch modellers use a network of control points to define and modify the shape of the patch, which is usually a lattice of either splines or polygons. These control points have a magnet-like influence on the flexible surface of the patch, stretching it in one direction or another. In addition, patches can be subdivided to allow for more detail. Like spline modellers, patch modellers are very suitable for building organic and smooth forms.

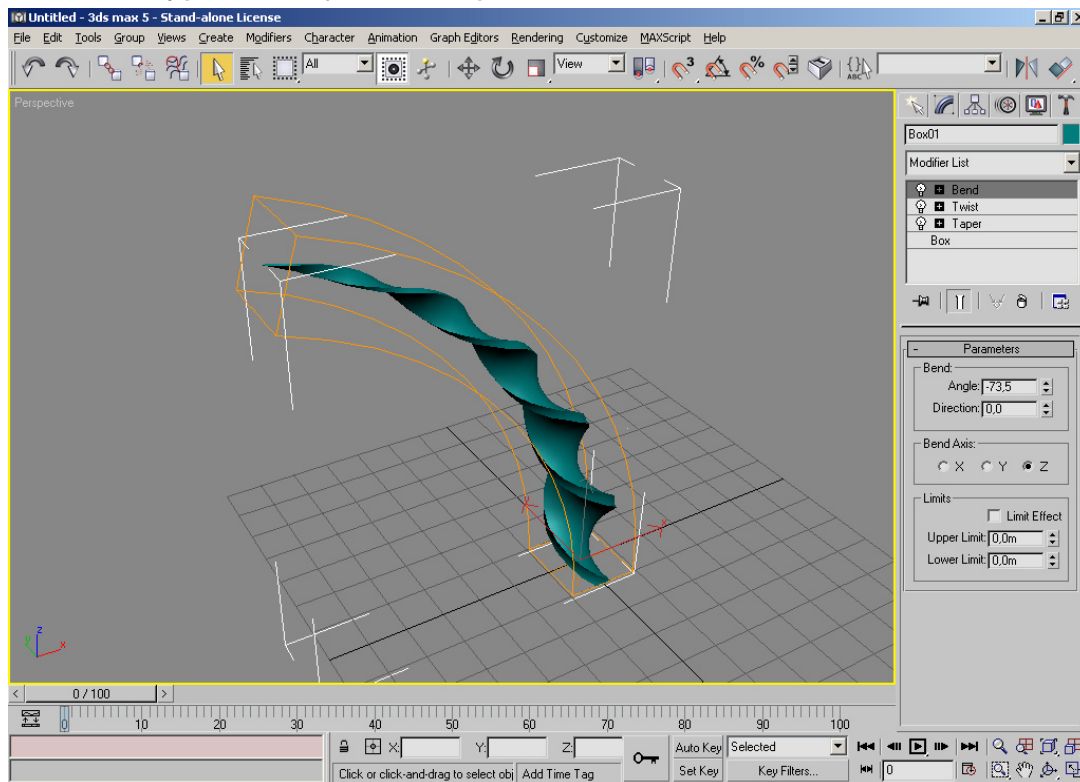


## Parametric Modellers

Parametric modellers allow the parameters of an object to be changed later in the process for maximum flexibility. Although parametric modelling is usually spline-based, not all spline modellers are parametric.

In 3ds max, parametric modelling is implemented with the concept of the modifier stack. Every object can be assigned any number of modifiers, meaning specific transformations. The user can access the parameters of any of these modifiers at any time, or even animate them.

This system will not always give predictable results but it provides a level of functionality far beyond of any undo mechanism. The flexibility comes at the price of more computational intensive modelling, but as soon as the user completes the model, he/she can convert it to one of the above types of objects for optimization.



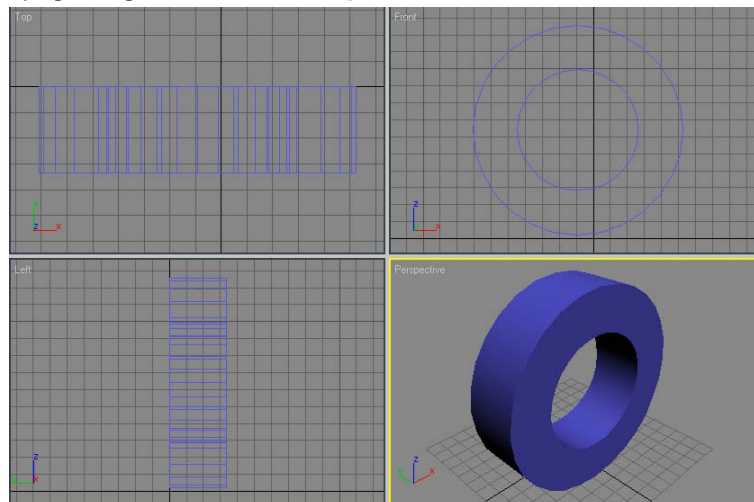
## Chapter 6

# Modelling – Basic Methods

There is a basic modelling in which the user defines 2D shapes and later applies to them a modifier, to make them 3 dimensional.

## Extrusion

Extrusion is the process of pushing a 2D shape into the third dimension by giving it a Z-axis depth.



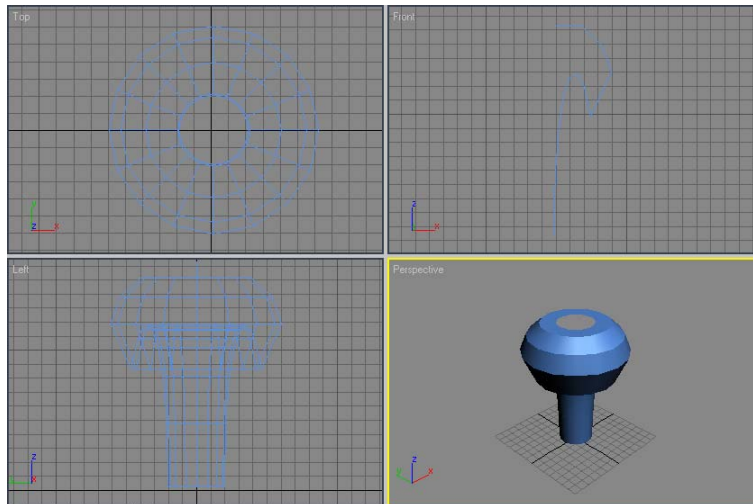
## Lathe

The lathe modifier revolves the shape, producing cylindrical symmetrical objects.

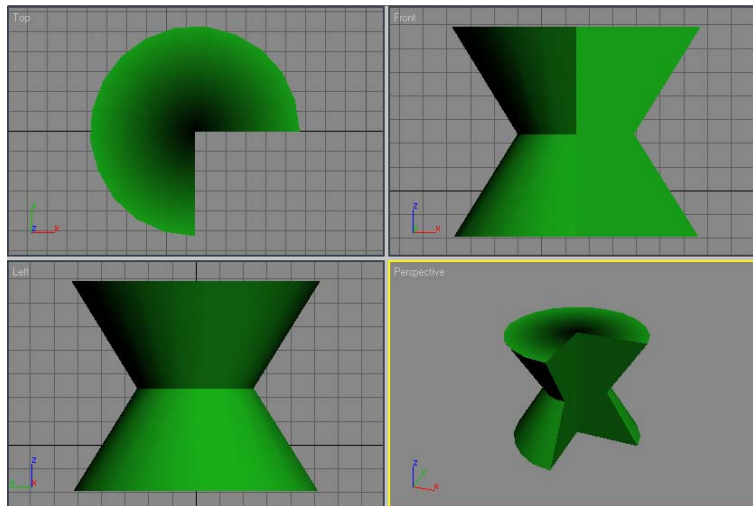
- closed lathe, axis is at the center of cross-section
- open lathe, axis is away from the cross-section



# Chapter 6 : Modelling - Basic Methods



- partial lathe, fewer than 360 degrees



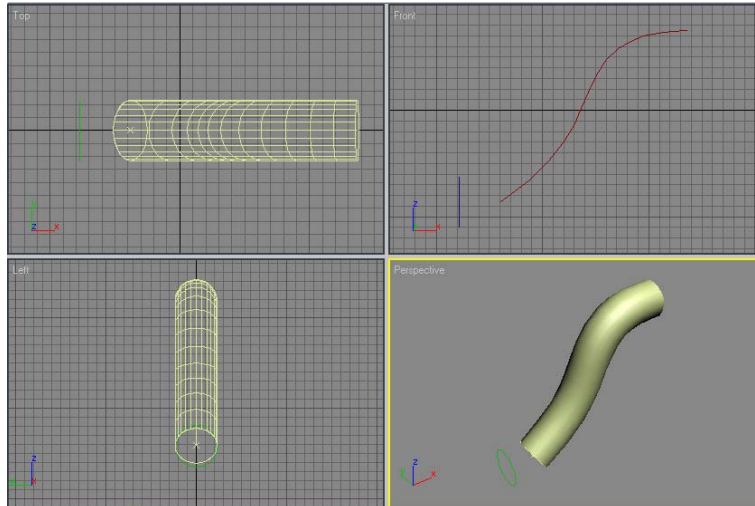
## Sweeps (loft)

Sweep is a powerful modelling method, there is a path spline and there can be one or more shapes along this path. Very easy texture mapping, good level of detail with generally low face count.

Note: if more than one shape is being used, care must be given in the alignment of their first vertex.

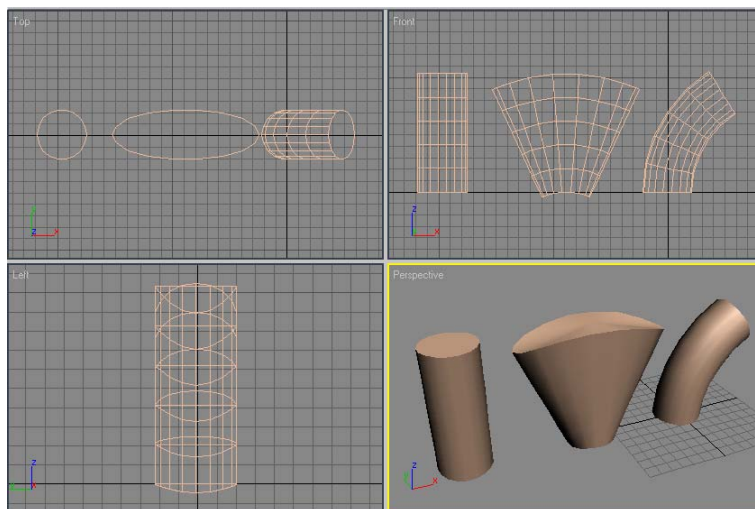


# Chapter 6 : Modelling - Basic Methods



## Bend

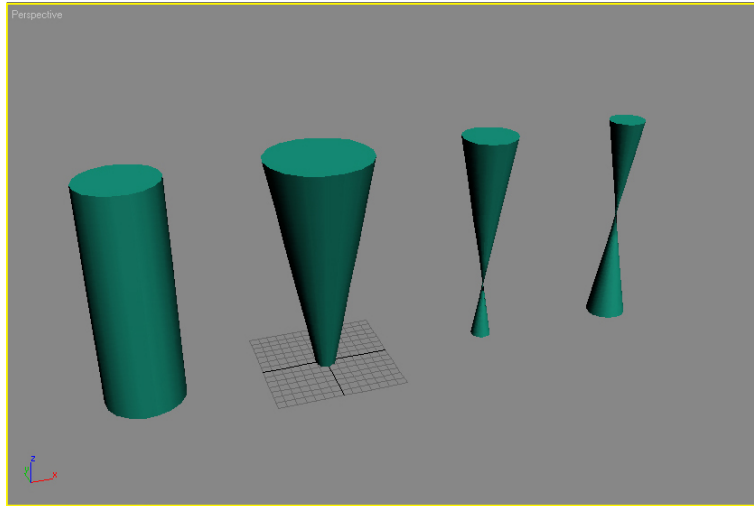
The bend modifier bends the object wrapping it around a center point in the direction of an axis. Should probably be one of the last deformations applied to an object, because the bend axis can no longer be used properly. Needs some extra detail to produce a smooth result.



## Taper

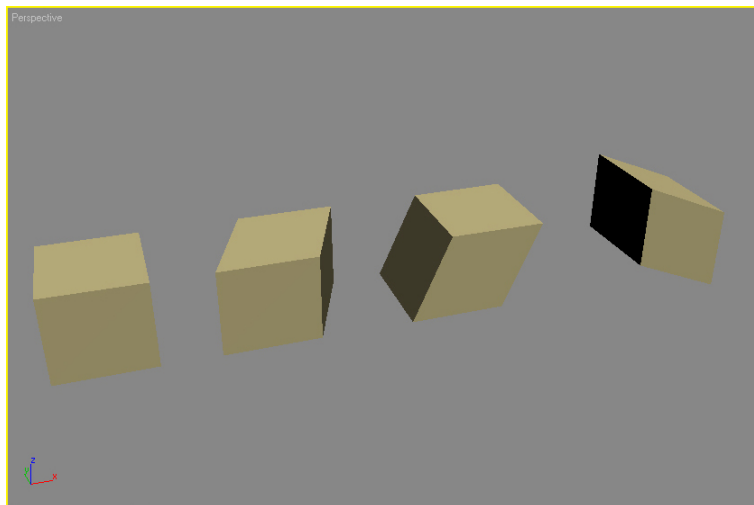
The taper modifier is used to scale up or down portions of the object and the rest of the form will accommodate these changes. Very Little extra detail is required for this modifier to work properly.





## Skew

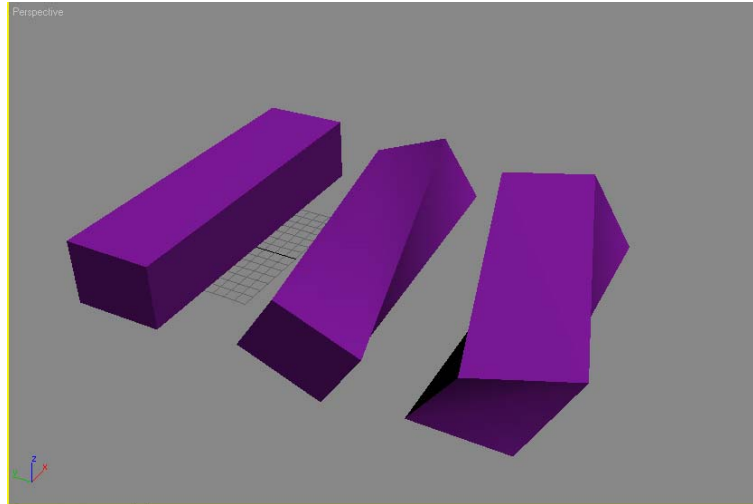
The skew modifier distorts an object forcing each opposite side to move into opposing direction. Very little extra detail is required for this modifier.





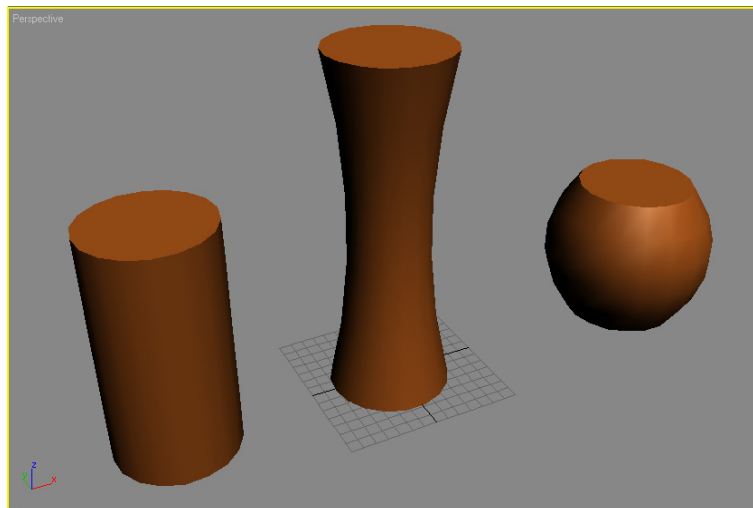
## Twist

Twist is one of the most demanding modifiers. It revolves the surfaces of an object around an axis. The rotation can be applied for more than 360 degrees.



## Squash and Stretch

The melt, squash and stretch modifiers treat the object as flexible material and melt or spread it over an axis or plane.



## Chapter 7

# Modelling - Advanced Methods

## Sweeps (lofts)

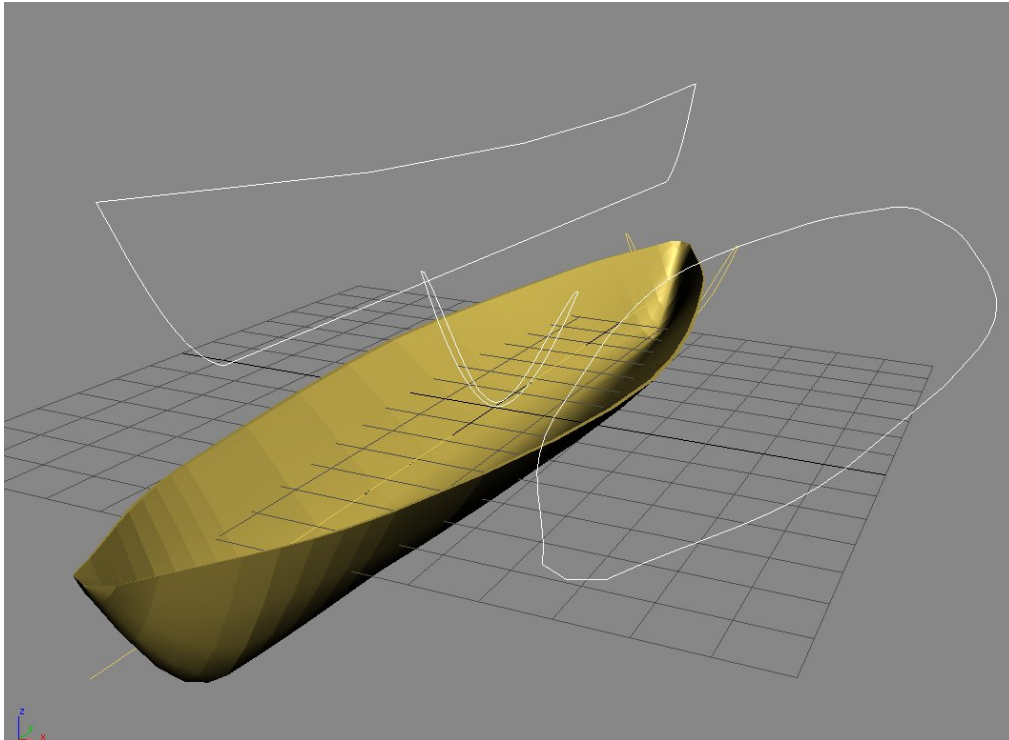
Beyond the basic method of loft, deform modifiers can be applied along the path of the sweep, like scale, twist, bevel, teeter and deform/fit. The resulting objects would be very difficult to be achieved using the standard parametric methods.

All of the deform modifiers can apply varying values along the path, which would require multiple modifiers to achieve using the parametric method.

## Deforms

- **Scale**, controls the scaling of the cross-section shapes along the path. The scale can be controlled in both axis (X and Y). Defaults to 100%
- **Twist**, rotates the cross-sections around the path. Defaults to 0%
- **Teeter**, rotates the cross-sections around their local axis. It defaults to 0% for the whole path of the sweep.
- **Deform Fit**, allows the user to define the shape of the object along the path. Very powerful tool, allows the creation of fairly complex objects merely by drawing their outlines.



