3D Wed Gallery for Game

Title: 3D Web Gallery for Game

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Chapter 3 **INTRODUCTION TO THREE-DIMENSIONAL (3D)**

Learning Outcome

Objectives of this chapter are: -

- About 3D
- Interface and menu
- Selection Methods
- Workspace

About Three dimensional (3D)

Introduction

In recent years' computer graphics, has made tremendous progress in visualizing 3D models. Many techniques have reached maturity and are being ported to hardware. What required a million-dollar computer a few years ago can now be achieved by a game computer costing a few hundred dollars. It is now possible to visualize complex 3D scenes in real time.

2D Coordinate system

For understanding of 3D first we look at 2D. A two-dimensional Cartesian coordinate system is formed by two mutually perpendicular axes. The axes intersect at the point O, which is called the origin. (Figure 1)

The coordinates of any point on the XY-plane are determined by two real numbers x and y.

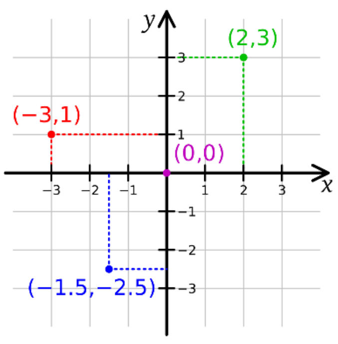


Figure 1 2D Cartesian Coordinate system with x and y numbers

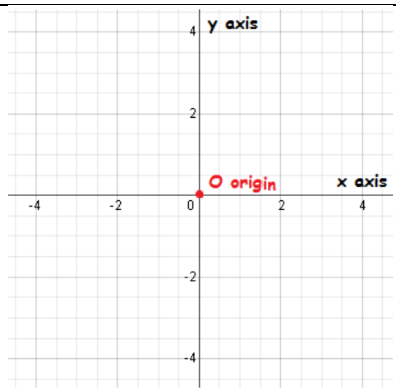
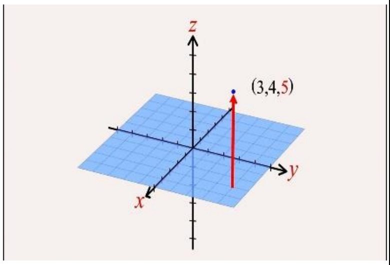
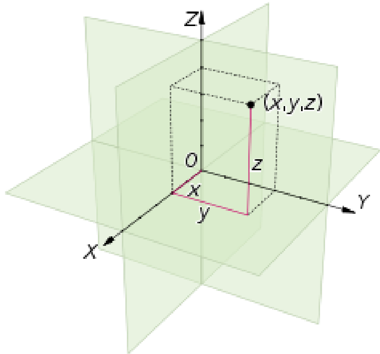
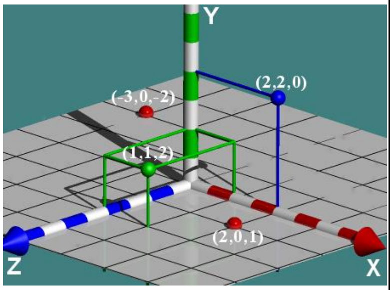


Figure 2 2D Cartesian Coordinate system

3D Coordinate systems

In mathematics, analytic geometry (also called Cartesian geometry) describes every point in three-dimensional space by means of three coordinates. Three coordinate axes are given, each perpendicular to the other two at the origin, the point at which they cross. They are usually labelled x, y, and z.

 *Figure 3 point showing for x = 3, y = 4, z = 5*	 *Figure 4 3D axis points*	 *Figure 5 realistic 3D view of points*

In computers, 3-D (three dimensions or three-dimensional) describes an image that provides the perception of depth. In the broadest definition of the term, "3D" would describe any object that occurs on a three-axis Cartesian coordinate system (X, Y, and Z).

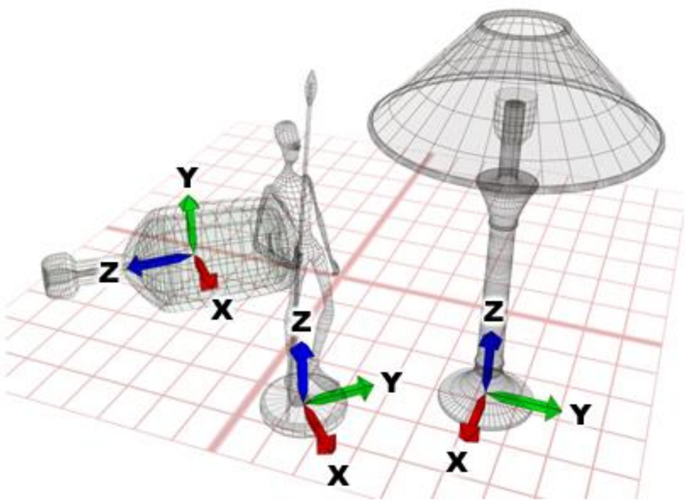


Figure 6 Object occurrence in 3D space

what is 3D?

In the broadest definition of the term, "3D" would describe any object that occurs on a three-axis Cartesian coordinate system. If that sounds a tad technical, fear not we'll clear it up right away.

So, by definition, any object that can be represented on a three-axis system is 3D.

