Basic 3D Concepts

3D can be an abstruse and complex world with a large variety of systems and components. Indeed the software we use in this class –Alias’s Maya – operates in 3 major modes (modeling, rendering, and animation) to each of which a professional can dedicate an entire career. However, it is possible to become conversant in all of the primary elements of 3D content creation in a few short weeks, and apprehending some basic 3D concepts will hold you in good stead regardless of where your interest in 3D might take you.

Modeling

Perhaps the most fundamental activity in the 3D world is creating objects. We refer to this process as modeling since you are typically attempting to produce a simulacra of a real world object, or give perceivable form to a specific idea. However, before one begins creating a 3D object it is instructive to examine 3D nothingness, or exactly what you have before putting “pen to paper.”

The Scene Graph
The scene graph is what we call our virtual universe. It consists of a 3 dimensional (4 dimensional if you consider animation key frames to represent time) Cartesian coordinate system including X, Y, and Z, axes. The x axis typically represents what we characterize as left and right if we imagine we’re viewing the scene graph from an orthogonally frontal perspective. The Y axis represents up and down, and the Z represents forward and backward into the “page” or “screen.”

Every object placed into a scene graph has a position expressed as the (x,y,z,) coordinates of its pivot point and an orientation generally expressed degrees of rotation around the various axes or as the (x,y,z) unit vector of its local x axis with respect to the world coordinate system.

Hierarchy

While 3D objects are most frequently visualized in the context of the scene graph, they also, in many applications, exist in what’s referred to as a hierarchy. Most programs allow you to set up certain persistent relationships among objects. The most common of these is “Parent-Child,” which generally allows two linked objects to move and rotate together. The classic example is in setting up a humanoid character you make the hand a child of the forearm, and the forearm a child of the upper arm, & so on to the root vertebra of the spine. Depicted below is a simple hierarchy, as seen in Maya’s “Hypergraph” panel:
Objects

Objects are perhaps the most common functional category of 3D content. Several objects can be combined into groups, scenes, or characters. Objects have a relatively large number of constituent components and attributes some of the most important of which are detailed here. An object typically is composed of a mesh with a material applied. Below are a couple “primitive” objects in Maya. Primitive objects are simple geometric components out of which you can sculpt more complex objects.
Meshes

Meshes are the skeletons of objects. They are in turn composed of vertices, edges, and polygons.
Vertices

Vertices are on some level the fundamental unit of 3D geometry. They represent a point in space defined by its (xyz) coordinates. Below is depicted part of the sphere in “vertex selection” mode.
Edges

Edges are lines connecting 2 vertices. Shown below is the sphere with some edges selected (in orange).
Polygons

Polygons are shapes defined by a group of ordered vertices and the edges that are defined between pairs of those vertices. Every polygon has a normal which is a vector extending perpendicular to the surface of the polygon. This is important to the extent that most rendering engines only bounce light off of one side of any polygon. So only the side from which its normal extends will be visible.
Transformations

Most 3D objects can be subject to 3 basic transformations. The changes are typically made with respect to an object’s pivot point, which you can think of as it’s center, though you can position the pivot point wherever you want, even outside the object’s mesh.

Translation

Translation is the act of moving an object according to a directional vector and its magnitude in the 3 spatial dimensions. In Maya this is accomplished with the Move Tool which has convenient handles to restrict the dimension in which you’re moving your object.

Rotation

Rotation occurs when you turn an object about an axis. As you might imagine Maya has a rotate tool as well. Pictured below:

Scale

Scaling changes and objects size with respect to one of the 3 axes. A uniform scale changes its size with respect to all three axes simultaneously, which is helpful in preventing squashing and stretching.
Below are three illustrations of our sphere after having been moved, scaled, and rotated:

Rendering

Broadly speaking, Rendering is the process of creating an image or sequence of images from a scene. This is an occasionally time consuming process wherein the software makes a series of complicated calculations concerning how light reacts with all of the objects in a scene according to their shapes and various material parameters. With respect to this class we use the Rendering mode mostly in the application of materials and textures to our scenes and 3d objects. Virtools then becomes the software that performs real time rendering of these assets.

Materials

Materials constitutes tell the rendering engine what the surface of a 3d object looks like given the lights operating in the scene. Materials have a wide variety of attributes that we’ll get into later. The most important point for now is that they can contain textures. Below are our objects with different materials applied as rendered by Maya.
Textures

Textures are images that can be mapped onto your 3d objects. Your textures UV coordinates and mapping mode determine exactly how it will be applied to any given object. Below is our sphere with a snake skin jpeg texture applied.
Lights

Lights provide illumination for your scene, and can be used to simulate a wide variety of real world lighting conditions. Some important types of lights include: Point, Ambient, Directional, and Spot. Below is a rendered illustration of a spotlight on our objects.
Animation

Obviously, animation is an enormous discipline. For now let’s just say that there are two kinds of animation we’ll be using this semester: KeyFrame animation in Maya, and Procedural animation in Virtools. Though bear in mind that both programs handle both types of animation.

Keyframe animation in Maya is analogous to many 2D authoring packages such as flash. Essentially you can compose objects in a scene, set a keyframe, move the various objects, and then set another keyframe later in the timeline. The software will then smoothly interpolate the objects’ movement in the intervening keyframes according to a wide variety of parameters.

Procedural animation dynamically feeds data about objects’ various characteristics to the rendering engine based on some sort of scripted algorithm, or alternatively based on user input.

Interaction

Viola Le Scene Graph de Virtools! Elle est la meme chose de Maya!
Level Manager

The level manager in Virtools presents a categorized list of all of the assets and objects that exist in your scene including some basic information about their states such as whether they are visible.
Schematic

The schematic is the view in Virtools that collects all of your scripts. Scripts are little snippets of code used to manipulate the objects and properties in your composition. Scripts are composed of building blocks (or behaviors) that can be connected together to achieve various effects.
Building Blocks

Building Blocks can be accessed through the building block manager tab found in the upper right of the program. They are categorized according to (a rather quixotic conception of their) function. You can also check the help to find a specific building block. Building blocks tend to have Behavioral Inputs on the left which typically turn them on or cause them to execute one loop. Behavioral outputs get triggered when the BB finishes what it’s doing. Parameter in’s allow you to feed data to your BB, and Parameter outs allow the BB to spit out data.