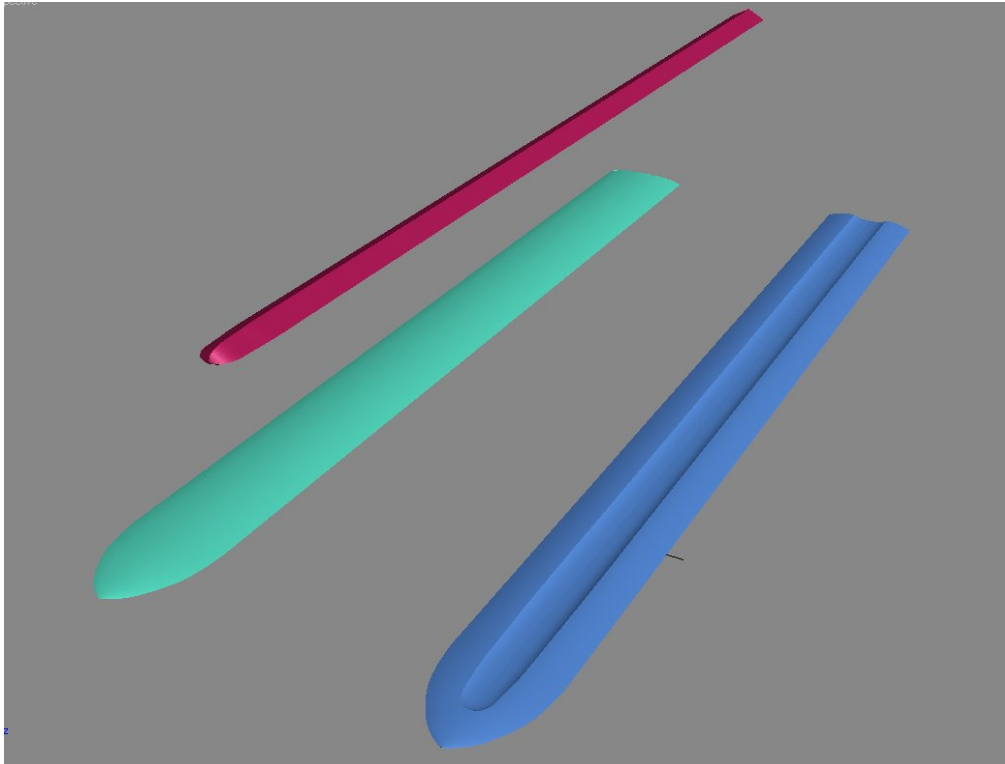


## Booleans

Boolean operations can add/subtract from an object by using operands. Booleans can be applied in both for 2d shapes (surface) and 3D objects (volume). Booleans give a lot of flexibility, and can be used to create extremely complicated objects by using simple operands. Additionally, while using booleans, one can assign id to the surfaces of the operands and these changes will be reflected to the resulting object, allowing for fast texture coordinates setup.

- **Union**, combines the operands and erases any overlapping surfaces (that are inside the boolean).
- **Subtraction**, carves out of one operand the intersected faces of the other.
- **Intersection**, only the intersection of the operands remains.





NOTE: Despite their unquestionable usefulness, Boolean operations can some times be the cause of frustration, like problems with the resulting mesh and software crashes. This is why care must be given whenever they are employed. Things to remember are:

- Always save before any Boolean operation
- Make sure that the objects intersect and are not just osculating.
- Boolean works with volume, sometimes special care must be given when using operands that are not entirely closed.
- Operands must have roughly the same resolution in the intersection area.
- When using multiple operands, try to attach them and perform only one operation.
- If every other option fails, try to move one of the operands a little.

## Editing Mesh

This is the very first method of 3D modelling. Of course today's mesh editing methods are far more advanced than they were 15 years ago, yet the basic principle is still the same: vertex manipulation.

This can be achieved in various levels: vertex, edge, face, polygon.

Most common operations:

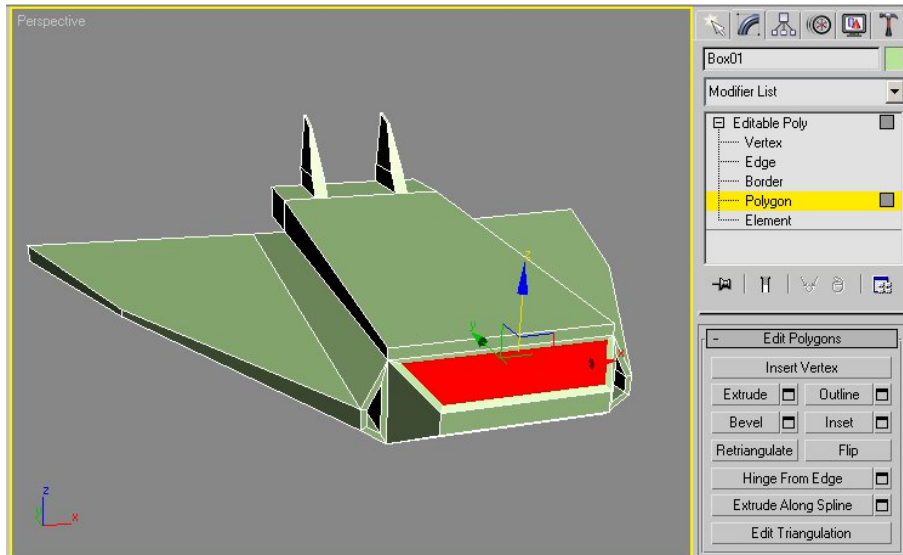
- Face/Poly extrude



## Chapter 7: Modelling - Advanced Methods

- Face/Poly bevel (extrude + scale)
- Vertex/Edge chamfer, clone
- Element attach and detach

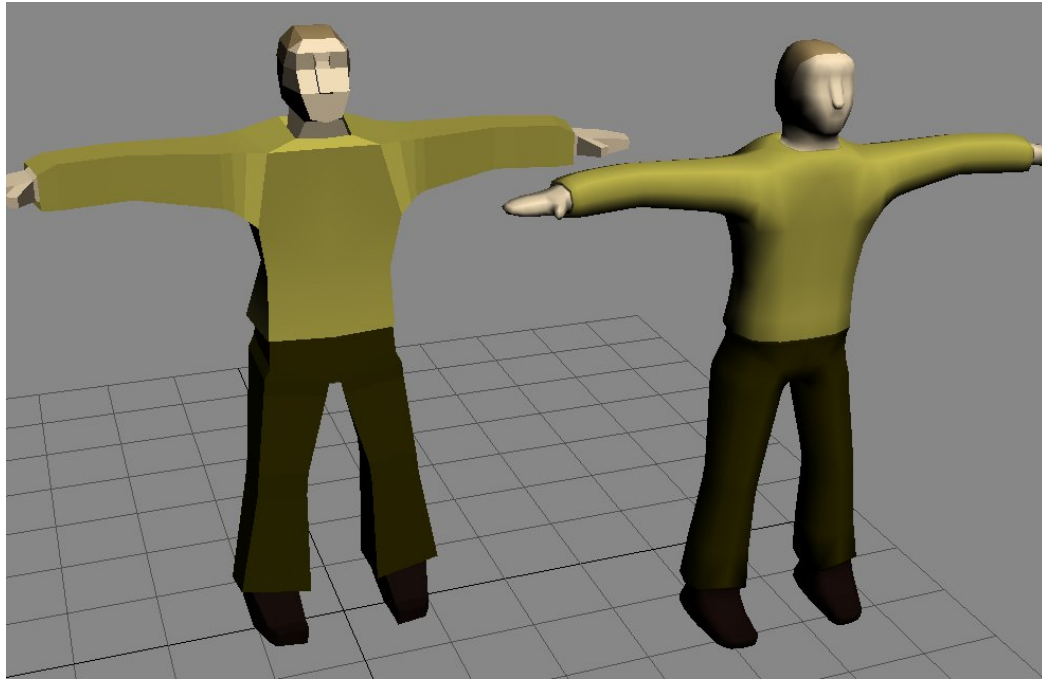
This method is mainly used to create low resolution objects for real time applications because of the absolute control that the modeller has. On the other hand is totally inappropriate for hi res models, since it can be a little difficult to handle tens of thousands of vertices. This is a job for subdivision surfaces.



## Subdivision Surfaces

With the subdivision method, the modeller works in a low res object, which looks quite primitive, using the same methods with low-polygon editing, while the result is a hi res mesh with organic curves and a host of small details. Sounds too good to be true but it is! Actually with a simple setup, one can work on the low res model and have feedback on the result in real time. The low res model is being subdivided according to some parameters; the face count is around 4, 16 or 64 times the count of the low res model (for 1, 2 or 3 steps of subdivision). Of course one can choose to subdivide even more, or use subdivision locally, in a high detailed area, in an attempt to control face count.





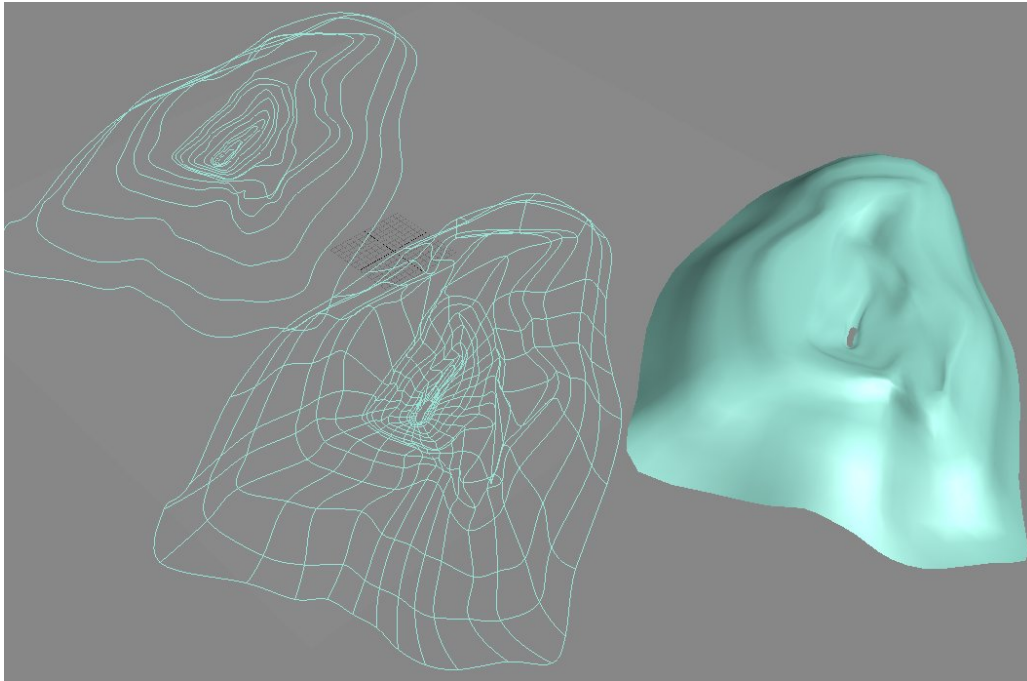
The modeller has some control over the resulting mesh, but this is not the first thing in mind when someone wants to make accurate curvatures.

### Skinning

In the skinning method, the user creates a series of splines that define a 3D object. The 3rd dimension splines can be created either automatically or manually for maximum control.

Afterwards, this wire-cage is being skinned to form a surface or even a closed object. This method has been used over the years to create any kind of object. There were some 3D packets that even rushed to ignore polygon modelling and support only spline skinning.





It is a powerful method that is hard to master. But its real drawback is the unjustified difficulty in expressing small details, while other methods can do it with relative ease. On the other hand it can be used to create accurate curves so it is most appropriate to define man made organic shapes, like car bodies.

### Displacement Mapping

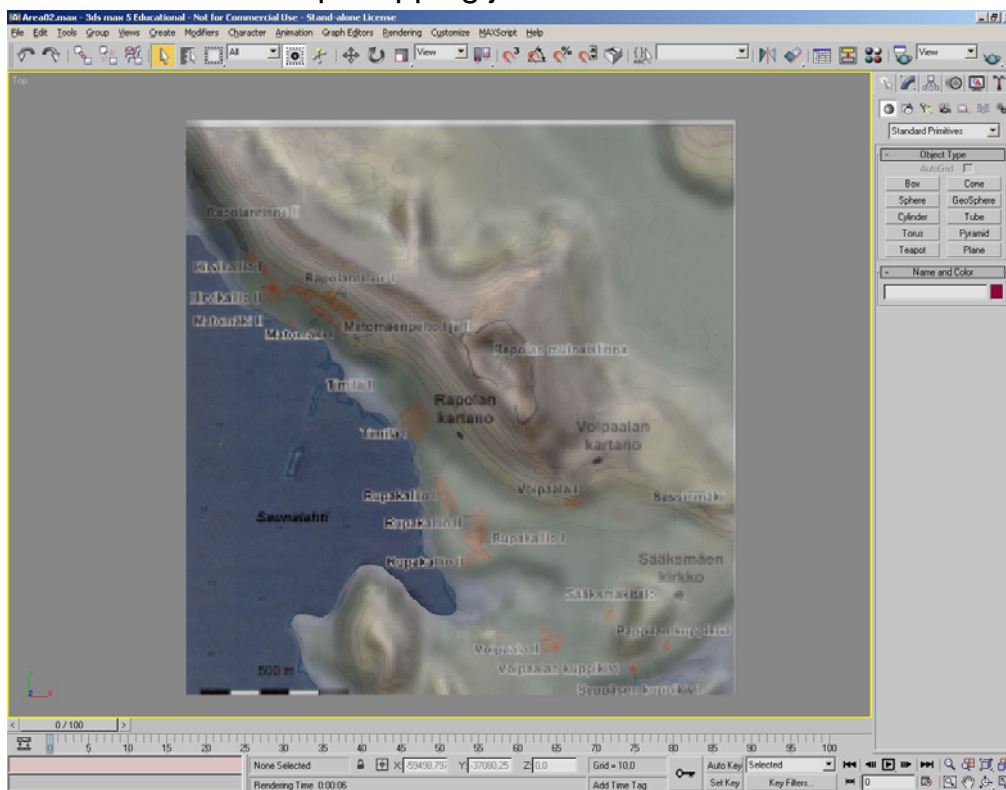
The method of displacing mesh resembles a lot texture mapping, but it has one major difference, it actually changes the model's shape, so it is referred as a modelling method. A grey-scale map is used to determine which part of the surface will rise, according to the pixels values. Usually this greyscale map is generated by some other source, or even painted by hand.



# Chapter 7: Modelling - Advanced Methods



It is a relatively accurate way to model a landscape from a specially edited map, which shows the area from a top view and is coloured according to altitude information. Of course it can be used also to model small details when bump mapping just won't do.





## Metaballs

The user places a set of spheres (Metaballs) or even other objects in close proximity and the render engine creates a smooth skin covering the shapes. The shapes themselves are not renderable; they are the means of defining the skin. Every shape either attracts or forces back the skin.

## Mesh Relax

The Mesh Relax modifier causes the vertices of the object to move closer or away from each other, effectively changing the apparent tension between them.





## Chapter 8 Modelling efficiently

### Bevels

3D objects that represent real world objects, should not have sharp corners. A simple or smoother bevel must be applied so that specular highlights will vary in the corner and give the illusion of higher resolution.

### Scaling (3ds max)

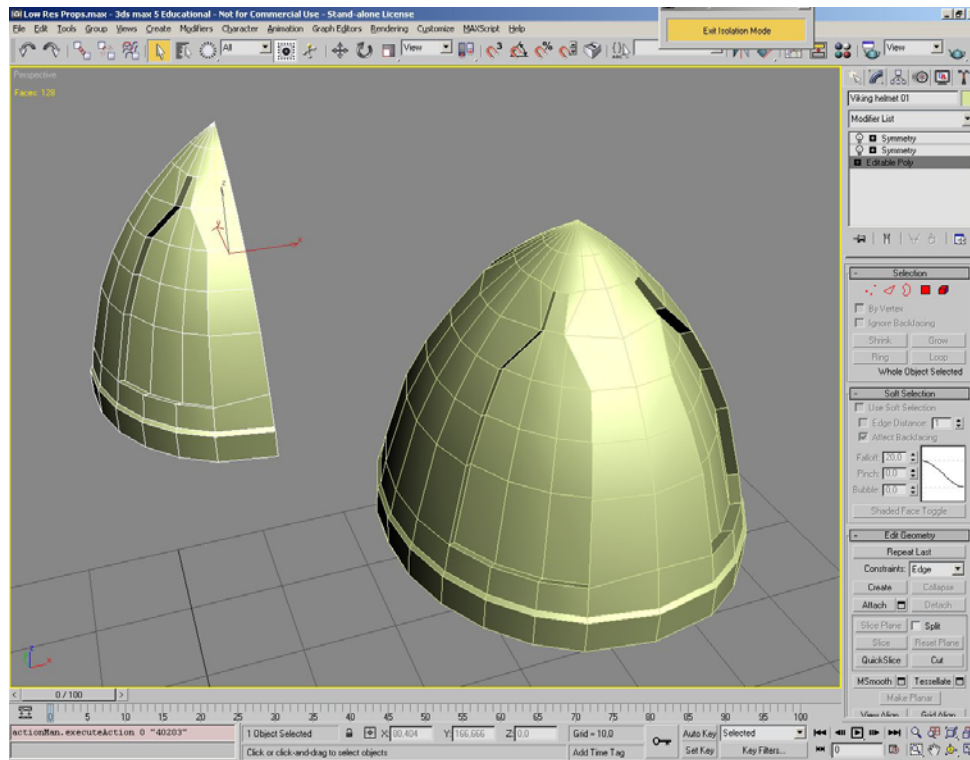
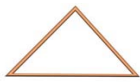
Using the scale transform in object level is not recommended, as the transformation is being done in world space and will lead to problems later on. The transform will be calculated as the last in the stack and not in the proper order that has been applied. Instead the X-Form modifier must be used and the scale should be applied to the modifier's gizmo.

### Mirroring

The mirror tool uses scaling to mirror the object. So to mirror an object an X-Form or mirror modifier should be applied in the modifier stack.

An advanced mirroring tool exists in 3ds max, called the symmetry modifier, which allows the artist to create symmetrical objects with relative ease.





## Other Modelling sources

- Free models
- Commercial mesh libraries
- 3D digitizers

## Mesh Tessellation - Optimization

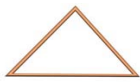
Tessellation subdivides faces, adding more resolution to the model. It does not necessarily smooth corners and curves.

Optimization combines faces that have a given (usually small) angle between them, reducing the face count. If the object was assigned mapping coordinates, they will be distorted.

Notice: Most 3d packets use arbitrary unit scale during modelling and most users don't care about the size of their objects, as long as they have correct proportions to each other.

But photometric lights use real world scale to light the scene, so objects must have right proportions and a realistic volumetric light for them to work together properly. For example, a small light bulb cannot (and of course shouldn't) light an entire city block like the sun. The user must give realistic sizes to objects and properties to lights.





### Cloning

Cloning is not a modelling technique; still it is used to generate objects. There are some different methods to create a clone of an object:

- **copy**, complete independent object
- **instance**, not a new object, the same object in a different location and orientation
- **reference**, an object that can have other modifiers but also inherits manipulation from the prototype.
- **arrays**, multiple clones with one of the above options, arrays of cloned objects can be created in 1,2 or 3 dimensions in a user defined line, plane or volume around the originating object.

### Grouping

Multiple objects in the scene can be grouped together in a single group. This can help organize a cluttered scene and can facilitate the appliance of the same transformations to all of the objects in the group.

NOTE: (max) groups may cause peculiar behaviour. Opt for selection sets and layers.





# PART IV: Texture Mapping

3D models can have beautiful shape and an exploding amount of detail, but unless someone ‘paints’ their surfaces, they will look plastic and lifeless.

Texture mapping is the process of ‘painting’ the 3D models’ surfaces; and it consists of two phases: creating textures and mapping them on the model.