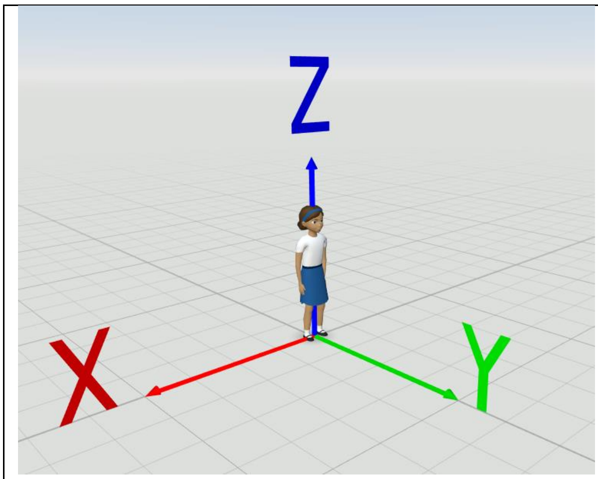


Figure 7 Object in Cartesian system

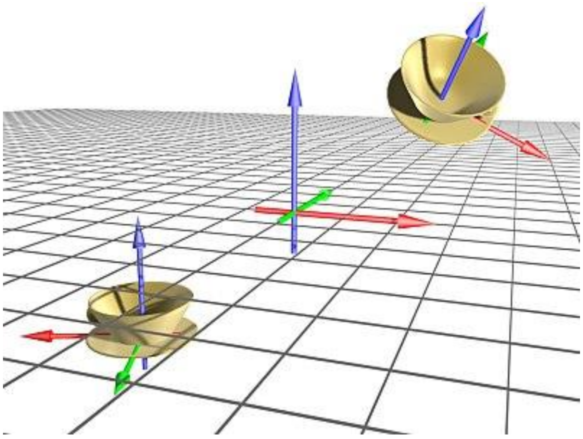


Figure 8 Object in Cartesian system

3D MODELLING

Any representation of an object in digital space, is called a **3D model**. If you took a look at the raw information that comprises a basic 3D model, it would simply be a collection of data points that mark thousands or millions of different coordinates in Cartesian space.

The software does the math: Luckily for artists, 3D software deals with most of the difficult mathematics. Within the graphical user interface of a 3D software package like Autodesk 3ds Max, Maya, or Blender 3D models are automatically interpreted and visually represented as geometric objects made up of edges, vertices, and faces. Most software environments have built in real-time render engines capable of displaying 3D models with realistic lighting, shadows, and textures.

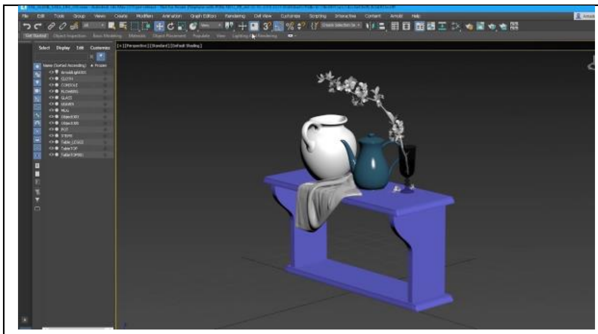


Figure 9 Autodesk 3D Max

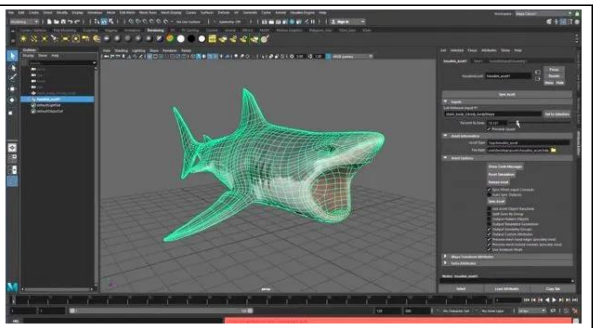


Figure 10 Maya 3D

What is 3D Modelling & What's It Used for?

3D modelling is a technique in computer graphics for producing a 3D digital representation of any object or surface.

An artist uses special software to manipulate points in virtual space (called vertices) to form a **mesh** and collection of vertices that form an **object**.

These 3D objects can be generated automatically or created manually by deforming the mesh, or otherwise manipulating vertices.

3D models are used for a variety of mediums including video games, movies, architecture, illustration, engineering, and commercial advertising.

The 3D modelling process produces a digital object capable of being fully animated, making it an essential process for character animation and special effects.

The core of a model is the **mesh** which is best described as a collection of points in space.

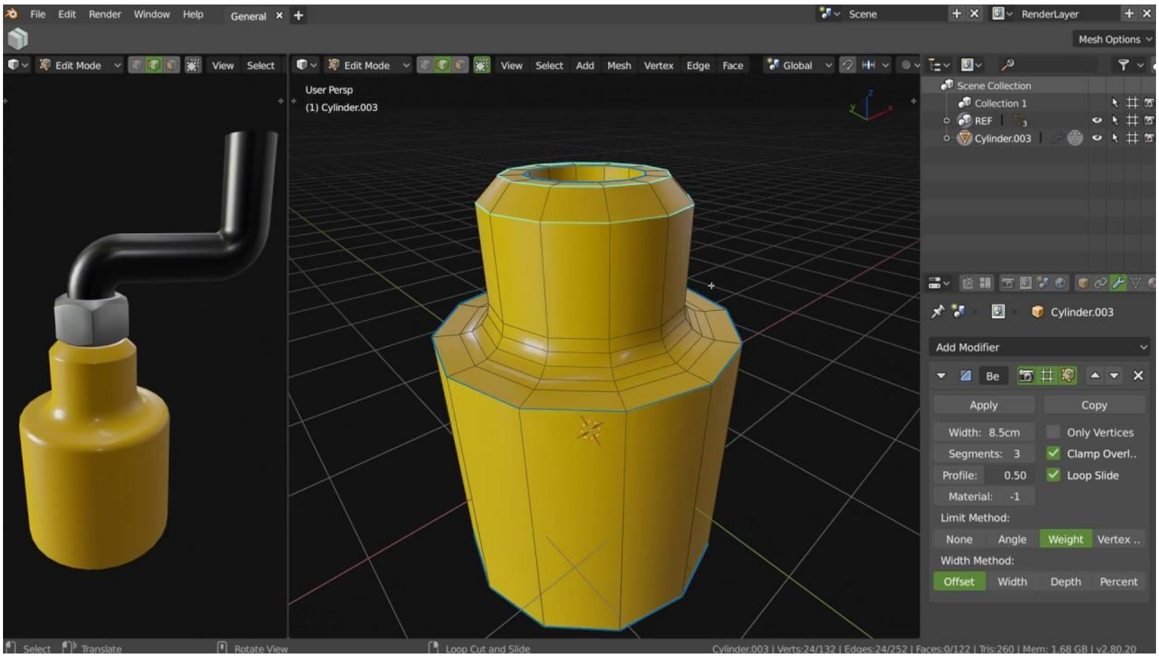


Figure 11 Source Image created in Blender

These points are mapped into a 3D grid and joined together as polygonal shapes, usually triangles or quads. Each point or vertex has its own position on the grid and by combining these points into shapes, the surface of an object is created.

Models are often exported to other software for use in games or movies. But some 3D modelling programs allow the creation of a 2D images using a process called 3D rendering. This technique is fantastic for creating hyper-realistic scenes using sophisticated lighting algorithms.

Once the model is complete the surface can be painted and textured.

The texturing of models is beyond the scope of this article, but it is important to note that textures can be used to fake surface details.

In this way an artist can make a model appear more complicated than it is. This technique is especially useful in video games where complicated meshes can prove taxing on a CPU and interrupt the gameplay

How Does 3D Modelling Work?

An artist usually begins by generating some type of **primitive** like a cube, sphere, or plane. The primitive is just a starting shape to begin modelling.

The artist will build upon this basic form and manipulate it using various modelling tools. For 3D modelling it's almost always a good idea to start simple and work towards complexity.

Primitives

A common object type used in a 3D scene is a mesh. Blender comes with a number of "primitive" mesh shapes that you can start modelling from. You can also add primitives in Edit Mode at the 3D cursor.

Adding Mesh in Object or Edit Mode: -

- Menu
  - Add ▸ Mesh
- Hotkey
  - Shift-A

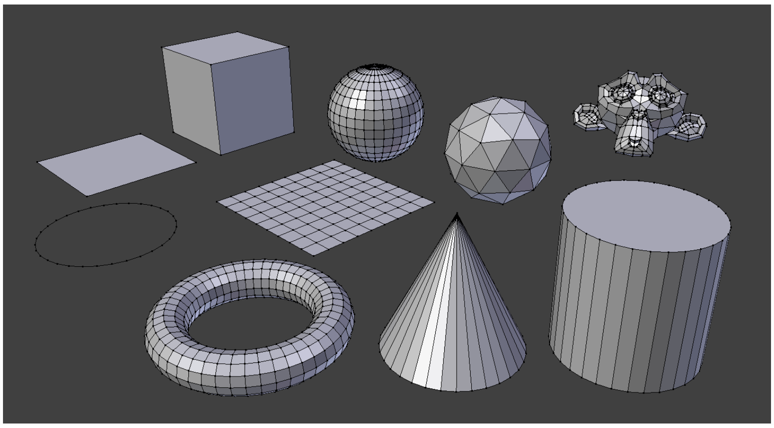


Figure 12 Blender's standard primitives.

Planar Primitives

You can make a planar mesh three-dimensional by moving one or more of the vertices out of its plane (applies to Plane, Circle and Grid). A simple circle is often used as a starting point to create even the most complex of meshes.

Plane

The standard plane is a single quad face, which is composed of four vertices, four edges, and one face. It is like a piece of paper lying on a table; it is not a three-dimensional object because it is flat and has no thickness. Objects that can be created with planes include floors, tabletops, or mirrors.

Cube

A standard cube contains eight vertices, twelve edges, and six faces, and is a three-dimensional object. Objects that can be created out of cubes include dice, boxes, or crates.

Circle

- Vertices

The number of vertices that define the circle or polygon.

- Fill Type

Set how the circle will be filled.

- Triangle Fan

Fill with triangular faces which share a vertex in the middle.

- N-gon

Fill with a single n-gon.

- Nothing

Do not fill. Creates only the outer ring of vertices.

UV Sphere

A standard UV sphere is made out of quad faces and a triangle fan at the top and bottom. It can be used for texturing.

- Segments

Number of vertical segments. Like the Earth's meridians, going pole to pole.

- Rings

Number of horizontal segments. These are like the Earth's parallels.

Icosphere

An icosphere is a polyhedral sphere made up of triangles. Icospheres are normally used to achieve a more isotropical layout of vertices than a UV sphere, in other words, they are uniform in every direction.

- Subdivisions

How many recursions are used to define the sphere? At level 1 the icosphere is an icosahedron, a solid with 20 equilateral triangular faces. Each increase in the number of subdivisions splits each triangular face into four triangles.

Cylinder

Objects that can be created out of cylinders include handles or rods.

- Vertices

The number of vertical edges between the circles used to define the cylinder or prism.

- Depth

Sets the starting height of the cylinder.

- Cap Fill Type

Similar to circle (see above). When set to none, the created object will be a tube. Objects that can be created out of tubes include pipes or drinking glasses (the basic difference between a cylinder and a tube is that the former has closed ends).

Cone

Objects that can be created out of cones include spikes or pointed hats.

- Vertices

The number of vertical edges between the circles or tip, used to define the cone or pyramid.

- Radius 1

Sets the radius of the circular base of the cone.

- Radius 2

Sets the radius of the tip of the cone. Which will create a frustum (a pyramid or cone with the top cut off). A value of 0 will produce a standard cone shape.

- Depth

Sets the starting height of the cone.

- Base Fill Type

Similar to circle (see above).

Torus

A doughnut-shaped primitive created by rotating a circle around an axis. The overall dimensions can be defined by two methods.

- Operator Presets

Torus preset settings for reuse. These presets are stored as scripts in the proper preset's directory.

- Major Segments

Number of segments for the main ring of the torus. If you think of a torus as a "spin" operation around an axis, this is how many steps are in the spin.

- Minor segments

Number of segments for the minor ring of the torus. This is the number of vertices of each circular segment.

Torus Dimensions

- Add Mode

Change the way the torus is defined.

Major/Minor, Exterior/Interior

- Major Radius

Radius from the origin to the center of the cross sections.

- Minor Radius

Radius of the torus' cross section.

- Exterior Radius

If viewed along the major axis, this is the radius from the center to the outer edge.

- Interior Radius

If viewed along the major axis, this is the radius of the hole in the center.

Grid

A regular quadratic grid which is a subdivided plane. Example objects that can be created out of grids include landscapes and organic surfaces.

- X Subdivisions

The number of spans in the X axis.

- Y Subdivisions

The number of spans in the Y axis.

Monkey

This adds a stylized monkey head to use as a test mesh, use Subdivision Surface for a refined shape.

WHAT IS A 3D OBJECT?

An object that has height, width and depth, like any object in the real world. Example: your body is three-dimensional. Also, known as "3D".