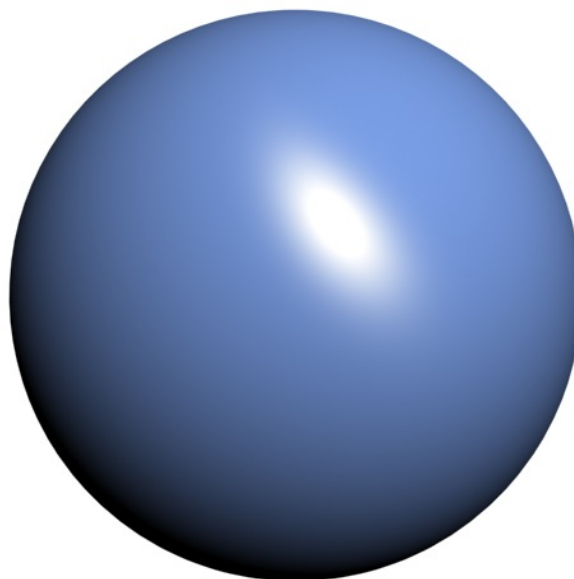


## Chapter 9 Materials

An object's material consists of a set of properties that define what the object is supposed to be made of. Each of these settings can use a map, procedural or bitmap, to alter their behaviour along the objects surface. This can be controlled using the amount of change that will occur in the base attribute. Some channels like diffuse and reflection use the colour information to actually project the map to the object's surface, while other channels like shininess, specular and bump, use only the greyscale information to define the areas of the object's surface that will have the most affect (grey to white pixels) and the areas that will not be affected (black pixels).

Additionally an object's material is affected by the lights in the scene. Both from light's position, intensity and colour:

Diffuse colour is the colour that the user assigns to the object; it is the colour that the object reflects where it is directly illuminated by a light source. Ambient colour is the colour that the object reflects when it is not directly illuminated by any light sources, but instead it is reflecting the light that other objects in the scene have reflected - in most cases this is just a darkened version of the diffuse colour and no bouncing light is calculated. Specular colour is the colour of the actual rays from the light source that the object reflects to the camera (highlights), it is usually white.





### Material Channels

Each material has a number of channels, that the user can assign a map to them. Channels use the map with a different way and they affect the object's appearance in a totally different manner, but because some of the surface's properties coincide in same locations on the object surface, the maps assigned to different channels are usually related.

Diffuse colour is the basic colour of the surface. Expressed in the RGB (Red, Green, Blue) or the HSV (Hue, Saturation, Value) formats. The diffuse map is probably the first map that someone will apply to an object, to define its overall appearance. The diffuse map is projected to the object and is the one that shows up in colour onto the objects surface in the rendering.

Specularity defines the amount of light reflected by the object, the intensity of it's highlights.

Shininess and glossiness express how the surface of the object reflects light, meaning the size of the highlights - shiny objects have small and more concentrated highlights.

There are many algorithms that determine the highlights shape that most of them suit a given type of surfaces, like phong for plastic or metal for metallic surfaces.

Specularity and shininess are extremely important attributes, since the human eye is accustomed to 'read' the highlights from our surrounding object's to determine what they are made of. If the diffuse information (like a wood or steel photo) is different from the one of the highlights, the object will seem confusing and artificial to the viewer.

Transparency or opacity is the same surface attribute defined by one of this opposite terms. The more transparent an object (or the less opaque) the more light passes through and the less visible it becomes - translucent.

There are settings that define the object's behaviour when it is translucent. There can even be additive or subtractive, where the diffuse colour is added or subtracted from the background, or the user can define a filter colour. There can also be a variation in the objects transparency using the surface normals.

#### Refraction

When light rays are passing through a translucent object (especially when it is curved) they are being bent, changing their exit vector. This phenomenon is called refraction and the amount of change in the lights trajectory is called index of refraction. Typical values are: 1.0 for empty space/clean air (no refraction), 1.3 for ice, 1.7 for glass.

Refraction can be calculated based on real world physics or it can be faked by using a refraction map to save render time.





## Chapter 9 : Materials

The reflection map is a secondary diffuse channel that is applied to the object to give the impression of reflectivity. The maps may be generated at render time or they can be faked with bitmaps, or someone can even use a totally different image to give the sense that e.g. the object is reflecting sky or clouds.

TIP: In a fairly curved metallic surface ray-tracing is overkill, as the viewer won't be able to tell which objects are being reflected anyway. So it is faster or even better to use a special reflection map created in some 2d paint program, or just a render of the scene from the surface's POV.

Self-Illumination gives the impression that an object is being lit from within. Actually no light sources are being added to scene and the only attribute that is affected is the ambient and diffuse colour.

Bump maps give the illusion of extra complexity in the surface's materials, by varying the objects normals and creating shadows and highlights of actually not existing bumps.

It does not affect the object's geometry however, that is way the effect is becoming unrealistic in the edges of a curved surfaces.

Tip: For better results try lower blur and higher Blur Offset settings.

NOTE: Most packets provide the user with the ability to blend and combine a great number of maps to each channel.

## Maps

Maps can be static or animated (video clips or animated procedural

### 1. Image Maps (Bitmaps)



The information of pixel colour is provided by a file.

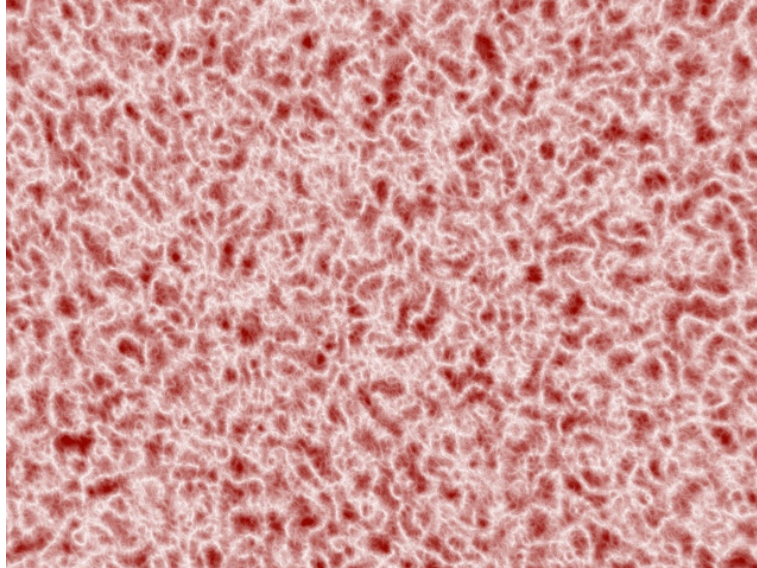






- + They offer very realistic surfaces (from real photos)
- Require texture coordinates
- Consume system memory (especially video)
- The image must be tillable to be repeated in the surface

### 2. Procedural Maps



The information of pixel colour is provided by an algorithm, like noise, smoke, marble etc.

- + Have none of the disadvantages of bitmaps
- + Can provide seamless tillable textures of random surfaces (like bump maps)
- + They can be animated very easily to provide effects
- May be too difficult to create a realistic texture

Usually, image maps are being used to provide the basic information about the objects material and then procedural textures are added to provide additional flavour and variation to the material properties.

Especially noise type procedural maps are very effective in every channel, because they help breaking the too perfect quality of 3D graphics and create a more real life picture of a surface that is imperfect, has small bumps, is more or less reflective and shiny and has faced dirt and age. These are some qualities that separate good from photorealistic 3D graphics.

## Seamless tillable image maps

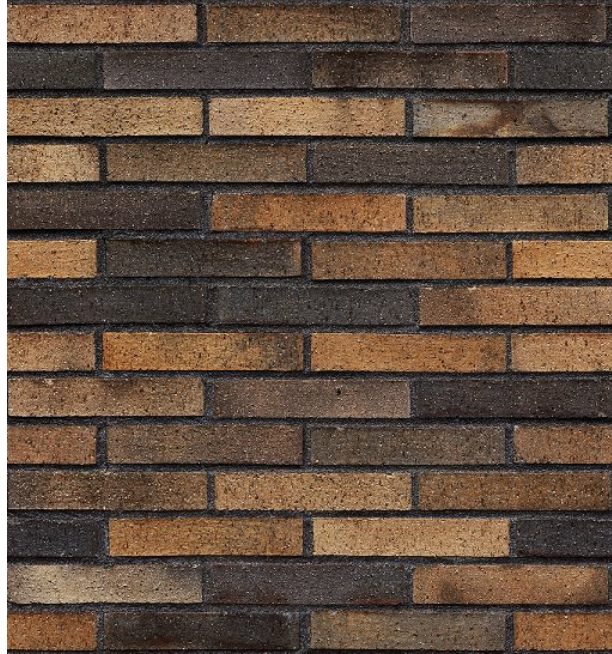
When an image map is applied on a large surface, it will have to be tiled several times. To provide a realistic rendering the edges of the





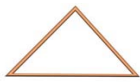
## Chapter 9 : Materials

tiling will have to be seamless, meaning that there must not be identifiable.



To create a seamless tillable image is not an easy task, because not only the corresponding edges of the image must fit perfectly, but also the overall look of the image must be uniform in colour, intensity and detail. Yet no matter how hard it is, the results can be so pleasing that one that has the image editing abilities required would do well to invest the time.





## Chapter 10

# Mapping Coordinates

Once the object's material is defined it must be applied to the object's surface. One method is the face mapping. Each pair of faces that are separated by an inactive edge, are being drowned with the image. This method is seldom being utilized. For every other method, mapping coordinates must be applied to the object.

## Image Coordinates XY

When an image is assigned in a material channel, every pixel of it has a pair of XY coordinates, to define what part of the image will correspond to each part of the material.

## Mapping Coordinates (UVW)

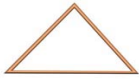
The object's surface is also being assigned a set of Uvw coordinates (these letters have been chosen just because they are preceding XYZ). They are used in pairs like UV, UW or VW to correspond to the XY image coordinates. Mapping coordinates define how the applied texture will be displayed on the object's surface.

There are several coordinate types, some general and some special purpose:

### Planar mapping

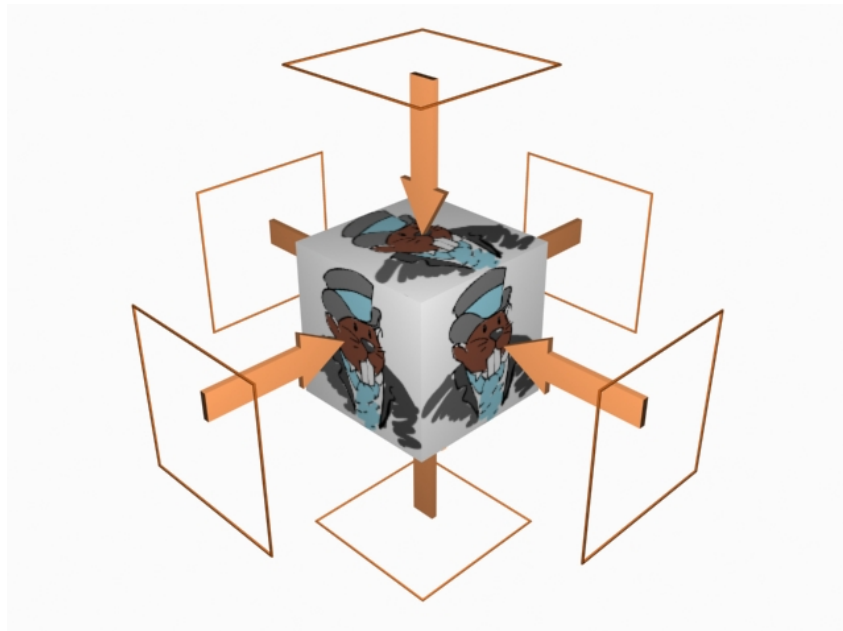
These type of coordinates are flat and are good for mapping objects like walls and doors. They act as though they are pushing the map through the mesh, which may create streaks along the sides of the object.





### Box mapping

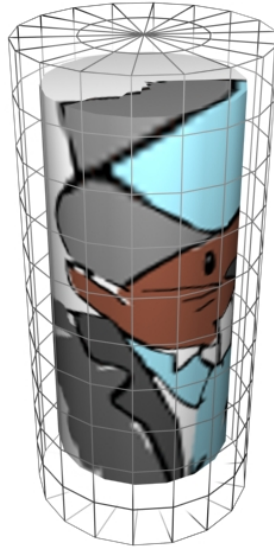
It provides six cubic, vertical planar coordinates.





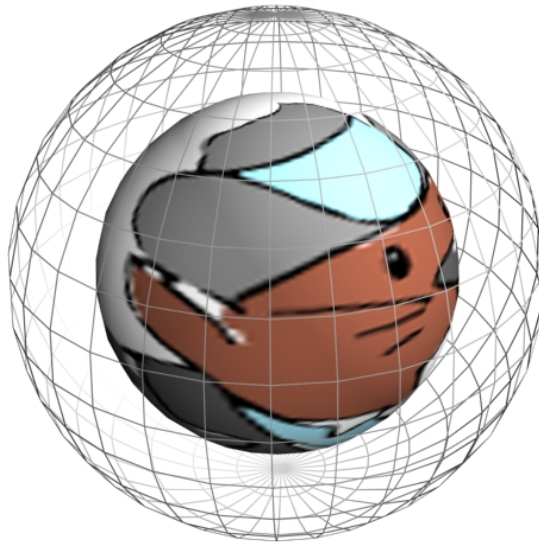
### Cylindrical mapping

Wrap the image around an axis. Create streaks to faces up and down the axis, so a cap option for planar mapping may be used. There may be a seam.



### Spherical mapping

Like cylindrical only that the caps are wrapped closed.



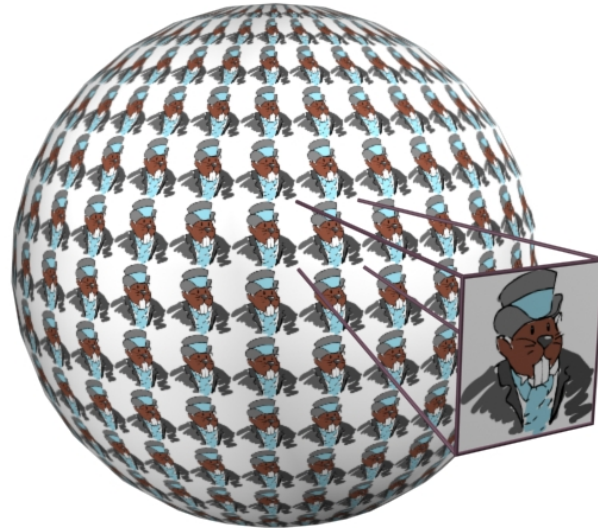
### Wrap mapping

Wrap mapping tries to conform to the object's shape and provide a spherical deformed mapping.

### Face mapping

Applies a copy of the map to every face of an object





### Sweep/Loft

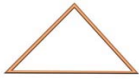
Lofted objects provide an easy way for mapping coordinates, with mapping that conforms to the path's curvature and achieves a texturing that would be next to impossible with any other method.

When it comes to complex objects there is no perfect mapping method. In this situation the modeller can break the mesh polygons into sub-groups that the texturer is going to apply mapping coordinates separately.

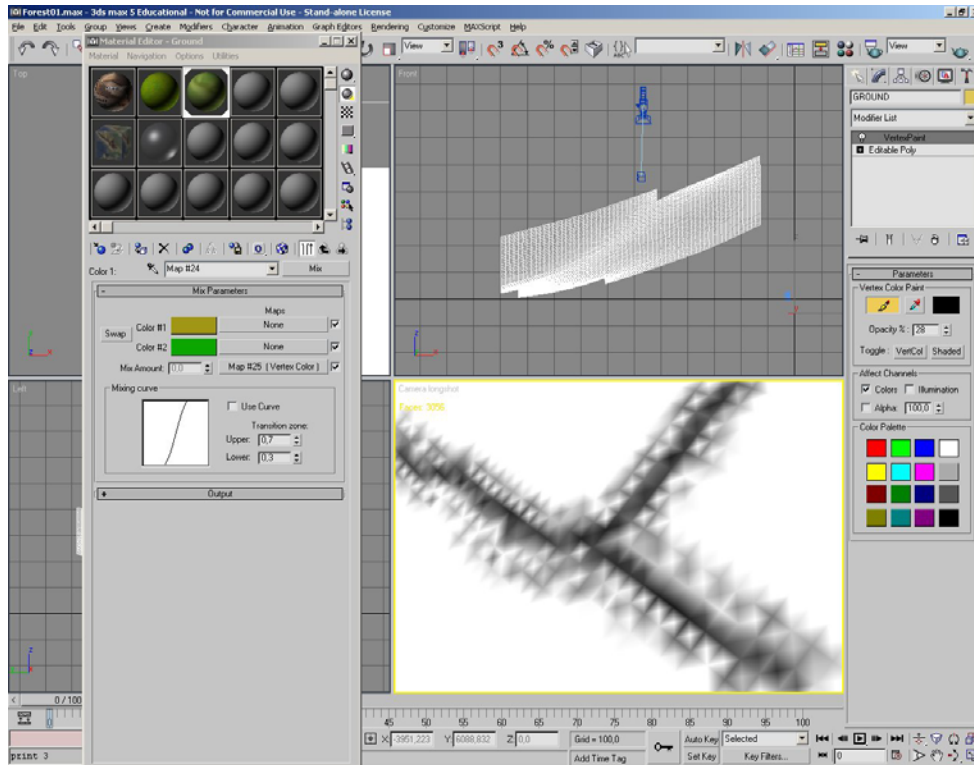
### Vertex Paint

Another way to define material boundaries (and not UVW coordinates) is to "paint" the vertices of the surfaces. This way it is easier to define where exactly each material will be assigned.



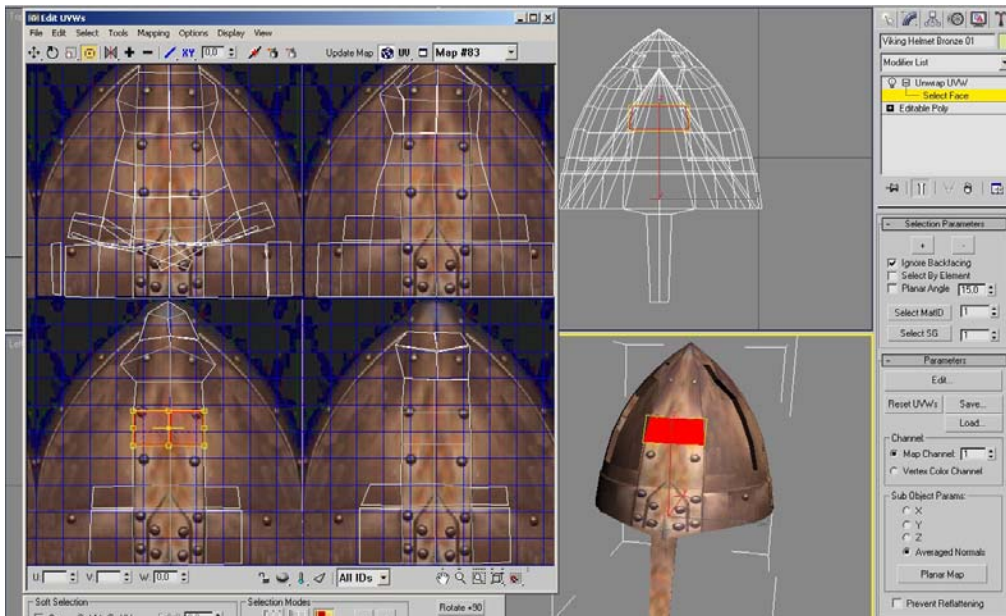


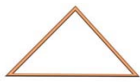
# Chapter 10 : Mapping Coordinates



## Unwrap UVWs

There is an even more powerful method of breaking up the mesh and then define manually the texture coordinates for each poly (usually groups of neighbouring polygons). This method is referred to as Unwrap Mapping and can be utilized to map every kind of object, but must be used with caution because it can cause variations in the texture resolution or streaking.