Figure 13 Objects Example

Figure 14 Car Object

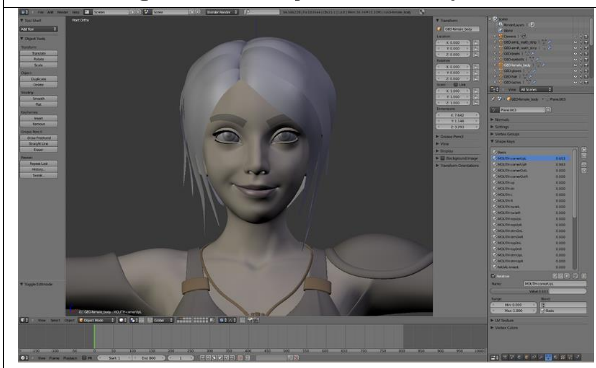


Figure 15 Character object

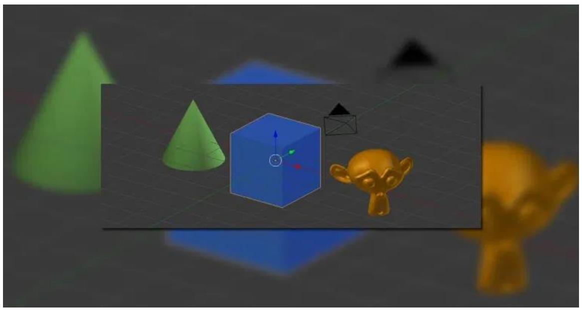


Figure 16 primitive objects

WHAT IS MEANING OF CLONING IN 3D?

Cloning means duplicating objects in 3D. There are three types of clone option: -

Copy

A copy is a simple copy and they are not linked in any way.

Instance

An instance of an object means that modifying one would modify the other.

Reference

A reference is a hybrid between the two. If you change any parameters within the modify stack of either the clone or the original, changes would be duplicated. If you add modifiers to the original, this would also be applied to the reference also.

WHAT IS THE MEAN 3D TRANSFORMATION?

3 operations collectively are called transformations. The three operations are: -

- Move
- Rotate
- Scale

Move

Moving an object in space. Relocate an object in space in order to move an object to its final position, it can be moved in all 3 axis or constricted to certain axis.

Rotate

Rotating an object in space rotate an object into other orientation. Rotations, like translations are usually written as a set of 3 values, on each for the X rotations, the Y rotations and Z rotations.

Rotate (90, 0, 0) means rotate X 90 degrees around and nothing around Y and Z.

Scale

Changing size an object. Change the size or the proportions of the object.

There are two types of scaling.

proportional scale/uniform scale, scaling factor is the same for all axis.

non-proportional scale/non-uniform scale. An object is scaled on one or 2 axes at a time.

10 DIFFERENT TYPES OF 3D MODELLING TECHNIQUES

There are many types of 3D modelling techniques today. These are the types of modelling techniques: -

- Box modelling
- Polygon modelling
- NURBs and curve modelling
- Digital 3D sculpting
- Photogrammetry
- Simulation
- Procedural modelling
- Boolean modelling
- Kit bashing
- Modular modelling

Box modelling

Let's start with box modelling. What makes box modelling its own type is that we start with some primitive object, such as a cube or sphere, and we use classic modelling tools to create a shape from it.

We have a starting point, and we work with low poly shapes to create our object. This is a common way of modelling that is quite mechanical since we control individual faces, edges and vertices. With box modelling we have an emphasis on manipulating whole shapes and larger portions of an object at a time.

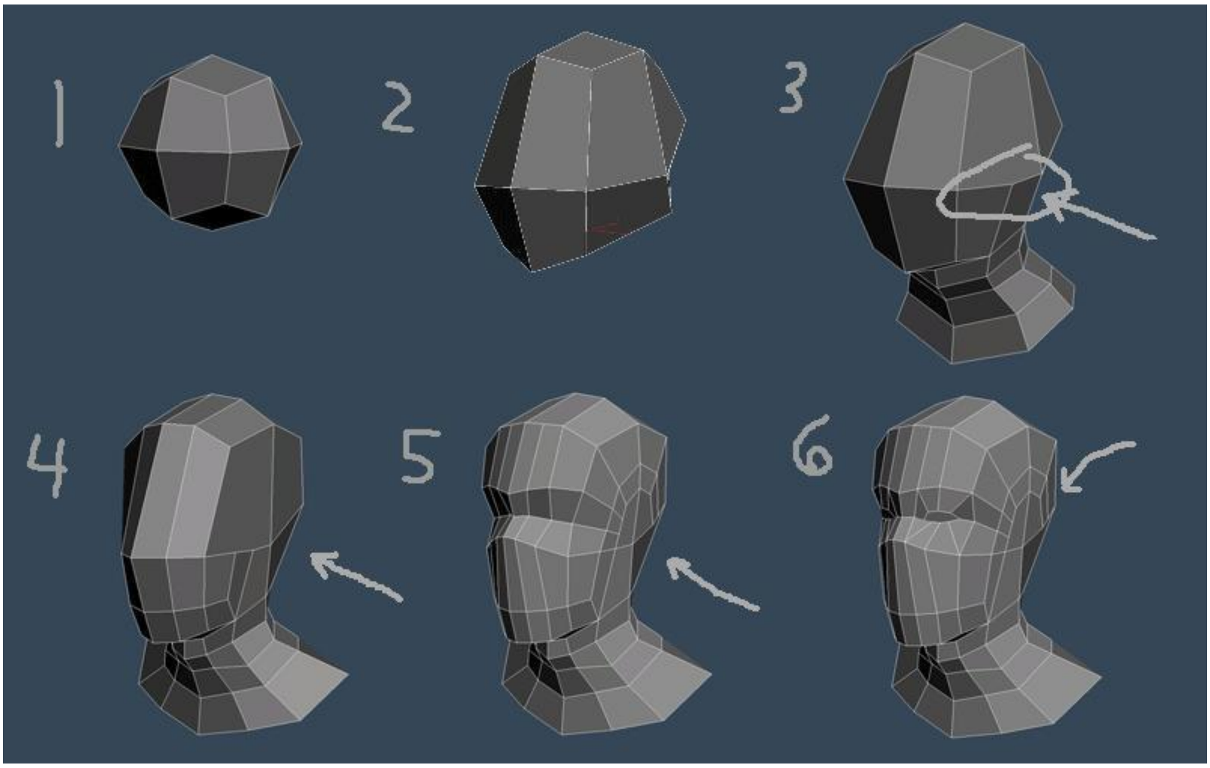


Figure 17 Start with Box and create shape

Most of the time we work with faces that have four sides, we call them quads. These are easy to work with since most modelling tools are designed to work with quads. But before we use a model it is often triangulated, either by the user beforehand or automatically by the software under the hood.