## Multi-Sub Object

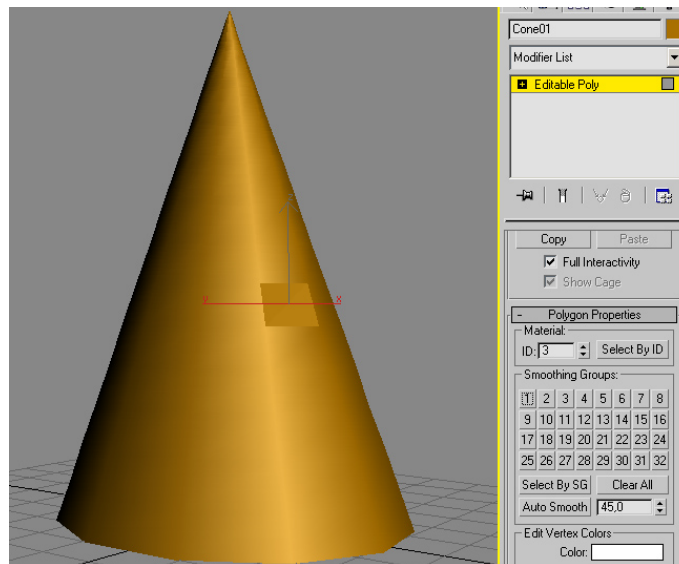
Finally, mesh can be assigned multiple materials that each one will be shown to different polygons. This is accomplished by changing the material id of the groups of polygons and creating a material that encapsulates all the materials for each id. Each material can be mapped to the object using a different mapping method.

The edges that reside in the borders of different ids have a very obvious seam, almost as though it is a different object, so care must be given in the modelling process if multi-sub object material is going to be utilized.

## Smoothing groups

While modelling, each face is assigned in a smoothing group based on positioning criteria. If adjacent faces are grouped in similar smoothing groups the rendering engine will interpolate any colour and textures, trying to make them seem smooth.

One can use this mechanism either to define smooth areas or to separate faces to achieve a more hard-edge styled look.



## Decals

In addition, small bitmaps that don't cover the entire surface (decals) can be used to add flavour to an object, like labels.





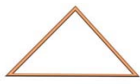


# PART V: Animation

Animation is technically the process of applying transforms to an object through time, usually to different frames. Like so animation is a form of modelling through time. Most of an object's properties can be animated in most 3D applications, giving flexibility to the artists.

The true essence of animation though is to breathe life to mesh, give them character and realistic motion. One must remember, in any sequence the star of the movie is not the mesh of the character, it is the animation that the animator is giving to it. A medium detailed and textured mesh that is animated brilliantly with graceful soft moves can convey much more realism and emotional response to the viewer than a highly detailed and textured object, whose animation is awkwardly mechanical.





# Chapter 11 Keyframing

The most common time measurement in the world of 3d graphics is the frame. Most 3D applications set the animator's transformations over the mesh in frames, not seconds. This means that an animator works in a frame-based timeline.

What is not common is how much time each frame sustains. This depends on what is the frame rate that the output medium will have.

## Frame rate

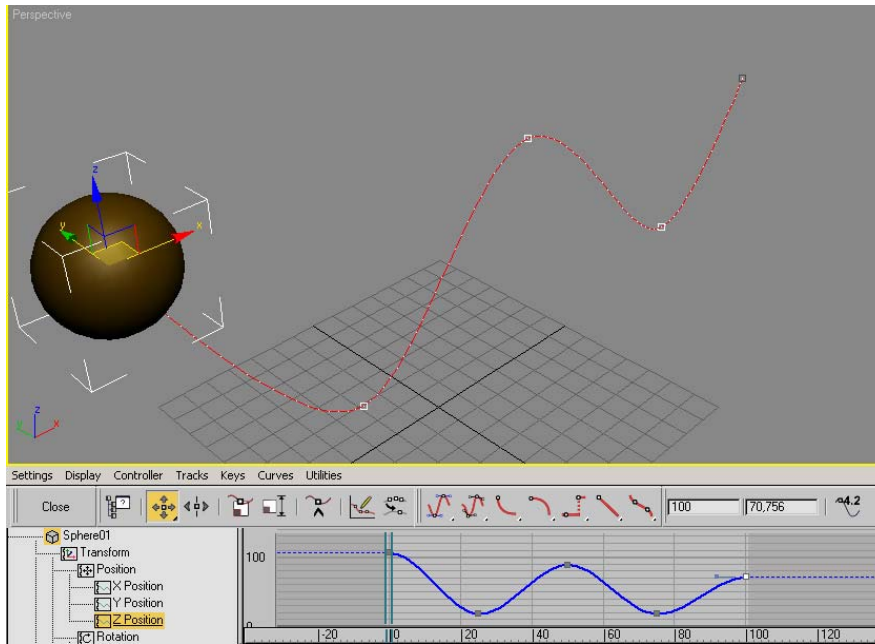
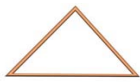
Frame rate defines how many frames are projected over one second. For the human eye to perceive a seamless animation sequence we must project at least at a frame rate of 16-18 frames/second (fps). To use also sync audio we will need 24 fps. 3D applications allow the user to define any frame rate, although it common to work in a frame rate around 30 fps.

## Keyframing Animation

Keyframing animation derives from the early hand drawn cartoons, where a key-animator was painting the master poses of the cartoon and then some secondary animators where filling the in-betweens. This is also the case with 3D animation. The user sets the transformations in specific frames and the application calculates the in-betweens.

The way the application calculates the rest of the frames is adjustable via graphical tools that allow to control how exactly the keyframes interact with each other.



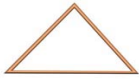


## Animation Controllers

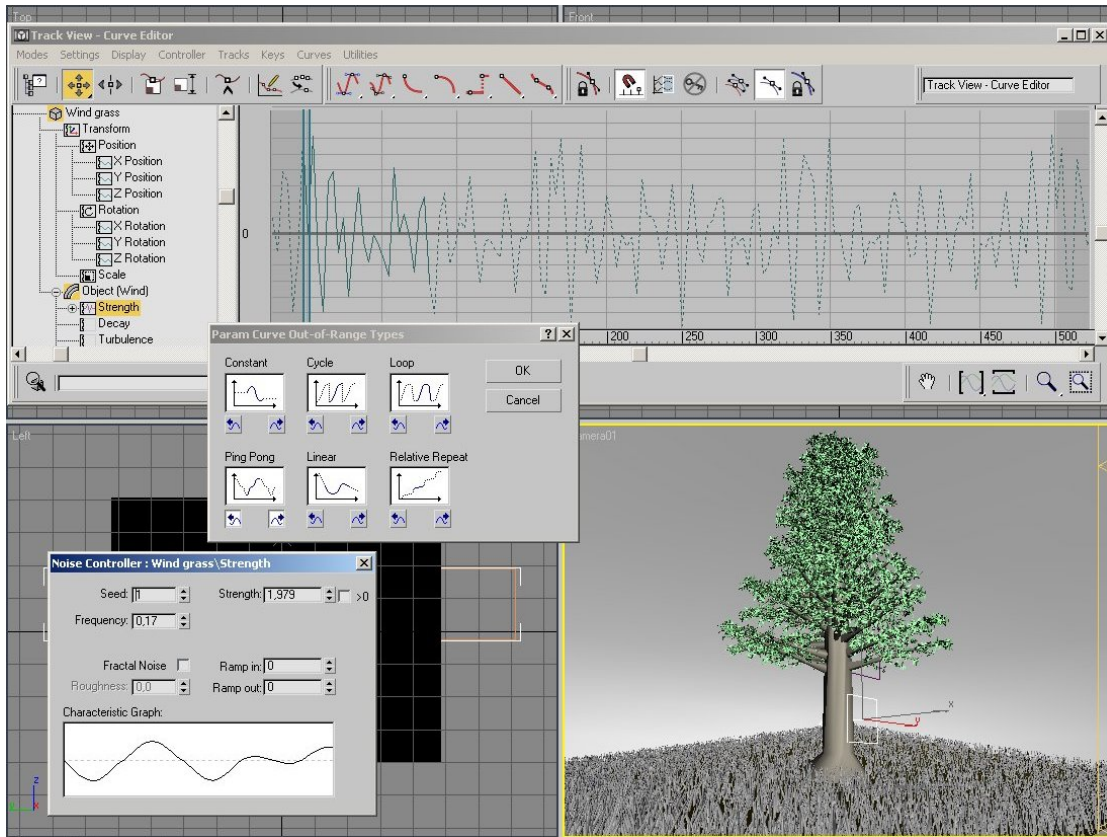
Keyframes can have a great variety of properties that define how exactly each of them effects the animation, called animation controllers. There are different mechanisms that provide different attributes to define how much 'weight' has each keyframe.

Also there mechanisms that produce animation based on some algorithm, for example random noise.

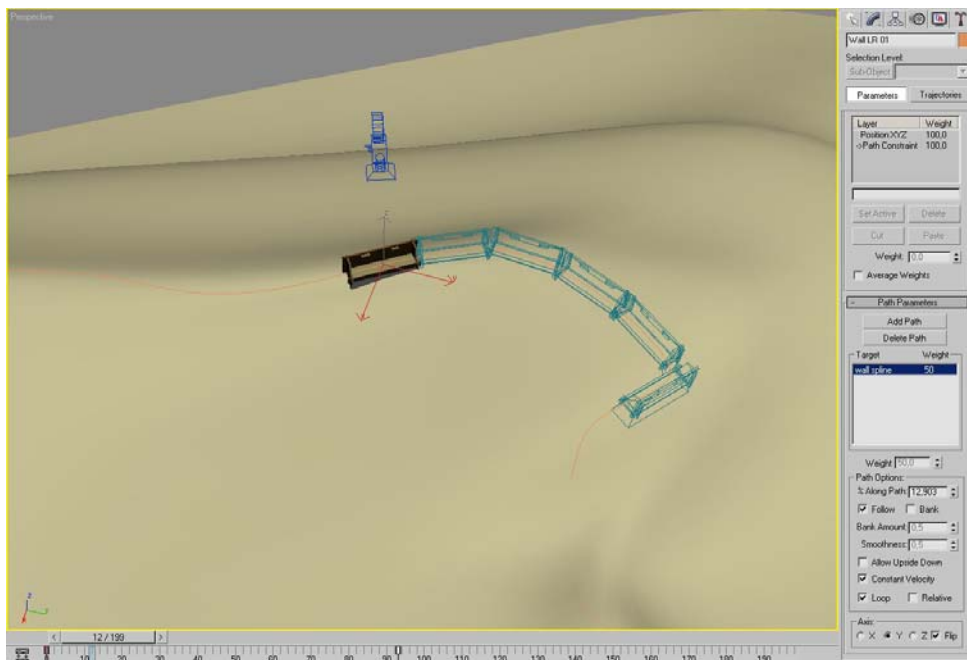


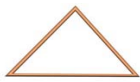


# Chapter 11 : Keyframing



Animation controllers can also be used to position multiple clones of an object along a path. There are other, more straightforward methods to accomplish this task, but sometimes it may be preferable to use this one.





## Chapter 12

# Animation mechanics

Practically, by activating the keyframing mechanism of the 3D application, the user can start applying transformations (move, rotate etc) to objects, in different frames though the timeline.

Animation though is a complicated task and more often than not, it requires a lot of effort and trial-and-error. In order to facilitate the animation process, 3D applications provide a toolset of helpful features to the animator, than can simplify the most common tasks he/she is undertaking.

Therefore, before the animation phase starts, there is a phase of setting up the models in order to facilitate a more trouble-free animating process. This phase usually overlaps with the modelling process and it is generally necessary to revise all three phases (modelling, setting up, animating) until the animation is ready.

## Hierarchical Structures

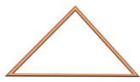
In order to describe any kind of motion that consists of several parts, like the human skeleton or a machine, one must define object hierarchies.

The hierarchy is being defined in a parent / child manner, so that certain transforms that ones apply to the parent are inherited by it's children.

## Dummies

Each 3D packet provides a series of helper objects to ease the taunting process of animating. The most common objects are dummies. A dummy is a very simple object (usually a cube) that does not has surfaces and does not render. It's only purpose is to be assigned as a parent in a hierarchy and be used to apply transforms instead of a complicated and hard to use object.





## Skeletal Deformation

When a character is composed by separate objects, like a puppet, it can be animated directly. Most of the characters however are single meshes, to facilitate animation in such objects one can use bone deformation. Bones are objects that are positioned inside the mesh and with some method (like the skin modifier) are being linked to the mesh. Thus animating the solid bones one animates the mesh.

## Inverse Kinematics

As we saw, when a transform is applied to a parent of a hierarchy, the transform gets inherited to its children. This technique is called Forward kinematics and is the most straightforward way to animate a structure. The results are predictable and accurate.

Animating a complicated hierarchy though can become very taunting when one wants to achieve a specific goal. For example to animate an arm grabbing a pen, one will have to rotate the upper arm, then the lower arm etc. After the fingers have been animated to actually reach the pen, usually it is necessary to change the upper arm's position, after that the whole hierarchy will need revising as well.

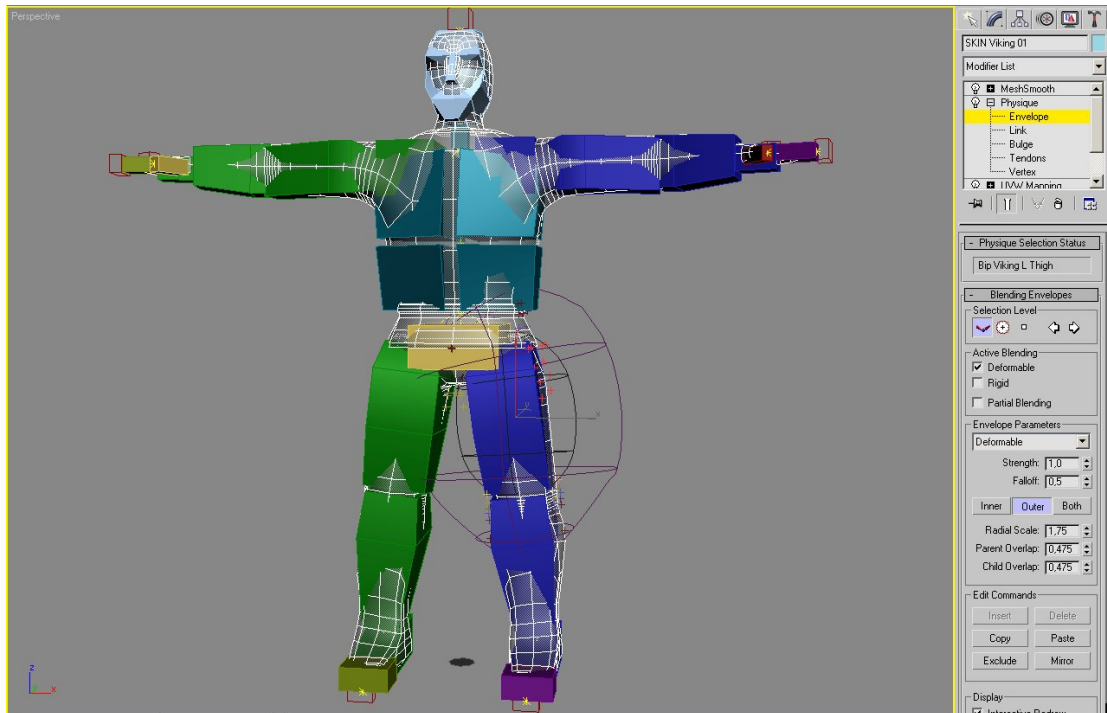
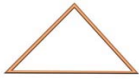
This is where Inverse Kinematics (IK) comes to save the day. IK defines a root (a parent of a hierarchy) and a goal (the end of the IK chain). After an IK chain has been defined, the user can affect the goal of the hierarchy and the rest of it will try to follow it. This process involves a lot of tweaking and the results can be unpredictable, but it is the method of choice for almost every animator.

## Character rigging

The process of defining the relationships between bones and mesh and the one of defining proper IK chains on a character is called rigging. A well defined rig is a necessity for animation, since the time that will be invested on it will be saved multiple times in the long run.

Depending on the complexity of the character and the required animation, a proper rig may take weeks, since it is a very iterative process that requires a lot of trial and error revisions.





## Motion Capture

Some times it is more efficient to actually digitise an actor's movements instead of just using them for reference. The actor's joints are defining his movement and motion capture's (mocap) purpose is to transfer these movements into the 3D packet. Mocap techniques can also be used to capture facial expressions.

This can be accomplished with several techniques. One is to attach bright reflective surfaces on key positions of the actor's body and film his actions using multiple cameras. Specialized software then will use those images to extract each position.

Another way is to attach special transmitters that each sends its exact position to the receiver and thereby the software can calculate the performer's position.

Mocap animation usually requires some additional classic keyframing 'clean up' to refine and correct the final animation.





## Morphing

Morphing is a word that in the 3D graphics lingo means “metamorphosis”; to change shape. This method creates smooth transitions between models, in a way that the first will appear to “melt” and form the other. The objects that are used in this process are called morphing targets.

Morphing has a basic requirement: all the morphing targets must have the exact same number of vertices. That means that the most common way to achieve this is to clone the original object, manipulate it using methods that don’t change the vertex count and finally use all the clones into the morphing process.







## Chapter 13 Systems

Most 3D packets offer systems that allow a certain degree of atomization, to facilitate the creation of complicated effects, like snow and rain. These systems differ from ordinary objects in their mechanisms that provide to the user. Most of these mechanisms have a focus in producing realistic animation, in tasks that would be too difficult or extremely time-consuming to complete by hand.

### Force Fields

Force fields, or space wraps (in 3ds max) are objects that do not render, but they apply a certain effect to other objects under their influence.

These effects like wind, bomb or wave, can be used to animate the objects' basic transforms, or to completely change their topology.

### Particles

Particle system is a mechanism that generates from an emitter a large number of small objects travelling through space and usually vanishing after some frames.

The user can alter all of these parameters and control with various ways the movement and appearance of those particles. Moreover, particles can be assigned texture mapping and with the use of opacity can be made transparent. When a host of transparent particles are packed together they can simulate effects like smoke or dust and they are very appropriate for this task.





Particles can also interact with special space wraps like deflectors and wind and with the proper positioning in the scene can look as they interact with the objects in the scene.

## Simulations - Reactor

Many 3D packets ship with systems that allow simple physics simulations. The objective of these systems is not to accurately simulate physical phenomena, but rather to provide a “realistic” animation that can convince the viewer.

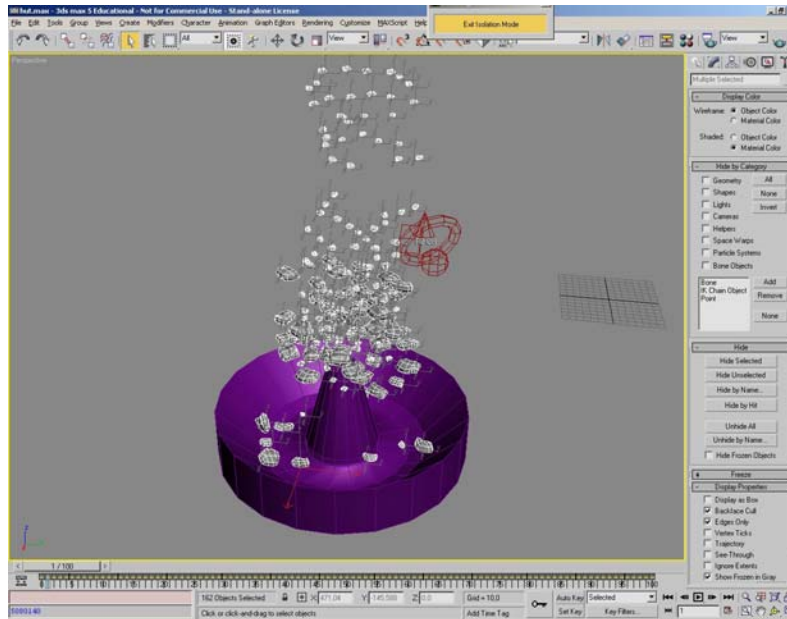
This is accomplished by allowing the user to define a set of parameters for typical objects, like weight and surface parameters. If the object is too complex then the user can define a lower resolution proxy, or the system can produce it automatically, in order to be used in the simulation process.