This type of modelling tends to work best with hard-surface objects such as architectural visualization and man-made objects or products.

We use tools such as extruding, creating loop cuts and bevelling. Box modelling is often used together with subdivision surface.

Subdivision surface is a technique that adds extra geometry in between the edges, vertices and faces that we manipulate with traditional modelling tools. The geometry that we control becomes like a cage that we used to shape the subdivided version of our object.

A subdivided low poly object becomes more rounded according to the catmull-clark algorithm. This may sound technical but essentially, we just add geometry that rounds the surface of our object.

There are different schools on how to use subdivision surface. Since this is a kind of layer that is added on top of our original geometry some people say that you should never model with the subdivision surface visible just because the original mesh may become unusable without subdivision surface added. Limiting our use of the original mesh.

Others argue that it is much easier to see what you are doing and the intention is still to use the object with subdivision surface anyway.

Polygon modelling

Polygon modelling is a type of 3D modelling that is quite similar to box modelling. The difference here is that we usually start with a single vertex or simple shape without and depth to it. Then we build our model piece by piece. We often use the same tools as with box modelling, but we use them in a kind of detailing way.

The emphasis here is to work with edges and vertices a lot more. The type of objects we create with this technique still tend to be hard surface quite often but with more organic shapes.

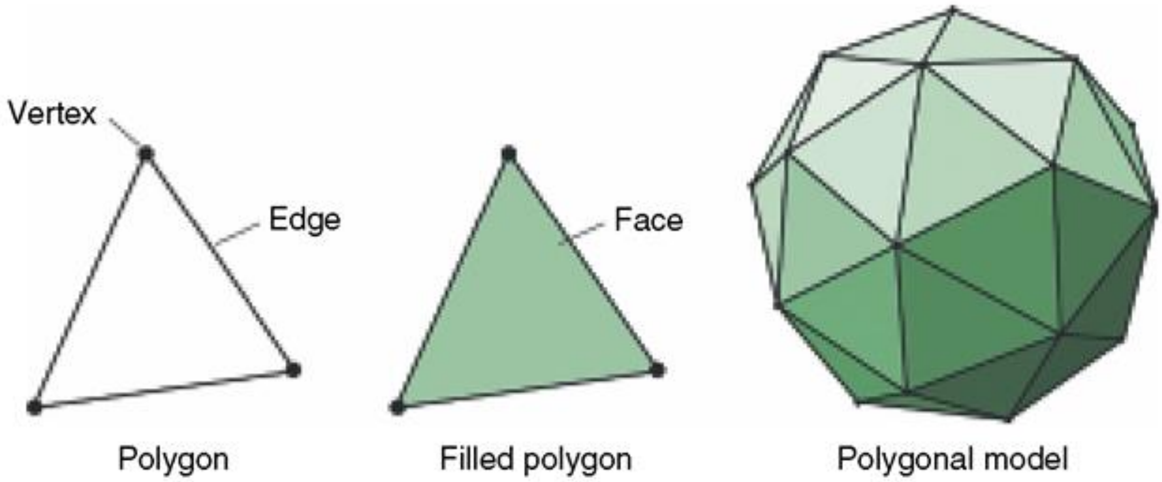


Figure 18 Polygonal modelling

Polygon modelling, like box modelling often has an emphasis on using quads in the topology. This is because many tools are designed to work with a quad topology.

This we create with polygon modelling may fall into the hard-surface category. But many times, the kind of models we create have some organic characteristic. It could be a statue or building ornaments for example.

But it can also be some accessory, tool or other gear that we create with this technique.

Subdivision surface is often used here as well to smooth the object's geometry.

Essentially the tools used with box modelling and polygon modelling are the same, we just use them differently.

NURBs and curve modelling

NURBs stand for non-uniform rational b-spline. No wonder we have an acronym. With this kind of modelling, we switch to a completely different kind of modelling. We create curved surfaces that we control based on control points. We can use it to create very smooth curved surfaces.

We can both interpret between points within the same curve and also create bridges between multiple curves. We can set up a net of curves that act as the edges of an object then fill in the geometry in between to create an object.

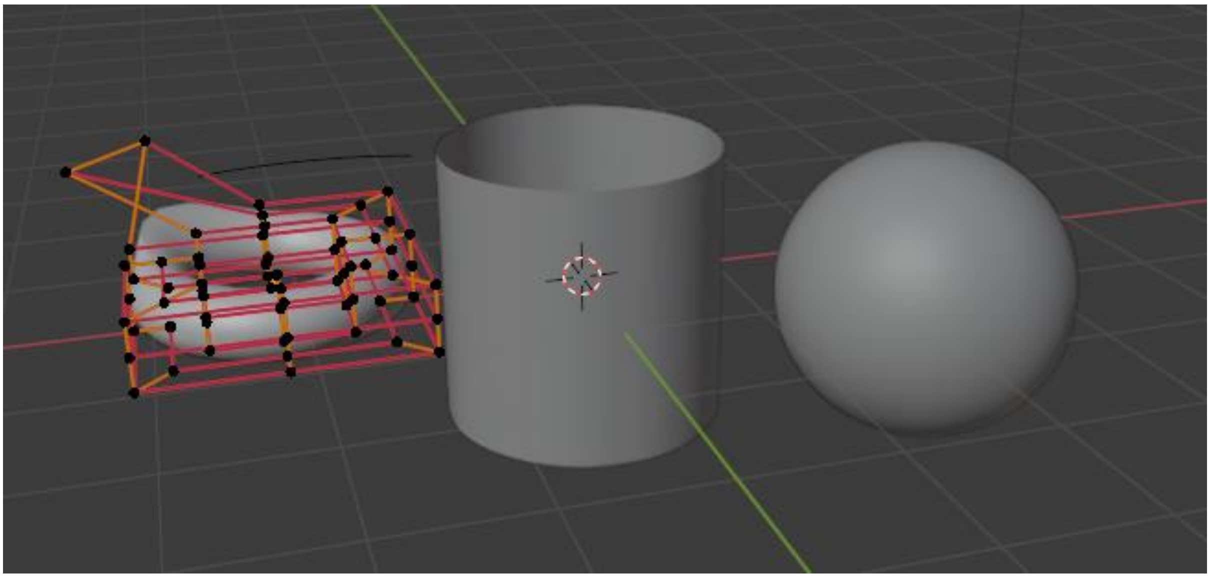


Figure 19 NURB's Modelling

This kind of modelling is mostly used in engineering and CAD like software. Not so much when it comes to VFX and the art side of 3D.

Imagine if you have an object that you want to 3D print. In this case if you have a polygon model, that we created with box or polygon modelling and you scale it up. All those faces and triangles will start to become visible, just like when you scale up a raster-based image.

On the other hand, with NURBs, we can scale up and down the model and the curves will remain smooth. This could be said to be the equivalent of vector art in 2D graphics.

Since we no longer work with vertices, faces or edges and instead use curves. This means that the tools are very different.

We may have tools that open or close a curve or create a new curve that interpret between two other curves. But we also have tools that are very similar like moving control points, scaling and rotating.

Digital 3D sculpting

Sculpting takes us back from the engineering part of 3D modelling into the generally more artistic leaning side. Sculpting uses vertices, faces and edges, just like box and polygon modelling. We use sculpting to separate the shaping process from the more technical details of worrying about the individual elements. Instead of manipulating based on selection we have brushes. The brush has an influence area and more organically reshapes the geometry based on the brush type and settings.

Sculpting is generally used with character, animal or creature design. But can also be used to sculpt detail that would be hard to create with traditional box and polygon modelling.

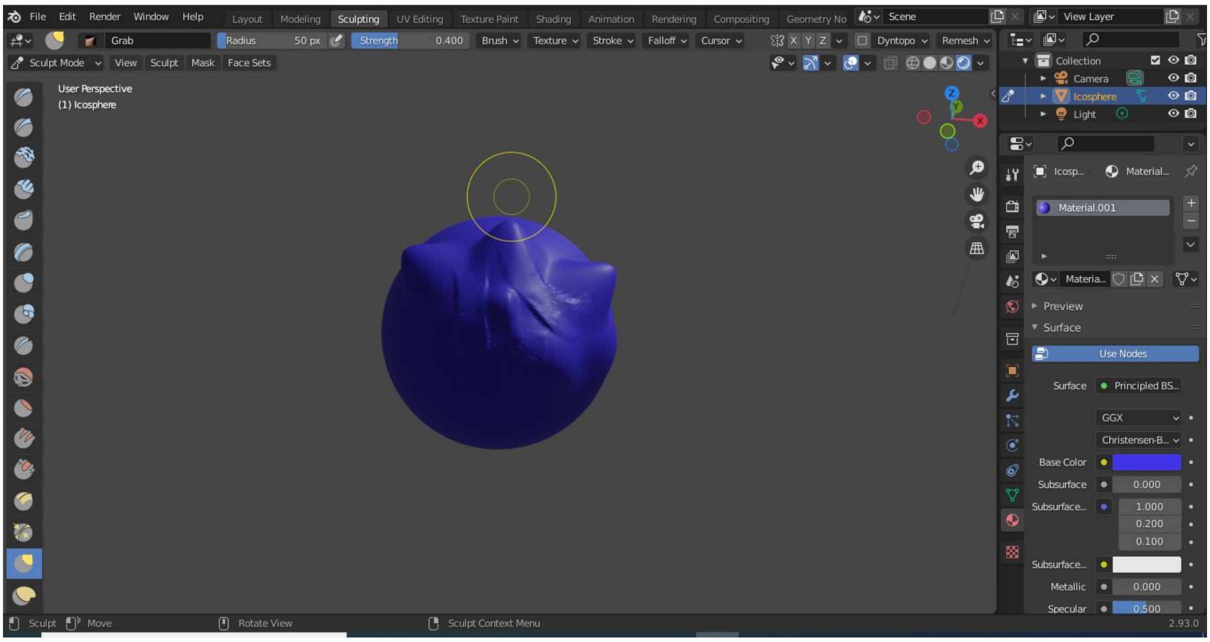


Figure 20 Sculpting

There are different types of sculpting. We may sculpt on the mesh as it is and this would move the vertices, edges and faces around to shape according to the brush. Using this method, we need to have very much geometry available from the start, or we will soon reach the limit of how much detail our geometry can hold.

When we are done sculpting, we need to make the mesh usable again. After a sculpting session the mesh is often in a very bad condition in terms of performance reasons and workability.

Sometimes we can accomplish a better mesh automatically through different re-mesh algorithms that can the surface of the object and apply a new mesh on top of it. Many times, thought we have to go through a process called retopology and manually recreate the mesh on top of the sculpted object.

Photogrammetry

Photogrammetry is yet another completely different way of generating 3D models. With this technique we use a camera and photograph an object multiple times from all angles in a lighting condition that is as even as possible. Then we feed these images into a program that interprets them and generates a 3D representation of the object.

There are obvious advantages and disadvantages here. We get real world data meaning that whatever we create is bound to be close to realism. Many times, we get textures and UV Maps generated in the process, so we don’t have to spend as much time on these areas as well.

However, much like sculpting the mesh need to be reworked either by remesh or retopology. This means that we may need to recreate the UV Map as well.

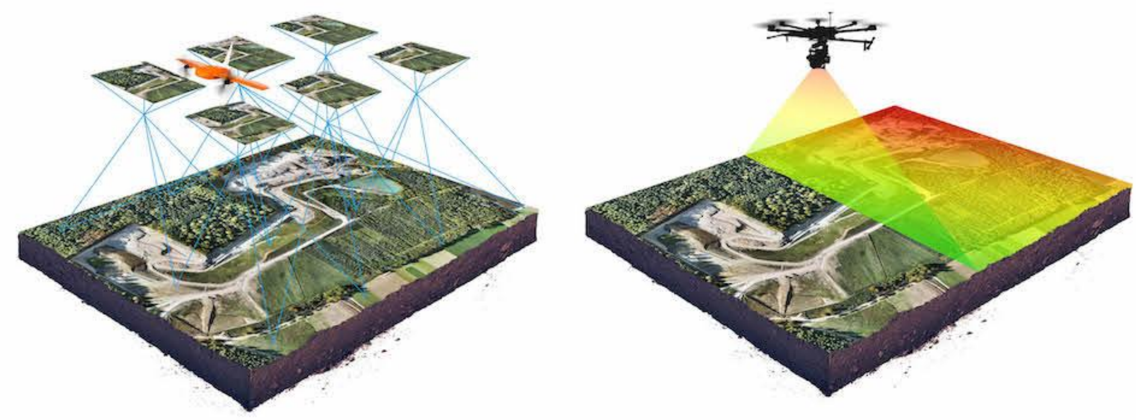


Figure 21 Photogrammetry

There will also be extensive clean-up work to do since the camera will catch not only the object in question but also the surroundings.