But one equally interesting application of simulations is also for the modelling and compositing processes. For example, it is easy to create a realistic pile of stones.

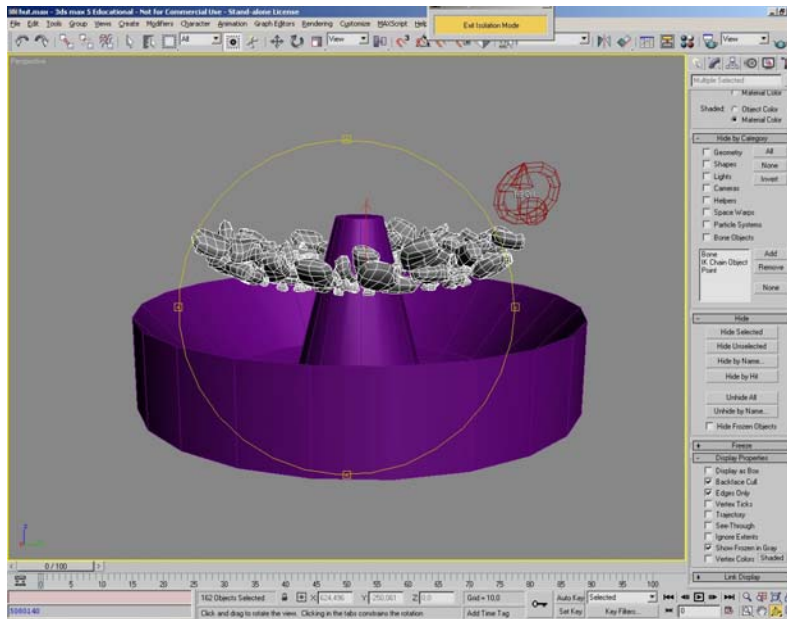




## Chapter 13 : Systems

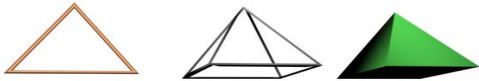


Then with some manual adjustments have it ready.

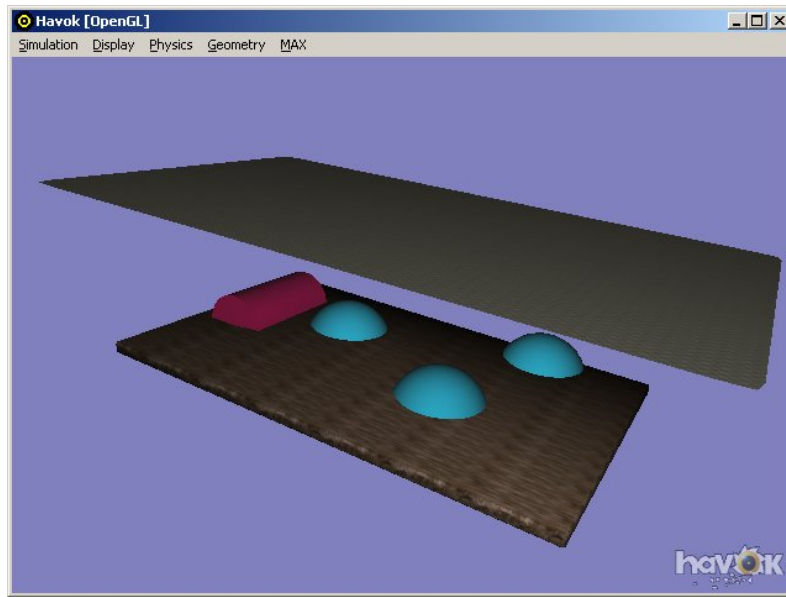


This technique can also be used with soft bodies, like clothes.

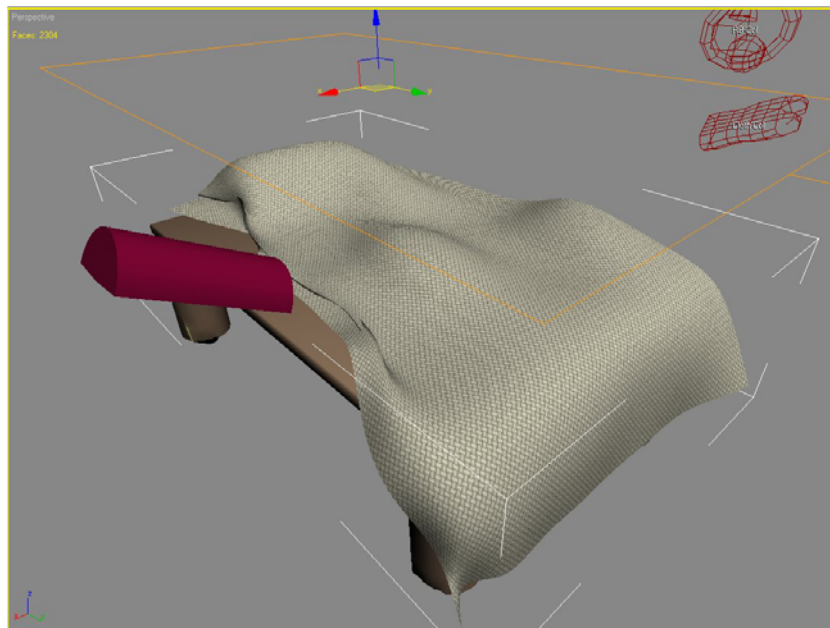




# Chapter 13 : Systems



The final result, after only some tweaking.



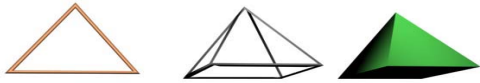


# PART VI: Composition

Composition has to do mainly with the placement in the scene of objects, lights, cameras etc, the overall feeling of the scene. The composition can convey a lot of information to the viewer, for example what are the habits of the characters occupying the scene. It can also set the mode of the story, how the models are positioned in the scene and how they are presented to the viewer can affect greatly the atmosphere.

The items in the scene should be placed based to some reasoning. The scene composition could be based on some characters, even if there are not going to be rendered.





## Chapter 14 Lighting

Lighting is one of those features that can so easily define a mood for the scene. Yet its significance is some times underestimated. Lighting setup should be a concern when it comes to complex scenes, especially when someone wants to evoke certain kinds of feelings to the viewer and set a pace for the scene. The person in charge of the light setup (cinematographer in filmmaking) has to make sure that both the mood is clearly defined but also that the number of light sources in the scene is not too large, because lights and especially shadow casting lights are very expensive in rendering times.

But let's start talking about how lights work and then we move on how someone can use them to achieve the desired emotional response.

**Include/Exclude:** It is a basic property of the light, the user can assign a list of all the objects that the source will or will not light. This is an invaluable tool, since interaction of light in complex scenes can drive a cinematographer crazy, when trying to achieve a certain result only to realize that other areas now need to be revised.

### Standard Lights

Light is usually simulated with simple models that are not very accurate. The user has to define a large number of lights to achieve photorealism. It's render times are very small, so is the type of choice for most video sequences. However setup times can be long, especially when someone wants to simulate the bouncing light of a complex scene.

### Intensity

Light intensity defines how bright the light source is. There must be a good balance of light and shadow in a scene and colours are also affected by intensity, if it is set too high then the surfaces will be covered with highlights and will look artificial. If this is not desired, then the best solution to light more the scene is to add more light sources in different angles and keep their intensity to low levels.





Some packets (like 3ds max) allow the user to define a negative intensity which means that the light source will absorb light. This can be used in complicated scenes to easily create a mood without too much tweaking.

### Light temperature

Light temperature is measured in Kelvin degrees, defines the temperature that a black metal is being heated and it indicates what colour the radiated light will tend towards to.

- Warm colours (shades of red) 2900 K, e.g. incandescent lights, candles
- Cool colours (shades of blue) 5000 K, e.g. fluorescent lights

A typical daylight is about 12000 K, while harsh midday sun light is about 15000 K and the light that bounces off the sky (skylight) is close to 25000 K.

### Light Colour

Any colour can be defined as the colour of the light source, which will make the scene look more like, is being lit by stage lights. Because light colour effects surface colour, it can be used to create interesting or even bizarre shots. Usually it is defined very closely to white with some tones of blue or red to simulate familiar lighting conditions.

### Attenuation

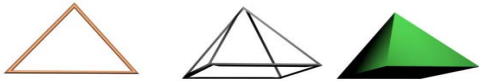
In the physical world, light weakens as it travels, especially through air. This property of light is simulated in 3D lights by using the attenuation values. This means that the further away the light source, the less light will contribute to the scene.

Since light is not visible in the 3D world, this property is being used mainly with volume lights (see below), so that one can control the light's appearance as desired.

### Hotspot and Falloff

Directional and spot lights cast a focused beam of light towards a specific direction. This creates a cylinder or cone of light originating from the source. At its center the light has the maximum defined intensity,



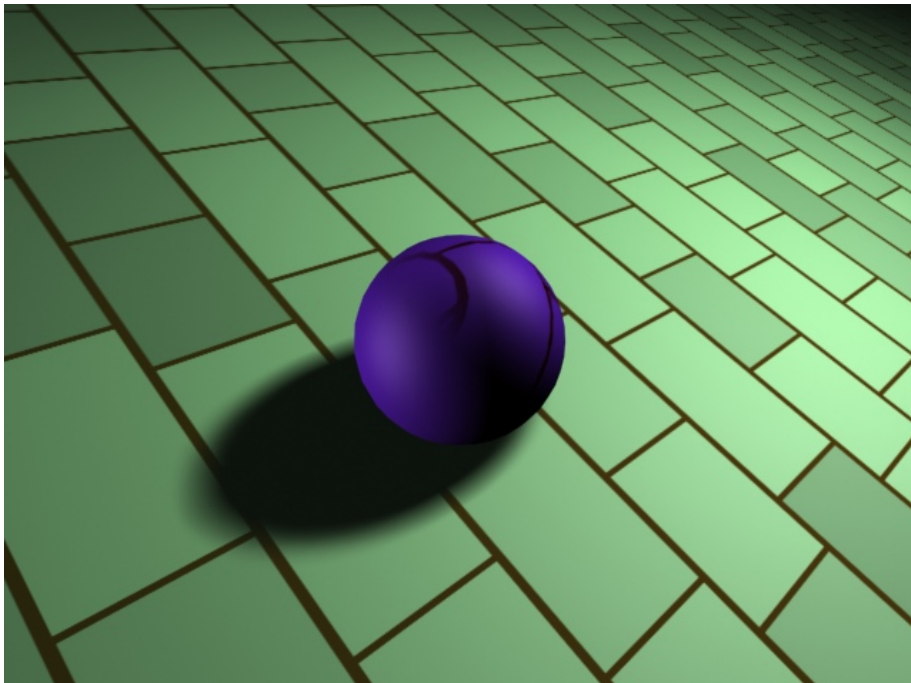


this is the hotspot area. As we move towards the edges the light's intensity gradually drops until is zero and this is the falloff area. This results in a smooth transition of light, resulting in a more realistic scene.

The areas are usually defined in degrees and the hotspot will always be a smaller angle than the falloff. It is common for the 3d packets to make sure that the difference between these values is never smaller than a defined angle (default for max: 2 degrees). Actually it is advisable not to use any other angle if the light will cast shadow-mapped shadows (see below). This angle can be used to simulate a highly concentrated light source, as e.g. a stage spot light, or a more diffused one, like a low intensity flash light.

### Projectors

A map can be assigned to a light, effectively turning the light into a projector. This mechanism's true purpose of course is not to simulate the effect of a projector (which can probably be achieved more easily) but to create the illusion that the light source is being obstructed partially by surfaces, like a window, a painted glass or the surface of water. It is a very effective way to convince the viewer, adding tremendous amounts of photorealism to the scene. Of course as any other kind of effect, it must be employed only as needed and should not be overused.







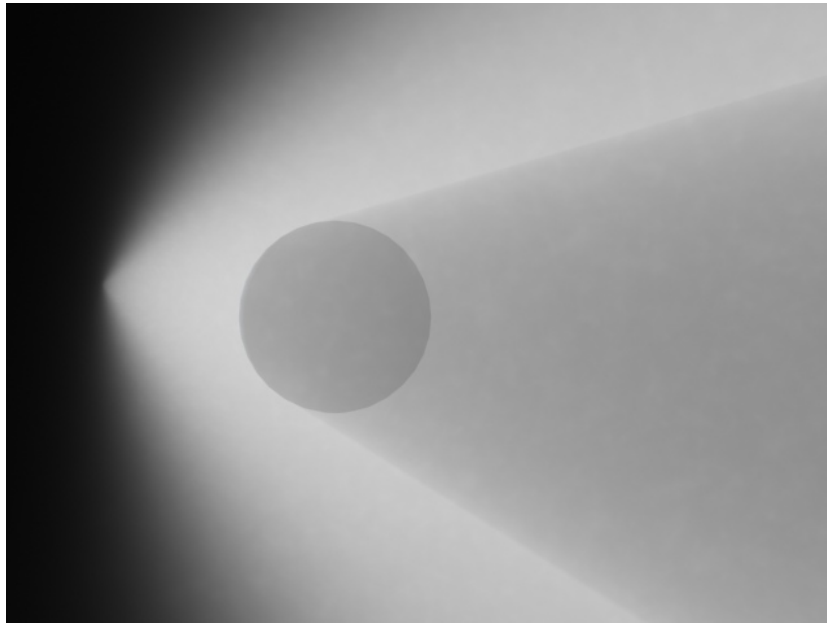
### Volume Light

We saw that 3D lights can have all sorts of properties that can affect the mood and appearance of a scene, but what lights do is making the objects' surfaces to reflect light to the viewer and cast shadows to each other, in other words, 3d lights are not visible. No matter how high someone sets a light's intensity, the light will not render. After all, light is invisible in the physical world. So how is it possible sometimes to see the light's rays? Well, what we see actually is the light reflected from tiny particles that may be smoke, fog or dust.

That is exactly what the volume light effect tries to simulate, effectively making a source casting visible light. What is even more impressing is the effect of an object partially obscuring the volume light, which we all know and love.

The light can 'have' noise, since after all it is supposed to become visible because there is some kind of particles in the air that they can move and have different concentration.

The downside of volumetric light is that is extremely computational intensive and should be used only in simple scenes for animated sequences, especially when the noise feature is being employed.



### Ambient Light

Ambient light is not a light source that the user can position in space. It is being used as a cheap method to simulate the fact that light bounces off surfaces. Its colour is usually a very dark shade of grey and is best to be kept alone, unless someone has special effects in mind.





### Basic three light setup

- **Key light**  
It provides the main illumination of the scene. Usually is the only light that casts shadows. When there is an apparent light source in the scene, like the sun or a lamp, the key light is usually set to match that light source.
- **Fill light**  
The fill light complements the key light, so it is usually positioned to light the objects from a different direction (like diametrically opposed). Its purpose is to soften the shadows of the scene and give the illusion of bouncing light.
- **Back light**  
It is a light that is positioned behind the objects of the scene. Its purpose is to give a sense of depth to the scene and separate the main actors (that might just be lifeless items) from the background, by brighten up their edges.

Tip: Instead of an actual back light, a falloff map can be used in the illumination material channel to simulate the effect, since the object will have brighter edges.

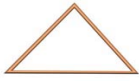
The basic-three light setup's purpose is to gives the cinematographer (both 3D and film) a starting point, for a more complex light setup. Especially the 3D cinematographer must take into consideration that bouncing light must be simulated with additional lights, which must be positioned properly and have a low intensity value.

### Radiosity

Radiosity is the property of light photos to bounce off surfaces, changing the ray's color and flooding the environment until they loose all their energy. This way, light can reach surfaces that are not directly exposed to it; and it how we can see clearly in a room only by the sun light coming from a window.

Several algorithms have been developed to simulate the bouncing of light in 3D graphics and they all have a very common property: they are all extremely computensional expensive. In 3ds max 5.1, there are two of these algorithms built-in the main package: Radiosity and light tracer.

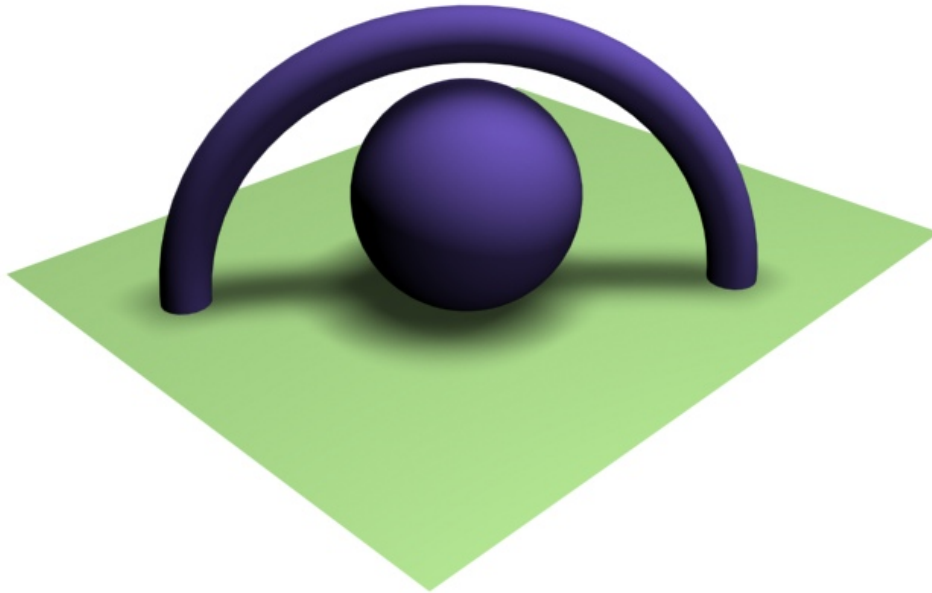




## Chapter 14 : Lighting

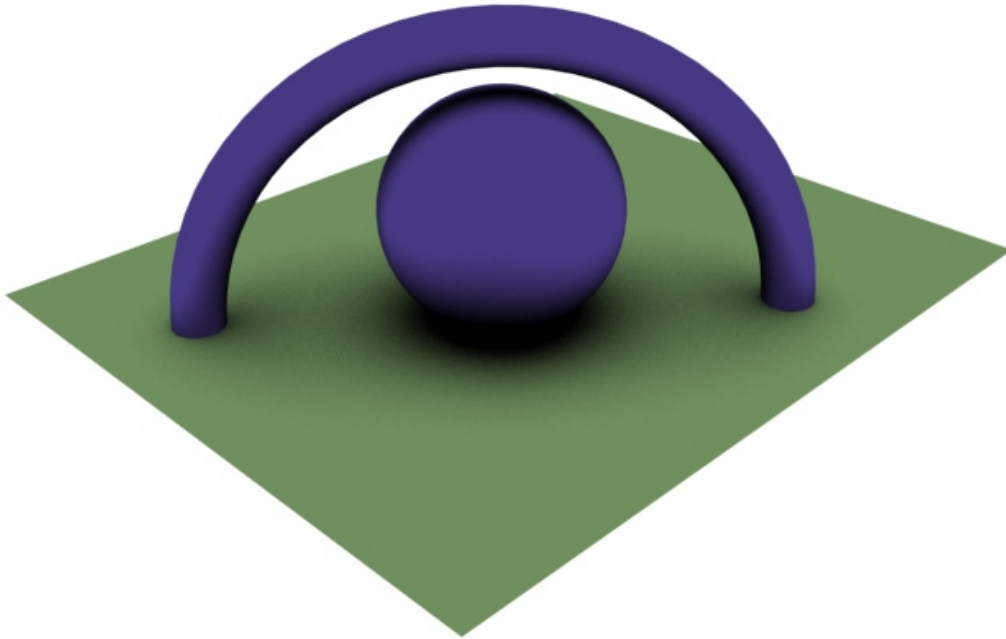
The radiosity renderer is too slow to be considered for an animation sequence; on the other hand the light tracer is somewhat faster. It primarily intended for exterior lighting. Light tracer is flooding the scene with light, simulating bouncing light and color bleed, the transfer of color from one surface to another by light.