Another downside is that we need to have the object available to photograph it, and we need to put it on a surface meaning that part of the object will be unreachable for us. For instance, a rock will have to lie down as we photograph it and the underside is not accessible during a single photo session. This will result in holes in our mesh that we have to deal with in some way.

Photogrammetry is a relatively new invention that has gained lots of traction lately. We can't only photograph small objects. We can also use a drone to photograph a whole area and recreate larger structures.

This is good news for preserving old buildings or to study an area faster.

There are also scanners that can be used to scan an object or area much like sonar works. The data can then be fed through a software to recreate a 3D map.

Simulation

There are many kinds of digital simulations. Here I will list a few.

- Physics
- Cloth
- Soft body
- Fluid
- Fire and smoke
- Ocean
- Particles

Each of these has its own purpose. Most of them also have multiple purposes as you probably can imagine. When we simulate something, we create a setup with different objects and parameters that will interact with each other over time. The computer calculates how things will move and what will happen for each frame we run the simulation for.

We can then use the result to create animation but also to create a scene or objects based on simulation rather than the raw manual input from other modelling techniques. Imagine if you were to create a wave splashing on a rock. You may model or use photogrammetry to create the rock but the wave is more difficult. You may be able to sculpt it, but it would be far more convenient to run a simulation and have it splash on the rock by itself creating the shape based on parameters such as the angle the wave hit the rock, the size and velocity of the wave and so on.

Similarly, we could use a physics simulation in combination with a soft body object to create a car crash. Instead of having to model every frame by hand.

Another example would be a cloth simulation. You could sculpt the pillows for your next architectural visualization scene or you can use a cloth simulation to create it with all the wrinkles included.

Simulations lean much more towards VFX than for instance NURBs. But we can still consider it a modelling technique since we create or deform objects with it.

Simulation is a much more technical type of 3D modelling. Since we mostly tweak and fine tune parameters rather than directly focusing on the shape.

Procedural modelling

Procedural modelling come in many shapes and sizes. I will divide this into two different types of modelling. The first one is tool based. We or someone else created a tool that is designed to procedurally generate a bunch of similar objects. For instance, we could have a building generator. We could then input a bunch of parameters like, how many floors, how high the ceiling should be and what kind of roof shape it should have. Then we run the program a number of times and for each time through, a new model that follows our criteria is spit out.

There are many such tools for specific types of models, and we can also create our own model generators and expose certain parameters that for the kind of model we want the tool to output.

The next kind of procedural modelling is closely tied to shading. A shader can have a displacement output and through this displacement we take s simple primitive such as a sphere or a plane, and we use mathematical formulas to deform the surface to become a complex object or surface.

This is a trend that has grown as more and better tools have become available to displace geometry through shading. Both traditional displacement that works on a single up and down axis and vector displacement are available. Vector displacement can displace geometry in all directions creating very advanced objects from simple geometry.

Boolean modelling

With Boolean modelling we start with a model and cut away or add other object to it to create a new shape. This is closely tied to box modelling, and we often use the two techniques together.

Normally we model basic shapes with box modelling and then combine different shapes with Boolean operations. The operations we have to work with are:

- Difference
- Union
- Intersect

The difference operator is the most common. This is the operator that cuts away the shape and volume of one object from another.

Union will merge two objects together and intersect will save only the geometry that two objects share.

Boolean can help us create shapes that would otherwise be time-consuming to mimic with other modelling techniques. We can combine circular or bent shapes with square hard-surface shapes and cut away or add these together.

Kit bashing

This is another type of modelling where we start with a kit of objects that we combine into more detailed objects. Or we may use kit bashing to detail an object that was made with some other type of modelling.

Kit bashing is also very common when creating hard surface objects. It allows us to explore how different pieces could fit together without needing a complete picture of what the final piece will look like.

Kit bashing is excellent to detail a scene. When using kit bashing one should keep in mind the ratio of high frequency detail, middle frequency and low frequency detail. Well composited shots usually have a good mix and arrangement between different distributions of detailing.

This is true both for hard surface and organic modelling. For instance, a fictional robot may have more detail around what should be perceived as the head or focus point while a forest may have different distribution of plants, trees and mushrooms depending on where each spice most effectively would grow. Some are evenly spaced across the scene while other are clumped together or concentrated to a specific area of the scene.

Modular modelling

This is not really a modelling technique, but a good practice. When creating 3D assets, it is a good idea to keep modularity in mind. It may be that we are creating a cityscape. We may need to model multiple buildings that look similar. In that case we should think about modularity so that we can reuse certain parts of one building in the next.

Final thoughts

When deciding on what type of modelling Techniques to use, we need to think about what end result we are aiming at. But in most cases, it is going to be a combination. Especially if we are creating a scene. In those cases, we may have some objects requiring some techniques while other objects will require others.

If you are a beginner artist, I would suggest to start with box modelling and polygon modelling, simply because it is the same tools used and these techniques are the foundation of all modelling. But if you want to niche in on 3D printing for example, NURBs modelling might be where you should start.

MESH

Mesh Modelling typically begins with a Mesh Primitive shape (e.g. circle, cube, cylinder…). From there you might begin editing to create a larger, more complex shape.