A scene rendered with the 2 standard lights.



The same scene with light tracer took about 9 times more to be rendered, using one skylight.





### Daylight

Daylight is not a single light source, but is the combination of sunlight and skylight; the light that we see outdoors in a sunny day.

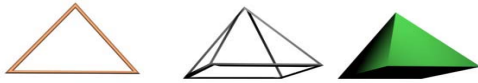
The sunlight changes colour temperature, a soft orange during dawn shifts towards blue for midday and then shifts to a golden orange during sunset.

### Balancing light sources

In cinematography is referred to the process of setting all the light sources to match the desired colour mood, like sunlight or indoors light. The same process must be employed within a 3D scene so that it looks more uniform and have better colour and brightness balance.

Boundaries of light and dark areas give a sense of depth to the scene. Lighting should be perceived more as a tool that can be used to draw the viewer's attention, to make the main characters stand out from the rest of the scene.





### Shadows

There are two methods that the user can choose, regarding the casting of shadows in the scene. This is an option that takes for each individual light source, so combinations of the methods can be used. It is most typical that only one light source casts shadows in a scene, though.

### Ray-traced

Ray traced shadows are being created by actually blocking the rays of light as they pass through objects in the scene. They are very accurate. Ray-Trace respects transparency and calculates the refraction of light as it travels through objects and changes colours, so it can provide colour shadows.

### Shadow maps

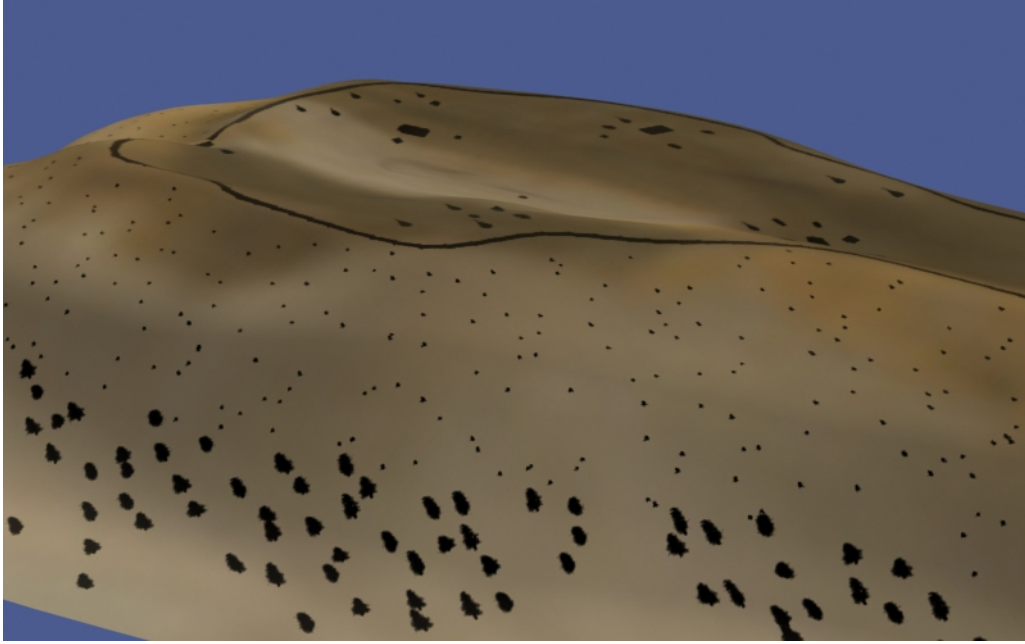
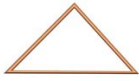
There is no ray-tracing involved, so it can be much faster. According to the positions of objects and lights in the scene, shadow maps create maps of the objects, from the light sources point of view. The map's size is usually from 256 Kbytes to 1024 or 2048 Kbytes. The shadows can be sometimes obviously inaccurate. The shadow has soft edges and sometimes can appear 'pixelated'.

Shadow maps do not support transparency, so objects with transparent surfaces cast full black shadows, which is probably undesirable. On the other hand, someone can use this feature to create shadows of invisible objects in the scene, in a composition with a real-life footage for example.

### Baked Textures

Baking a texture means that the 3D application renders directly on a file that will be used as a texture for an object. This texture will be specific to the object's position in the scene, as it will carry some scene related information, like shadows. The applications of baked textures are numerous and are all related with performance, mainly for real-time applications.







## Chapter 15

# Camera

The camera is the viewpoint of the viewer into the scene. The artist can animate the camera, thus allowing the user to “explore” the world in front of him.

## Field Of View (FOV)

Real world cameras have a lens to capture light. Their primary attribute is focal length, the distance from the lens to the camera's CCD (in digital cameras) or in the human eye the distance from the apple to the retina. It is measured in mm and is conversely analogue to the Field of View (FOV) which is measured in degrees.

When the focal length is short, the Field of View is wider and more objects in the scene are visible. Some typical types are:

- measured in mm or degrees
- 50mm or 40 degrees (human eye)
- 35mm (cinema cameras)
- 85mm (telephoto)

A wide Field Of View gives to the image more sense of depth, but distorts the objects in the scene. It can be used for some shots to create a particular feeling like a character being confused. Wide lenses in conjunction with ingenious camera positioning can provide the most dramatic effect to the mood of the scene.

The most profound choice for a presentation is a not-too-short focal length of about 35-60 mm with the camera dollied in and out to achieve the desired framing.

Telephotos compress the sense of depth too much to be used extensively, unless this is the feeling we want to give to the viewer, like someone is under surveillance from far away with binoculars.

## Focus and Depth of Field

Real world lenses have a focus attribute. You can get a rough idea if you hold your pen high enough to see also the wall that is further away. Now look with one eye closed at the pen and then to the wall, observe





## Chapter 15 : Camera

that when you focus at the pen the wall appears blurred and vice-versa. What happens is that one of the objects is out of focus.

Depth of Field is the part of the picture that appears in focus. In most cameras (especially the cheap ones) the depth of field starts about 50 cm from the camera and extends to infinity. 3D cameras lack this attribute; hence everything is rendered to be in focus with sharp details. This may appear to be a blessing, but in some situations is a curse.

Cinematographers are using focus to blur the background or foreground and draw the attention to the main characters of a scene. This is very profound when the focus changes during one shot that the camera is not moving or zooming and a face that was unclear at the beginning of the shot becomes obvious. This is a tool that the 3D cinematographer MUST have.

To compensate for the lack of focus in 3D cameras, there are a couple of methods we can use. First we can render the scene without the main characters, then apply blur to it using some post-production technique and then Alpha blend the main characters in the scene in focus. If the characters cast no apparent shadows in curved surfaces and do not move a lot in the scene then the only real concern will be to match the lighting conditions of the composite scenes.



The results from the aforementioned method are most of the time acceptable, but there will be cases that just won't do. In these cases we can use the 3D cameras focus effect. 3D packets implement this by providing the user a plane of focus, a distance from the camera that every surface will be in focus. The rest of the scene will appear blurred, as it will be out of focus. This awesome effect comes at a high price though. The image must be rendered multiple times (from 5-12) to achieve a realistic result. In an animated sequence this means that the render time will be multiplied almost that many times! Of course it is out







of the question to use such an effect for more duration than a couple of seconds, so one must carefully choose which the best shots to use it are.

### Camera Moves

- **Pan**  
camera rotates in vertical axis
- **Tilt**  
camera rotates in horizontal axis

Pan and tilt are moves that a camera is performing while stationary on some tripod mechanism.

The camera isn't moving, yet the framing is changing rapidly, so they can be very disorienting to the viewer. This is why these moves have to be performed slowly and as a rule of thumb, separately. Due to the way monitors and TVs are displaying picture, fast pan moves can result in 'tearing', as horizontal lines of different frames may bump up in the picture. Avoid it unless special effect like motion blur is in use.

- **Dolly**  
camera moves closer to or further away from the scene (not zooming)

In real life a good dolly move is very hard to achieve, but because it is much better than lens zooming, cameras must be being mounted in special tracks to achieve it.

In 3D world however it is actually easier to animate dolly moves than lens' zooming, so it is preferable.

- **Track**  
Camera moves in its horizontal and vertical axis to 'track' down the target. As the character runs to escape, the camera is tracking his/her motions, effectively making the background appear to move as the character runs. Like dolly, track is much easier to achieve with 3D cameras than their real counterparts. Track move combined with motion blurred background is a very effective way to convey the sense of speed to the viewer.

- **Roll**  
Camera rotates around the viewing axis. As the camera follows an aircraft through its flying path, rolls to convey the anticipation of its motion.





- **Rack focus**

Achieved by executing a dolly and a reverse zoom of the lens at the same time. The focused objects remain in the same position of the frame, while the background is being distorted. Its purpose is to alert the viewer about something very important like a dramatic swift of the story and the reaction of the character.

- **Handheld**

There is no reason to discuss about handheld 3D cameras since nobody is supposed to hold it. Yet some times we can give a little 'noise' to the camera moves, so that we can simulate the POV (see camera shots) of someone running or exploring an area.

## Scene Shots

- **Master/Establishing Shot**

A long, static shot with wide angle FOV. It is usually the first shot of a scene, used to set the location, time and characters. Often the master shot holds up until the first few seconds of dialog or action in the scene and then we move to a much closer shot.

- **Crane**

The camera is located high above the ground and is allowed to execute most of the moves, usually employed to smooth the transition from a long shot to a closer one or to another nearby location.

- **Wide shot**

A shot that shows one or more of the main characters, whole.

- **Medium shot**

Used primarily on characters, shows the person, top half. In this shot one can clearly read a person's 'body language' from the gestures of the hands and roughly see it's facial expressions.

- **2 shot**

A variation of the medium shot that shows 2 or more characters.

- **Medium close-up**

Like the medium shot only that the character is visible from shoulder height.

- **Over-the-Shoulder**

Usually used in conversations between characters, can also be used to reveal a character's actions without revealing his/hers identity.

- **Close-up**

The character's face fills the entire frame; the viewer's emotional response is more intense.

- **Extreme close-up**





A very tight shot that shows a particular part of an object, like the hands of character reaching for a gun or the end of a bare wire reaching as it produces a sparkle. The viewer is literally forced to view anything we show in close-ups that is way they should be used with great care.

- **Dolly**

Used for a smooth transition from a long shot to a medium or close-up shot. It can evoke a greater emotional response to the viewers if they are moved towards the action, or can unbind the viewers from the scene's action by moving them away.

- **Reveal**

Usually starts from a close-up, moves to a medium shot and then another camera move follows, one that reveals something that was not apparent, like a close-up to one of the characters holding a knife or a long shot of a car closing to the location.

- **Point Of View (POV)**

The POV from an object, usually an existing camera in the scene (like a security camera or a TV camera), or the POV of a character as he/she moves in the scene. Can be used to impersonate the viewer with the character, evoking intense emotional responses, like a character running to escape. Usually in this case small random movements of the camera convey the sense that someone is walking/running in the scene.

- **Pan / Tilt / Roll**

Can be used to give a sense of exploration, like a POV of a character looking for something in a scene. Can be disorienting for the viewer if it is overused.

- **Camera Shake**

A small but very fast camera move that is used to convey the viewer that a major event has occurred, like an explosion or a car crash. It is usually combined with heavy motion blur during the 2-3 frames of the camera shake. Its duration may also be larger, to simulate dramatic events like an earthquake or a space-rocket launch. Of course audio effects are at least as important as visual effects in these types of shots.

## Framing

All these camera movements and positions lead to one concept: framing. It is what the viewer will see and the way we show it makes much difference in the way it will be perceived. For example a worm's-eye shot, meaning that the camera is positioned very low and is looking up with wide FOV, can convey a sense of mass to the objects and will make the characters seem powerful. If the same scene is being shot by a camera above their level and dollyed a little backwards, the same objects will seem tiny and fragile.



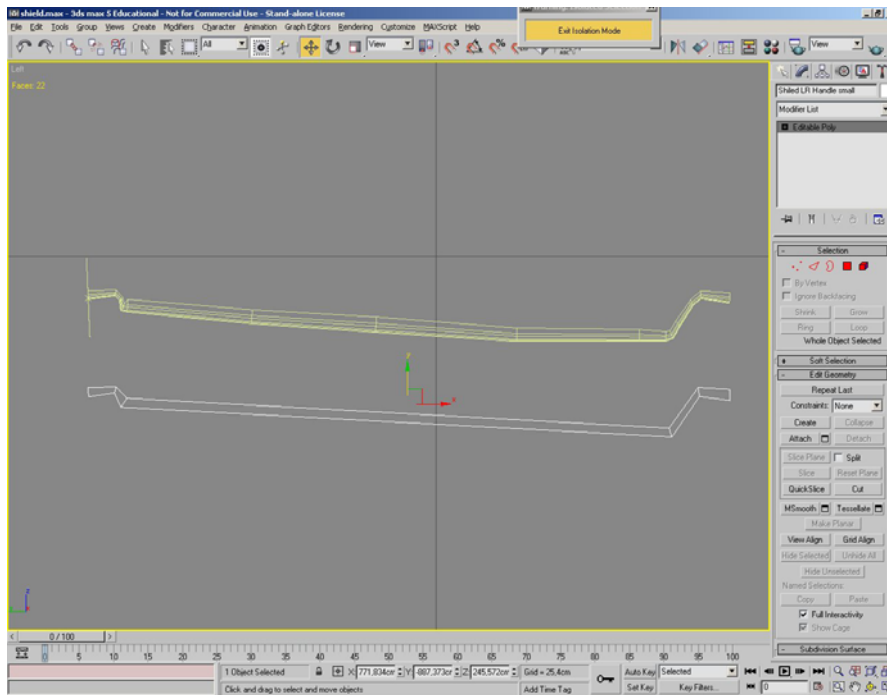


## Chapter 15 : Camera

Framing also means that the cinematographer must draw the viewer's attention to the main objects. This is 3D graphics we are dealing about! We can't let the viewer notice every little detail in the background and on our secondary objects! Unless someone deliberately created a scene in which every single object is detailed, most of the times a project's budget won't allow it. Make sure your framing is tight and the viewer's attention is right where you want it.

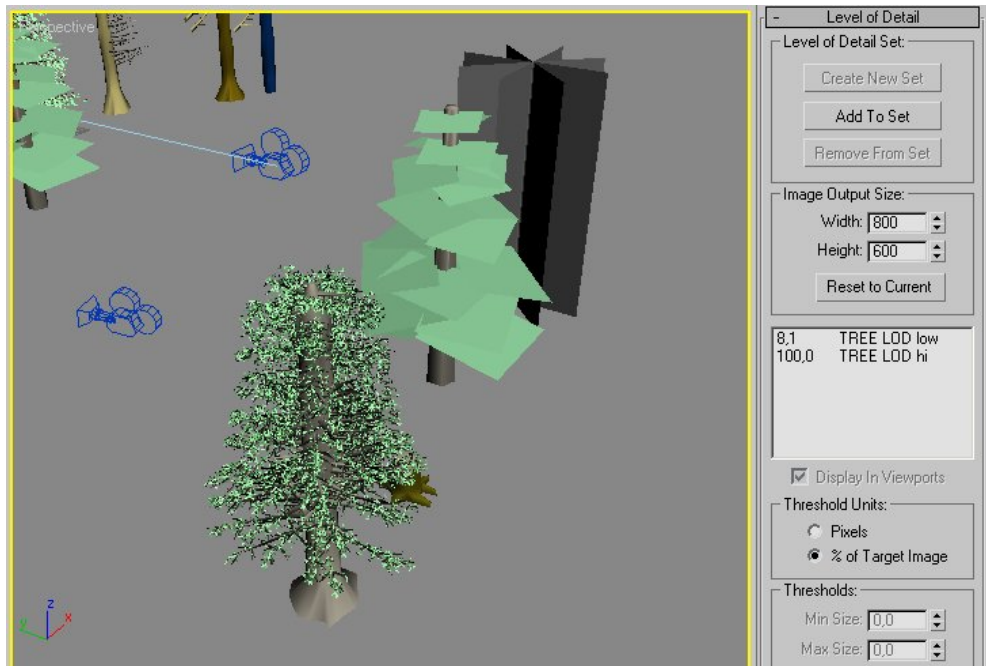
### Level of Detail (LOD)

When an object is far away from the camera it does not need to be highly detailed. Usually multiple versions (of different level of detail) of an object are created: The lower detail level versions will have less polygons, less detailed materials without expensive effects attributes ray-tracing and they will probably be illuminated by fewer lights and will cast no shadows.



Usually the 3D package will include some kind of management tool for all the different versions of the object and will use the appropriate one according to how close the object is to the viewer.





### Safe Frame

Depending on the final target output one may need to consider the limitations that some formats have. For example TV sets clip a part of the image and there is no way to know how much area will be visible in each TV set. This is why some general guidelines have been developed so that one will be sure that the audience will not miss something important, like text in the picture or subtitles.

To aid the user, 3D packets can show the area which the user should frame something that the viewers have to see, the safe frame.

### Anticipation

Avoid anticipation of the animation in your camera moves. If there is a character that is going to start running towards the right side of the frame then hold the camera steady and start following after the character has passed the middle of the frame, then frame the character back to the center as he runs. Don't change anything in the camera's framing right before some major animation starts, because it will disorient the viewer.



## Chapter 16

# Environment & Atmosphere

3D packets often provide atmospheric effects that give the illusion of depth to a scene. Unlike particle systems this effects are more post affect that are applied in render time.

## Background Colour

The background color is the default color of the image before anything else is rendered on it, so it is the color in the areas of the image that there are no models.

## Background Map

Any map that can be applied to a surface (bitmap or procedural), can also be applied to the background. This is similar to applying a map to a background plane, to be used as a back-stage.

However, there are two major differences between these techniques: first, the background map doesn't follow the camera movements, so it is appropriate only for static scenes; second, the background map doesn't affect the alpha channel, only the actual models do. This way, it is more appropriate for rendering the foreground elements for an alpha blended scene.

## Fog

Fog is a simple effect that can simulate layers of fog in the scene. It is a smoke type effect that can be used to simulate mist, create similar effects or other kinds of special effects using a noise option.





Fog can stay on the background or it can interact with the actual scene, giving a sense of depth to the image. Also it can partially hide models in the scene, that otherwise would be completely visible, adding a little bit of mystery to the composition.

## Fire

Similar to the fog environment effect, the user can set a fire-like effect in the scene. Some restrictions apply, but generally it is a convincing affect.





## Chapter 17 Editing

Editing is the process of selecting which shots will be in the final sequence, their order, duration (in-frame, out-frame) and what are going to be the transitions between them.

The above technical explanation is by all means correct, though it lacks one simple concept. Editing is an art by itself; and it is a very peculiar form of art, since it is supposed to be seamless, hence invisible to the common viewer.

This means that the viewer must not be distracted by the editing of the shots but rather naturally follow the flow of the scenes. That is of course unless someone intentionally wants to distract the viewer.

The flow is perhaps the most fundamental concept of the editing art. So, despite of the action in the shots and the camera movements, the major factor that will determine the pacing in a scene is editing.

Let the viewer feel comfortable, make him feel part of the scene or completely detach him from the action, editing is a tool that can deliver the final emotional touches; and it is a powerful one. Movies have been saved or slaughtered in the editing room; and this goes for 3D graphics too.

Editing a rendered sequence has one major difference with films though: nobody has the luxury to discard rendered frames! Not many anyways. This is why one has to edit using an 'offline' method. Make some draft renders to set the framing and the animation, afterwards lock the camera, go back in the scene, refine the detail (only what the camera will show) and render the final version with all the effects and in hi resolution.

Beyond the script, editing is the final storyteller in the sequence. The viewer (usually) doesn't know the script, he knows what he sees and this is defined by the editor. In short, editing is a rewrite of the script.

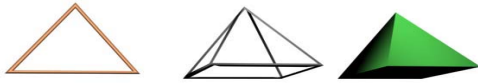
### Cuts

A cut in the scene means that the viewers are suddenly looking to something different from what the previous frame/s. This means that for a moment they will be disoriented and distracted and the process of trying to understand what they are looking at will start all over again.

This is what makes seamless editing important, cuts must have motivation; the user must anticipate the change in the picture by some







action, dialog, sound effect or music change. This will make the cut seamless and natural. On the other hand, if our purpose is to distract the viewer, then we can use jump cuts.

### Cutaways

Cutaways are secondary shots of the scene that may provide additional information to the viewer or can be used to intensify or calm down the viewer's emotional response. Such cuts are usually composed of close-up shots, like a hand turning the handle of a door or a shot of a painting in the wall.

Cutaways can be used as an easy way to cover difficult portions of an animation sequence, as a method to 'cheat'. For example in an action scene of two characters fighting someone could show just their shadows in the wall. This way the animation will not require the same detail as if the actual characters were shown.

A word of caution though should be that cutaways can wreck a scene's emotion, as they can be distracting, annoying or unintentionally humorous to the viewer. Cutaways should always be motivated or used when a scene is flat and monotone by its nature, so they can help by keeping up the pace of the edit.

### Reaction shots

Physics suggests that every action has a reaction. This is also very true for just about anything that someone will animate in a 3D graphics sequence. For example, the viewers anticipate seeing what the characters' reactions are in a dialog scene, or what are the people doing once that giant piece of rock starts tumbling down a hill near them.

Whenever an action takes place that everybody expects to have implications in some portion of the scene that is not in the frame, we can say that the cut to some shot that shows that reaction is not just motivated, it is a necessity. The reaction of a character to a line is just as important as the reply itself.

### Montage

The positioning alone of shots in a scene can have a major impact in the way that is perceived. The process of using a number of shots together to give a meaning different from what would give each of them





on its own is known as montage. Montage is a whole art of its own and it is well beyond the scope of this document.

### Transitions

Each frame in an animated sequence comes from a shot. When we want to change from one to another though, we have some options regarding the way this is going to be done.

Transitions between two shots are traditionally used only when the shots are parts of different scenes, meaning that there is some difference in time or the location. Transitions between two shots that follow each other real-time are very confusing, so they should be avoided.

Transitions' purpose is to give some clue for this difference of the location and/or time of the scenes. Also during the transition the viewers are given some time to think about what they have seen until now, so lengthy transitions are often used after an emotionally intense scene.

### Hard cut

A hard cut defines that there is no transition between the two shots; the first frame of the second shot will follow immediately after the last frame of the first. This is the most commonly used transition, as it helps keeping up the pace of the edit.

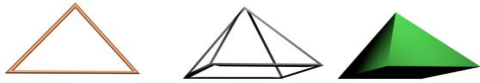
Hard cuts challenge the viewers' perception, as they break the continuity of the pace. An action shot can be interrupted by another shot with the use of a hard cut; this way the viewers will be forced to imagine what has happened. Often a good trick is to imply a certain fact to the viewers by using this technique, only to surprise them later, perhaps by showing what has really happened in the rest of the scene.

### Fade in/out

Fade-in/out is the gradual change from a picture of only one colour (usually black) to the frames of the shot; fade-out is the reverse process. Usually this process takes enough frames so care must be given to have extra frames with no important action, or use only the first/last frame for the effect.

The most typical use of fades is at the beginning and the end of the while sequence. Furthermore, well placed fades can enhance the mood of the story, like a fade-out after an intensive scene.





### Wipes

Wipes utilize a broad range of effects between the shots and are generally separate from the frames of the two shots, for example page flips. Wipes imply a significant change in the location or time between the two shots. They are also used between scenes that comprise different scenario aspects, like a sequence that involves parallel stories that don't intersect (yet).

The shots also may include some natural wipes. The motion of a large object or a main character while moving across the frame (and perhaps out of it) can be used as a natural wipe to lead to the next scene.

### Dissolve

Dissolve interpolates with some algorithm a few frames between the two shots, making for a smooth transition that relaxes the viewers and makes them feel comfortable. They are often used to indicate that the action in the scene is not happening in real-time, like being a scene that a character is narrating or dreaming.





## Chapter 18 Rendering

So, it's all done. The models, the cameras, animation, lighting; they are all just the way we want it. It's time that we render the final images. What are the considerations of the rendering process? This has mainly to do with what the output medium will be, in short, most of the times we will use the specifics that are used in the output medium.

### Image Resolution

Image resolution defines how many pixels long the width and the height of the image are. This is a serious consideration as resolution greatly affects render times. For example a render in 640 x 480 pixels will take more than 4 times as much as one in 320 X 240 pixels.

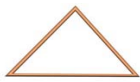
### Image Aspect Ratio

The image aspect ratio of an image defines if the picture will look more "square" like a video format or more "rectangular" like cinema. It is expressed by how many times bigger is the width of the picture from the height. For example the most common TV format is 4:3, or 1.333, for example 768 x 576 (PAL). It is generally accepted that wide formats (more than 1.6 aspect ratio) give a more cinematic and artistic sense to films.

### Pixel Size / Aspect Ratio

Not all formats have perfect square pixels like PC monitors do, meaning a pixel aspect ratio of 1.0. Depending on the destination format, the image may need to be rendered with stretched width or height dimensions. The final medium will display the picture correctly.





### Motion Blur

In the real world, when an object moves fast it appears blurred, try moving your hand fast and the effect is immediately apparent. In filmmaking motion blur is captured by setting a slow shutter speed (around 1/100th of a second). This way the movement appears natural in a film.

If the shutter speed is very high, then the camera will capture a series of almost still objects, which is called strobing, In real world cameras, if the shutter of the iris is left open for a very short time, the picture will be sharp and moving objects will appear odd, strobing.

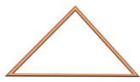
### Post Effects

Post effects are the effects and filters that are applied to the rendered image, so they are not truly a part of the rendering process. Typically a g-buffer will be used to determine how these effects will be interacting with the scene.

### Alpha channel

Alpha channel is an extra greyscale 8-bit channel that is added to an image, expressing how opaque is the given pixel. This technique makes possible the composition of multiple layers of images on top of each other.

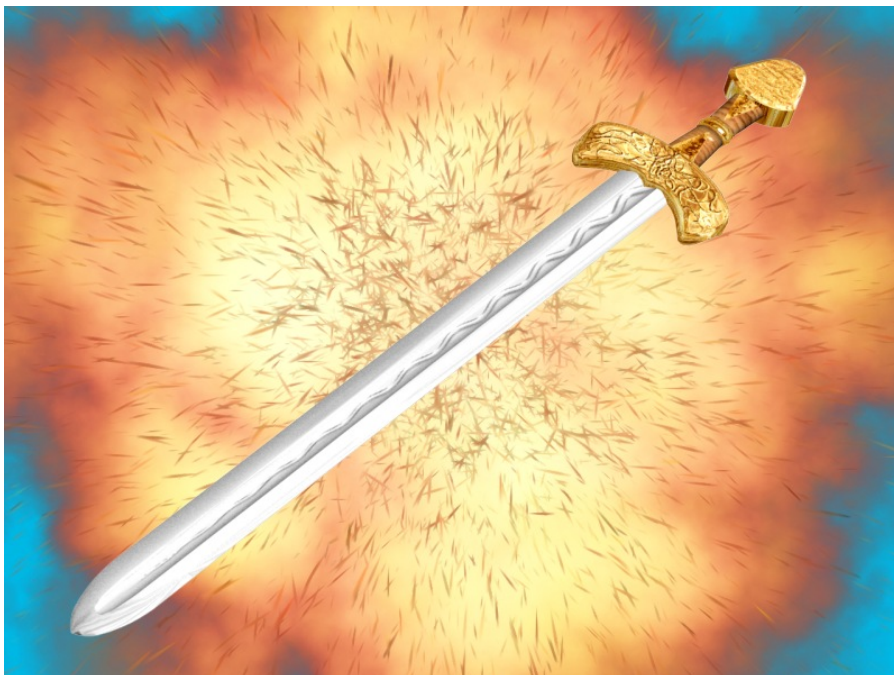




Can you imagine a usable alpha channel for the above image? Every pixel of the background would be totally black (value 0) and every pixel of the model would be completely white (value 255).

### Alpha blending

An image that has been rendered with an alpha channel can be rendered on top of another image, since the information in the alpha channel will be used to determine which part of the image will show up and how much opacity they will have. This composition is known as alpha blending.



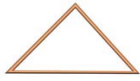
### Lens Flare

A lens flare effect simulates the flares that are created in some special type lenses that real cameras can use, when there is a bright light source in the scene.

### Glow

Glow creates a halo of light around specified objects in the scene, by using the pixel information. They are very effective and can spare the





trouble and rendering times of volumetric effect, with some cost in accuracy.

### Colour correction

Colour correction techniques affect the overall colour balance of the final sequence, in an effort to create a more uniform result. Often it is used to emphasize the colours of the skin tones on human models.

The process takes usually place in a 2D drawing suite like Paint Shop Pro or in a video editing application like Adobe Premiere. It is typical that films have a lower contrast ratio.

### Compressing

Although not involved in the process of rendering, most of the times the result will have to be compressed. Generally it is a good idea to render to series of a lossless quality image format, like bmp or tga. Later the images can be composed into a single compressed video.

### Keyframes

Compressors work by minimizing the required information. They hold a still picture for a frame, the keyframe and then they only store what has changed in the subsequent frames, which are called i-frames or delta/frames.

### Keyframe interval

Keyframe interval indicates how many i-frames, or how many msec will interpolate until the next keyframe. If the interval is set too high the resulting animated sequence may become very difficult to edit or view, as the player will have to calculate a lot of i-Frames to pause/rewind the video. The more often the keyframes (keyframe interval) are taken, the better the quality of the video at the cost of low compression.

After all these quality improvement techniques, there is one factor that will determine which will be used. This is the human eye. The image that looks best on you is the one that has the correct setups applied.



# Appendix A

## Synchronizing with music

There are two approaches to synchronize the picture with the pacing of the music: the first is to set up a basic "dope sheet" of the animation and give this to the music composer, so the music can be created based on the animation. The second is to go the other way around, for example in a music video clip, the music has been already created and the editor has to cut the scenes based on pace of the music. We will examine a basic methodology for the second approach.

In the Rapola project, there was a simple script that had to be supported by the music. The script was not definite, it consisted only by a general storyboard, one could only make a general guess for the duration of each scene in the storyboards.

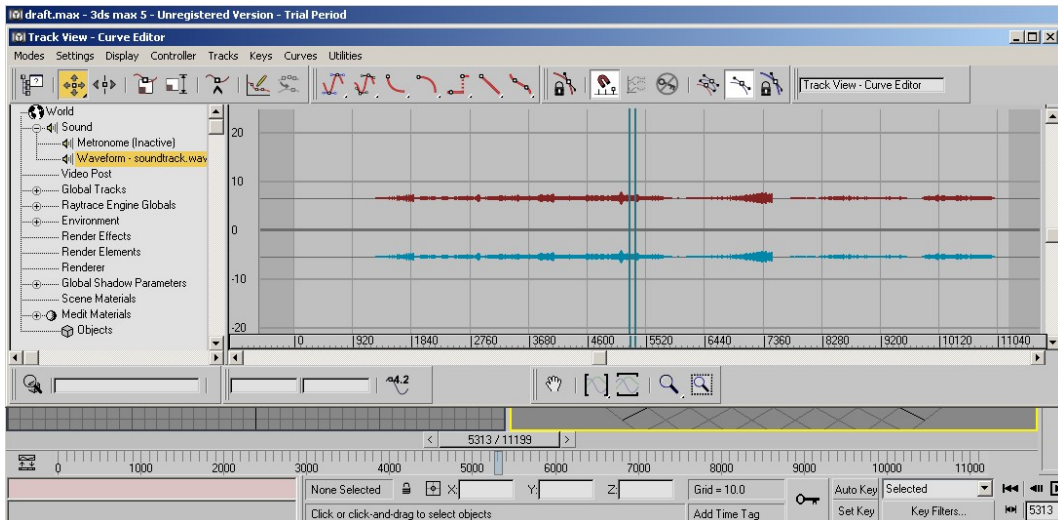
So the approach in this specific situation was to write the music, based on some rough estimations for each scene; and later "tailor" the video in the pacing of the music, where there will be definite durations for each one of the scene. In short, the music's mode and feeling was defined by the script and on the music's changes in the pace the individual cuts of the video were based.

To keep things simple, the variations of the music's pace were noted with frame numbers and not seconds. This was easily accomplished within 3ds max, once the soundtrack was loaded in the application, it was a simple matter to listen to the soundtrack and take note of the good frame numbers for a cut (using the play/pause keyboard shortcut).





# Appendix A Synchronizing with music



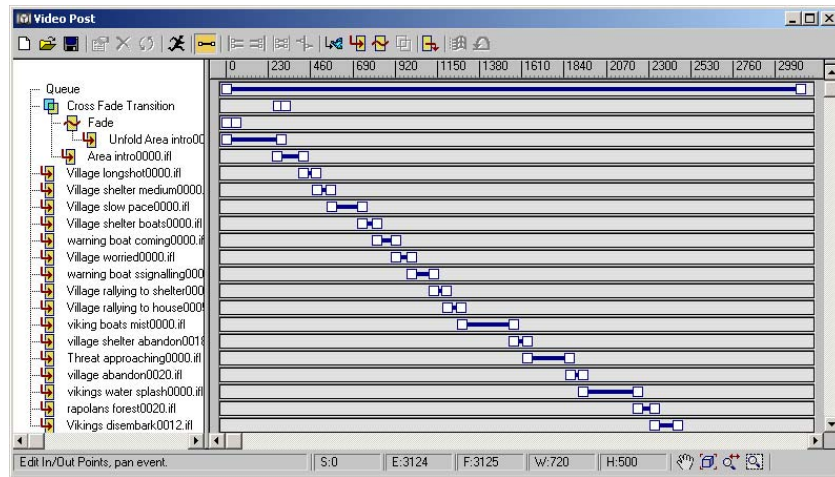
What was not so simple was to keep track of all those numbers. For this task a spreadsheet seemed to be an appropriate solution. With some simple formulas not only we can manage the frame numbers, but also we can have extracted the durations for each individual scenes, in frames. This way somebody can know exactly how many frames will be needed for each scene; and render only those.

<u>SCENE NAME</u>	<u>position</u>	<u>VP duration</u>	<u>transition type</u>	<u>frame in</u>	<u>frame out</u>
02 unfold area	0	300	fade in	0	299
03 Area intro	300	120	Dual cross fade	0	119
05 Village longshot	420	70	cut (DEFAULT)	0	69
07 Village shelter medium	490	80		0	79
08 Village slow pace	570	170		13	182
09 Village shelter boats	740	80		0	79
10 Warning boat coming	820	100		0	99
12 village worried	920	90		0	89
14 warning boat signalling	1010	120		0	119
16 Village rallying to shelter	1130	70		12	81
18 Village rallying to house	1200	80		20	99
20 Viking Boats emerging from mist	1280	283		117	399
22 village shelter abandon	1563	73		18	90
24 Viking threat approaching	1636	234		0	233

Once the frames of the scenes are rendered, everything can be composed together using some editing tools. One of those tools is eds max's Video Post. This utility has not been designed to provide support for very big projects, but if someone doesn't want to create many complicated transitions between the scenes, it can be enough.



# Appendix A Synchronizing with music





# Glossary / Index of terms

**3D graphics**, it is a 2D representation of a 3d world.(page 1)

**3D model**, a set of faces that are regarded by the application as a unit.(page 22)

## A

---

**alpha blending**, the composition of usually two images while the first, which has been rendered with an alpha channel, is being rendered on top of the other image.(page 101)

**alpha channel**, an optional layer of image data that provides an additional 8 bits of information about transparency.(page 100)

**ambient colour**, the hue an object reflects if it is directly illuminated by a light source.(page 53)

**ambient light**, the cumulative effect of all the light bouncing off all the objects in an area.(page 80)

**animating**, it is the process where you modify an object, light, material, or camera by moving it or changing its properties over time.(page 1)

**animation**, it is technically the process of applying transforms to an object through time, usually to different frames.(page 64)

**animation controller**, method for creating or modifying animation keyframes or object behaviour.(page 66)

**animation sequence**, sequence of animated objects.(page 1)

**array**, method that creates multiple clones.(page 51)

**aspect ratio**, the relationship between the height and width of an image or pixel expressed as a decimal ratio.(page 99)

**attenuation**, the gradual reduction in the intensity of light as it gets farther from the source, which is caused by light being occluded by particles in the atmosphere.(page 78)

**axes**, the plural form of axis.(page 13)

**axis**, it is an imaginary line in 3D space that defines a direction.(page 13)



# B

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**back light**, it is a light that is positioned behind the objects of the scene.(page 81)

**backed textures**, texture maps based on an object's appearance in the rendered scene.(page 84)

**basic three light setup**, the setup of the key light, the fill light and the back light.(page 81)

**bend**, a transform that deforms an object by applying torsion around the selected axis.(page 38)

**bevel**, a flat transitional plane located between two other planes, usually set at an angle that is half the difference between the two. It is used make objects look more real.(page 49)

**bitmap**, a 2D digital image.(page 55)

**bone deformation**, a technique of animating an object by defining and animating an internal skeleton that automatically deforms the surrounding mesh.(page 69)

**boolean object**, a boolean object combines two other objects by performing a boolean operation on them.(page 42)

**booleans**, operation that can add/subtract from an object by using operands.(page 42)

**bounding box**, a box that is an approximation of object's location and size (only for display).(page 28)

**box mapping**, a type of coordinate system well suited to rectangular objects. It applies the image coordinates from six different directions, one for each surface on the object.(page 59)

**bump map**, a grayscale image that varies the apparent surface roughness of an object by manipulating the normals.(page 55)



# C

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**CAD / CAM**, Computer Aided Design / Manufacture, the term refers to programs designed to help architects / engineers / designers by providing not only modelling tools, but also a toolset for the evaluation of their designs (with simulations).(page 2)

**camera**, it is an object that simulates still-image, motion picture, or video cameras in the real world.(page 86)

**Cartesian coordinate system**, the most common way of describing and delineating 2D and 3D space.(page 12)

**channel**, an individual attribute of a material that can accept images or be set in such a way as to affect the appearance of the object to which the material is applied.(page 54)

**character animation**, the process of imbuing objects not only with movement, but with personality.(page 6)

**cloning**, method to generate objects.(page 51)

**colour correction**, technique that affects the overall colour balance of the final sequence, in an effort to create a more uniform result.(page 102)