STRUCTURE

With meshes, everything is built from three basic structure : -

- Vertices
- Edges
- Faces

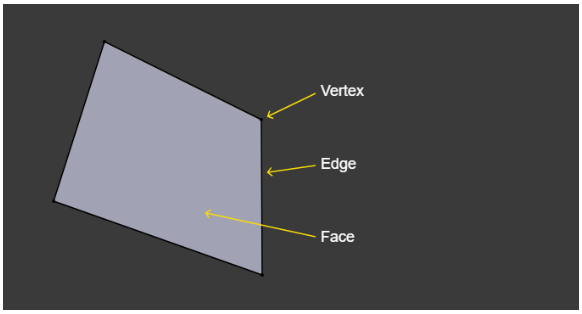
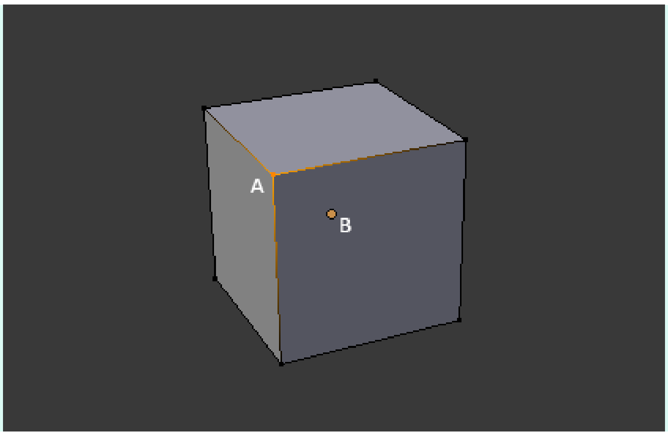


Figure 22 Example of mesh structure

Vertices

The most elementary part of a mesh is the vertex (vertices plural) which is a single point or position in 3D space. Vertices are represented in the 3D Viewport in Edit Mode as small dots. The vertices of and object are stored as an array of coordinates.



A is the vertex and B is the object's origin

Edges

An edge always connects two vertices by a straight line. The edges are the "wires" you see when you look at a mesh in wireframe view. They are usually invisible on the rendered image. They are used to construct faces.

Faces

Faces are used to build the actual surface of the object. They are what you see when you render the mesh. If this area does not contain a face, it will simply be transparent or non-existent in the rendered image.

A face is defined as the area between either three (triangles), four (quadrangles) or more (n-gons) vertices, with an edge on every side. The faces are often abbreviated to tris, quads & n-gons.

Triangles are always flat and therefore easy to calculate. On the other hand, quadrangles "deform well" and are therefore preferred for animation and subdivision modelling.

Normals

In geometry, a normal is a direction or line that is perpendicular to something, typically a triangle or surface but can also be relative to a line, a tangent line for a point on a curve, or a tangent plane for a point on a surface.

In the figure below, each blue line represents the normal for a face on the torus. The lines are each perpendicular to the face on which they lie. The visualization can be activated, in Edit Mode, in the Mesh Display Viewport Overlays panel.

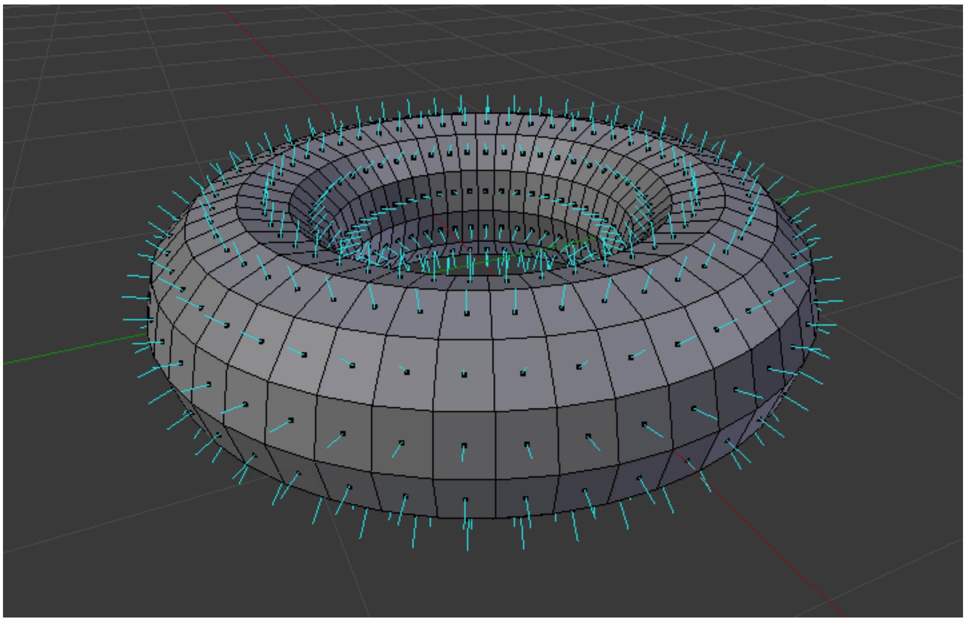


Figure 23 A visualization of the face normals of a torus.

Modelling

Introduction

The creation of a 3D scene needs at least three key components: -

- Models
- Materials
- Lights

In this part, the first of these is covered, that being modelling. **Modelling** is simply the art and science of creating a surface that either mimics the shape of a real-world object or expresses your imagination of abstract objects.

Depending on the type of object you are trying to model, there are different types of modelling modes. Since modes are not specific to modelling, they are covered in different parts of the manual.

Switching between modes while modelling is common. Some tools may be available in more than one mode while others may be unique to a particular mode.

MODELLING MODES

The 3D Viewport has three principal modes that allow for the **creation**, **editing** and **manipulation** of the mesh models. Each of the three modes have a variety of tools. Some tools may be found in one or more of the modes.

MODES THAT USED FOR MODELLING: -

- Object Mode
- Edit Mode
- Sculpt Mode

Object Mode

Supports basic operations such as object creation, joining objects, managing shape keys, UV/color layers.

Edit Mode

Used for the majority of mesh editing operations. Edit mode is the main mode where modelling takes place. Edit mode is used to edit the following types of objects: -

- Meshes
- Curves
- Surfaces
- Meta balls
- Text objects
- Lattice

You can only modify the mesh of the objects you are editing. To modify other objects, you can leave Edit Mode, select another object and enter Edit Mode, or use Multi-Object Editing.

Sculpting

Instead of dealing with individual mesh elements, supports sculpting with brushes (not covered in this chapter).

THE PROCESS OF 3D MODELLING AND ANIMATION

The process of a 3D animation pipeline is complex and can be a lot more complicated than any other forms of animation.

Depending on what project and which 3D animation studio is involved, the number of steps may vary.

In this lens, I’ve identified and illustrated the 11 most common steps involved in producing a 3D animation project.

They are namely: -

1. Concept and Storyboards
2. 3D Modelling
3. Texturing
4. Rigging
5. Animation
6. Lighting
7. Camera Setting
8. Rendering
9. Compositing and Special VFX
10. Music and Foley
11. Editing and Final Output