**composition**, the placement in the scene of objects, lights, cameras etc.(page 76)

**compression rate**, the speed at which digital video data is encoded for playback, defined in kilobytes per second(KB/s).(page 102)

**control points**, points that define and modify the shape of the patch.(page 33)

**cool colors**, shades of blue.(page 78)

**coordinates**, a set of numbers that represent a point in space.(page12)

**coordinate system**, see **Cartesian coordinate system**.(page12)

**copy**, method that creates a completely independent object.(page 51)

**current coordinating system**, the system in which you are currently modelling.(page 16)

**cuts**, it is the smallest individual piece of an animation or film. It may be a single frame, or an entire sequence.(page 95)

**cutaways**, secondary shots of the scene that may provide additional information to the viewer or can be used to intensify or calm down the viewer's emotional response.(page 96)



**cyberspace**, the coordinate-based virtual space inside the computer's memory where 3D scenes are constructed and animated.(page 13)

**cylindrical mapping**, a mapping coordinate system that wraps the image around one of object's axes until it meets itself, like a label on a soup can.(page 60)

## D

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**daylight**, it is the combination of sunlight and skylight.(page 83)

**decals**, an image that can be scaled and moved around on an object independently of any other texture mapping.(page 63)

**deform fit**, modifier that allows the user to define the shape of the object along the path.(page 41)

**depth of field (DOF)**, except for motion blur, that portion of an image that is properly focused.(page 86)

**diffuse colour**, it is the colour that the object reflects where it is directly illuminated by a light source.(page 53)

**diffuse map**, a mapping channel used to alter the object's colour away from that defined by the colour setting, usually into a pattern or image.(page 54)

**displacing**, it's a modelling method where a grayscale image is used to determine which part of the surface will rise, according to the pixels values.(page 46)

**displacement map**, a greyscale image applied to an object that actually distorts the mesh, deforming it according to the gray value.(page 46)

**dissolve**, it interpolates with some algorithm a few frames between the two shots, making for a smooth transition that relaxes the viewers and makes them feel comfortable.(page 98)

**dope sheet**, displays keyframes over time, using a horizontal graph. This provides tools for adjusting the timing of your animation.(page 103)

**dolly**, a camera movement made toward, away from, or around a subject as though the camera were mounted on a wheeled tripod.(page 88)

**dummy**, an object that does not render, so it can be used as an invisible component of a chain or as a reference point for establishing remote axes of rotation.(page 68)



## E

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**editing**, the process of assembling the various scenes created and rendered during production, turning them into a cohesive whole.(page 94)

**emitter**, a simple polygonal shape that acts as a point of origin for particles in a particle system.(page 72)

**exclude**, a basic property of the light with which the user can assign a list of all the objects that the source will not light.(page 77)

**extrusion**, the process of pushing a 2D shape into the third dimension by giving it a Z-axis depth.(page 36)

## F

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**face**, the area enclosed by the edges of the polygon.(page 20)

**face mapping**, an image mapping type that tries to conform the image to pairs of faces that share an invisible edge.(page 60)

**faceting**, when you can see the geometry of the object(polygons).(page 33)

**fade in/out**, it is the gradual change from a picture of only one colour (usually black) to the frames of the shot.(page 97)

**falloff**, the portion or range of a light source that is at a reduced or zero-intensity setting.(page 78)

**field of view (FOV)**, the angle, in degrees, that encompasses everything that can be seen through a lens or virtual camera viewport.(page 86)

**fill light**, light source used to fill in a dark area of a scene, such as a shadow cast by the key light.(page 81)

**first vertex**, the vertex in a shape that is used for orientation during skinning operations.(page 37)

**flat shaded**, display method where polygons are being painted and the whole polygon takes one colour.(page 28)

**focal length**, the distance in millimetres from the center of the lens to the image it forms of the subject.(page 86)



**focus**, an attribute that real world lenses have. The object in focus is clear while the other objects are blurred.(page 86)

**fog**, it is a simple effect that can simulate layers of fog in the scene.(page 93)

**force fields**, objects that do not render, but they apply a certain effect to other objects under their influence.(page 72)

**forward kinematics**, a manner of linking and animating objects in a top-down hierarchy; the movement of the parent affects all the children on down the chain, so many fine adjustments are often needed to position the end of the chain where you want it.(page 69)

**frame**, a single still image that is part of a sequence.(page 65)

**frame rate**, the speed at which the film, video, or animated images are displayed, in frames per second(fps).(page 65)

## G

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**g-buffer**, additional image channels that use greyscale images to describe the geometry, normals, textures, and other information in the model.(page 100)

**GIS**, Geographical Information System, a system that interactively provides information regarding topography.(page 2)

**gizmo**, it acts like a kind of container that transfers the modification to the object to which it's attached.(page 30)

**glossiness**, it expresses how the surface of the object reflects light, meaning the size of the highlights.(page 54)

**glow**, it creates a halo light around specified objects in the scene, by using the pixel information.(page 101)

**goal**, the end of the IK chain.(page 69)

**gouraud**, display mode which calculates the colour for each vertex and interpolates across the polygon surface.(page 28)

**grey-scale map**, grey coloured image.(page 46)

**grids**, special helper objects.(page 16)

**group**, a command that enables the user to select a related collection of objects, then temporarily combines them into a whole.(page 51)





# H

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**handheld**, camera movement that simulates a camera held by a man.(page 89)

**hard cut**, it defines that there is no transition between the two shots; the first frame of the second shot will follow immediately after the last frame of the first.(page 97)

**hierarchy**, the parent/child relationship of objects linked together in a chain.(page 68)

**hotspot**, the portion or range of a light source that is at the full intensity setting.(page 78)

**HSV**, a colour selection interface used in computer graphics that enables the user to adjust hue(chroma), saturation(intensity), and value(brightness) to select a colour.(page 54)

# I

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**i-frames**, the frames that with the keyframe are stored during the compression process.(page 102)

**IK chain**, a hierarchy of objects.(page 69)

**image aspect ratio**, it defines if the picture will look more “square” like a video format or more “rectangular” like cinema.(page 99)

**image resolution**, it defines how many pixels long the width and the height of the image are.(page 99)

**in-betweens**, the frames between the keyframes.(page 65)

**Include**, a basic property of the light with which the user can assign a list of all the objects that the source will light.(page 77)

**index of refraction**, the amount of change in the lights trajectory.(page 54)

**intersection**, Boolean operation where only the intersection of the operands remains.(page 42)

**instance**, method that creates the same object in a different location and orientation.(page 51)



**inverse kinematics, (IK)** a method of controlling linked objects by moving the far end of a hierarchical chain, which then causes the rest of the chain to conform.(page 69)

## J

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## K

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**key light**, it provides the main illumination of the scene.(page 81)

**keyframe**, a user-defined point where an animation event takes place. (page 102)

**keyframe interval**, it indicates how many i-frames, or how many msec will interpolate until the next keyframe. (page 102)

**keyframing**, the process of defining keyframes for animation. (page 65)

## L

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**lathe**, it creates a 3D object by rotating a shape about an axis. (page 36)

**lens flare**, it is an effect that simulates the flares that are created in some special type lenses that real cameras can use. (page 101)

**level of detail (LOD)**, means of referring to the relative resolution of an object. (page 91)

**line**, it is formed when a connection is made between two points. (page 19)

**light intensity**, it defines how bright the light source is. (page 77)

**light temperature**, it indicates what colour the radiated light will tend towards to.(page 78)

**light tracer**, algorithm that simulates bouncing light and color bleed.(page 81)

**lighting**, the lights that are placed in the scene.(page 77)



**local coordinating system**, it usually stays with the object and it is independent of the world coordinate system in which the object is placed with other objects to form a scene. (page 15)

**loft**, it is a modelling method where you can create one or more shapes along a path spline. (page 37)

## M

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**material**, it describes how an object reflects or transmits light.(page 53)

**mapping coordinates**, a set of coordinates that specify the location, orientation, and scale of any textures applied to an object.(page 58)

**melt**, modifier that applies a realistic melting effect to all types of objects.(page 40)

**mesh relax**, modifier that causes the vertices of the object to move closer or away from each other, effectively changing the apparent tension between them.(page 48)

**metaballs**, spheres or even other objects in close proximity on which the render engine creates a smooth skin covering the shapes.(page 48)

**mirroring**, the procedure where the mirror tool uses scaling to mirror the object.(page 49)

**model**, 3d object.(page 22)

**modelling**, the process of generating 3D models and the manipulation of their shape to bring them to their final form.(page 25)

**modifier**, they provide a way to edit objects.(page 36)

**modifier stack**, it is a stack with all the modifiers that have been applied to the object. The modifier on the top of the stack is the latest modifier that have been applied on the object.(page 49)

**montage**, the process of using a number of shots together to give a meaning different from what would give each of them on its own.(page 96)

**morphing**, technique that makes one image or form smoothly transform into another.(page 71)

**motion blur**, the smearing of an image when the subject or camera is in motion.(page 100)

**motion capture, (mocap)** process that enables a performer's actions to be digitized and used to drive a bones deformation system for 3D character animation.(page 70)



## N

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**n-gon**, see polygon.(page 20)

**noise**, it is a way to make objects look more natural. (page 56)

**normals**, they are perpendicular lines for each polygon, indicating the direction from which the poly is visible. (page 28)

## O

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**object**, every item that lives in the scene, like 3D models, 2D shapes, lights.(page 22)

**omni light**, a light source that casts light in all directions.(page 27)

**opacity**, it controls whether a material is opaque, transparent, or translucent.(page 54)

**operand**, an operand is one of a pair of objects upon which an operation such as [Boolean](#) is to be done.(page 42)

**optimization**, method that combines faces that have a given (usually small) angle between them, reducing the face count.(page 50)

**origin point**, the center point of the cyberspace universe, where the central axes meet. Identified by the coordinates 0,0,0.(page 13)

**orthographic viewport**, the viewport where the viewer's location is infinitely distant from the scene, so that all lines along the same axis are parallel.(page 18)

## P

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**pan**, a side-to-side rotation of a camera around its vertical axis.(page 88)

**parametric modelling**, modelling system where the parameters of an object can be changed later in the process for maximum flexibility.(page 35)



**parent coordinating system**, it is the coordinating system where an object is hierarchically linked to another object in the parent/child relationship.(page 15)

**partial lathe**, a lathe operation in which the cross-sectional shape is not revolved a full 360°.(page 37)

**particle system**, it is a mechanism that generates from an emitter a large number of small objects travelling through space and usually vanishing after some frames.(page 72)

**patch modellers**, modelling system where you use a network of control points to define and modify the shape of the patch.(page 34)

**phong**, display mode like smooth with specular highlights.(page 28)

**physics simulation**, simulation of physical phenomena that can convince the viewer.(page 73)

**pivot point**, it defines the center of the object's coordinate system and its direction.(page 23)

**pixel**, the smallest unit of graphics that a video adapter generates, usually about the size of a pinpoint.(page 99)

**pixel aspect ratio**, it defines the size of the pixel.(page 99)

**planar mapping**, a type of coordinate system well suited to flat objects. (page 58)

**point**, the smallest area that can possibly be occupied. (page 12)

**poly**, see polygon. (page 20)

**polyline**, a line with more than one segment. (page 19)

**polygon**, it is a series of vertices that define a plane in 3D space, also called poly or n-gon.(page 20)

**polygonal modellers**, modelling system where the surfaces are defined as a collection of squares or triangles (polygons). (page 32)

**post effects**, the effects and filters that are applied to the rendered image.(page 100)

**procedural map**, a type of map that is mathematically defined. It can be used to simulate wood, marble, smoke and other materials. (page 56)

**projector**, a light source that uses a projection map or gobo. (page 79)

**proxy**, an object that is an approximation of a highly detailed object. (page 73)



## Q

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**quad**, a four-sided polygon commonly used in 3D programs.(page 20)

## R

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**rack focus**, camera movement achieved by executing a dolly and a reverse zoom of the lens at the same time.(page 89)

**radiosity**, the property that states that light reflecting off an object goes on to illuminate other objects as well.(page 81)

**ray tracing**, rendering mode where an imaginary ray from the viewer to the scene can be bounced and bent.(page 29)

**ray-traced shadows**, shadows that are generated by tracing the path of rays sampled from a light source.(page 84)

**reference**, method that creates an object that can have other modifiers but also inherits manipulation from the prototype.(page 51)

**reflection map**, it is a secondary diffuse channel that is applied to the object to give the impression of reflectivity.(page 55)

**refraction**, the bending of light waves that occurs when they move through different types of material.(page 54)

**rendering**, the process of drawing the final image into the output device, usually the monitor. Usually defines the final output image that the end user will see.(page 99)

**resolution-independent**, the property of remaining smooth, no matter how much magnification or scaling is applied.(page 33)

**RGB**, the three primary colours in the additive colour model.(Red Green Blue).(page 54)

**rigging**, the process of defining the relationships between bones and mesh and the one of defining proper IK chains on a character.(page 69)

**roll**, camera movement around its viewing axis, making the scene appear to spin.(page 88)

**root**, the parent of a hierarchy.(page 69)

**rotate**, a transform that spins an object around the selected axis.(page 24)



# S

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**safe frame**, borders that show which portions of a viewport will be visible when rendered to video.(page 92)

**saturation**, the measure of how concentrated a colour appears to be. (page 54)

**scale**, a transform that adjusts the size of an object.(page 24)

**scene composition**, the placing of objects in the same scene.(page 76)

**screen coordinate system**, coordinate system based on the computer's screen, with X being horizontal, Y being vertical, and Z being toward and away from the viewer.(page 18)

**self-illumination**, a material channel or control that adjusts the degree to which an object appears to be lit from within.(page 55)

**shadow map**, it is a bitmap that the renderer generates during a pre-rendering pass of the scene.(page 84)

**shininess**, the overall reflective nature of the object, in other words its glossiness.(page 53)

**skew**, modifier that distorts an object forcing each side move into opposing directions. (page 39)

**skin modifier**, modifier that deforms one object with another object (page 69)

**skinning**, the procedure in which a wire-cage, made by splines, is being skinned to form a surface or even a closed object.(page 45)

**smoothing group**, if adjacent faces are grouped in similar smoothing groups the rendering engine will interpolate any colour and textures, trying to make them seem smooth.(page 63)

**space wraps**, objects that do not render, but they apply a certain effect to other objects under their influence.(page 72)

**specular colour**, it is the colour of the actual rays from the light source that the object reflects to the camera.(page 53)

**specularity**, a material channel or control that adjusts the colour and intensity of the object's highlight, if it has one.(page 54)

**spherical mapping**, a mapping coordinate system that wraps the image around the object in a cylindrical manner, then pinches the top and bottom closed to surround it.(page 60)

**spline**, it is a smooth line that is defined by control points that they are used to effect its contours.(page 33)



**spline-based modelling**, modelling with the use of spline modellers.  
(page 33)

**spot light**, a directional light source that radiates light from a single point out into a user-defined cone or pyramid.(page 27)

**squash**, modifier that scales two axes in opposite directions, maintaining the object's original volume.(page 40)

**storyboards**, simple sketches packed neatly in a form that may be accompanied with some text, resembling a comic book.(page 8)

**stretch**, modifier that applies a scale effect along a specified stretch axis and an opposite scale along the two remaining minor axes. (page 40)

**sub-object**, building blocks of an object.(page 30)

**subdivision**, method with which the modeller works in a low res object, which looks quite primitive, using the same methods with low-polygon editing, while the result is a hi res mesh with organic curves and a host of small details.(page 44)

**subtraction**, Boolean operation which carves out of one operand the intersected faces of the other.(page 42)

**sweep**, it is a powerful modelling method where you can have one or more shapes along a path spline.(page 37)

**symmetry**, modifier which allows the artist to create symmetrical objects with relative ease.(page 49)

## T

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**taper**, modifier used to scale up or down portions of the object and the rest of the form will accommodate these changes.(page 38)

**tessellation**, method that subdivides faces adding more resolution to the model.(page 50)

**teeter**, modifier that rotates the cross-sections around their local axis.  
(page 41)

**texture**, a bitmapped image that gives a material unique qualities that aren't available by simply varying surface attributes.(page 25)

**texture mapping**, see texturing.(page 25)

**texturing**, it is a process of assigning surface attributes to the models, effectively 'painting' them.(page 61)





**tilt**, the vertical equivalent of a pan, created by rotating the camera up or down around its horizontal axis.(page 88)

**track**, the movement of the camera along a single axis, be it horizontal or vertical.(page 88)

**transform**, it is an adjustment of an object's position, orientation, or scale, relative to the 3D world.(page 23)

**translucent**, the characteristic of transmitting light but distorting its path. (page 54)

**transparency**, a measure of the amount of light that can pass through an object.(page 54)

**twist**, modifier that revolves the surfaces of an object around an axis. (page 40)

## U

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**union**, Boolean operation that combines the operands and erases any overlapping surfaces.(page 42)

**unwrap mapping**, a powerful mapping method by breaking up the mesh and then define manually the texture coordinates for each poly. (page 62)

## V

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**vertex**,(plural vertices), it is a point where any number of lines come together and connect to each other.(page 19)

**vertex paint**, a way to define material boundaries by painting the vertices of the surfaces.(page 61)

**vertices**, see vertex.(page 19)

**video post**, post editing tool.(page 104)

**viewing plane**, it is the visible area.(page 26)

**viewpoint**, the point from where we are looking.(page 26)

**view coordinating system**, it is oriented relative to the camera or viewer.(page 17)



**volume light**, a type of light source with an adjustable 3D volume that can simulate the behaviour of natural light in an atmosphere. (page 80)

**VRML**, Virtual Reality Mark-up Language, a plain text format that describes used to describe simple 3D environments, designed to be used in Web pages. (page 2)

## W

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**warm color**, shades of red.(page 78)

**wipes**, it utilizes a broad range of effects between the shots and are generally separate from the frames of the two shots, for example page flips.(page 98)

**wire-cage**, a series of splines that define a 3D object.(page 45)

**wireframe**, display mode which draws lines for the polygons edges, either both sides or only the visible ones.(page 28)

**world coordinating system**, it is the principal coordinate system of a 3d workspace, which is independent of viewport and display.(page 14)

**wrap mapping**, a mapping coordinate system that tries to conform to the object's shape and provide a spherical deformed mapping.(page 60)

## X, Y, and Z

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**X-axis**, the horizontal or width axis, running left and right.(page 12)

**Y-axis**, usually the vertical or height axis, extending up and down. (page 12)

**Z-axis**, the axis normally associated with depth. It runs forward and back.(page 12)

**zoom**, to change the FOV of a camera so that the subject appears to grow larger or smaller.(page 88)



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### The Digital Filmmaking Handbook : Second Edition

Author: Bel Long / Sonja Schenk

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Author: Sonja Schenk

ISBN : 1-58450-016-0



# URLS

Note: These links were active the summer of 2004

<http://www.3dlinks.com/>

<http://www.3dkingdom.org>

<http://www.3dcafe.com>

<http://www.webreference.com/3d/>

<http://www.cgtalk.com/>

<http://www.maxhelp.com/>

<http://www.3dgate.com/techniques/2001/010702/0702viz.html>

<http://www.maxhelp.com/csc/index.htm>

<http://www.polyfarmer.com/Tutorials/Tutoriallinks.htm>

texture mapping

- A 3D leaf tutorial

[http://trainingvids.phpwebhosting.com/riddlaz/Tutorials/LeafProject/Leaf\\_Project.htm](http://trainingvids.phpwebhosting.com/riddlaz/Tutorials/LeafProject/Leaf_Project.htm)

- A UVW mapping of a spaceship tutorial

[http://waylon-art.com/uvw\\_tutorial/uvw\\_tut\\_01.html](http://waylon-art.com/uvw_tutorial/uvw_tut_01.html)

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