TNM061 3D Computer Graphics
Polygon Modeling
Lab instructions 2023

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January 26, 2024

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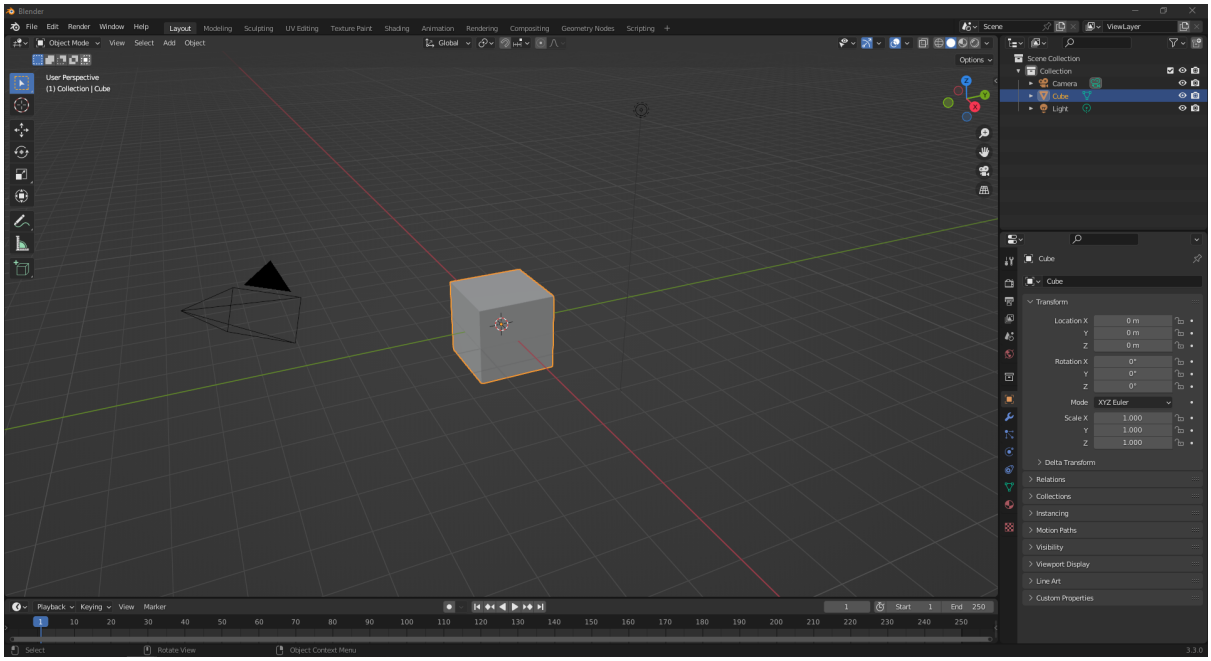


Figure 1: Screenshot of Blender.

1 Introduction

Software for modeling, rendering, and animation is often quite complex, provides a lot of different functionality, and can be quite overwhelming. This lab and the following labs are intended to get you started and experimenting with such tools.

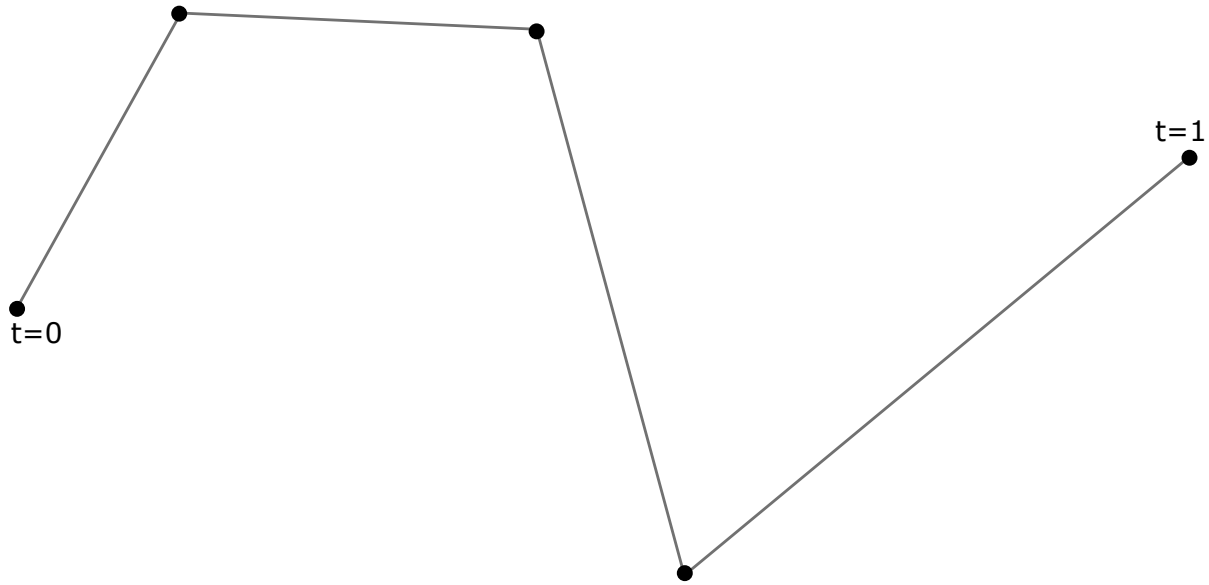
In this course we will use **Blender**, which should be available on the lab computers.

When you open Blender the first time you will see a user interface similar to Figure 1. The Blender window is by default separated by into four sections. The biggest is called the 3D Viewport, the bottom left one is called the Timeline (not relevant to this lab but might be useful for the project), the upper right is called the Outliner and gives an overview of the objects in the scene, and the bottom right one is called Properties. The different sections of the properties panel can be navigated by clicking on the symbols on the left side of the panel. Objects can be added into the scene by selecting the 3D Viewport and pressing ⇧ + a.

2 Theory

1. What is the difference between face normals and vertex normals? Is it necessary that a mesh has both?
2. Why is it sometimes necessary to split vertex normals along an edge?
3. The following control points belong to a Bézier curve. Apply the De Casteljau algorithm to the control points to determine the curve point of the curve at 0.75 (see 05-modeling.pdf, slide 26).

   Sketch the remainder of the curve using the control points. What is the degree of this Bézier curve?



3 Assignments

In this lab, you will be modeling objects using polygon meshes. A polygon mesh can be edited on four different levels. Transformations on *object* level affect the entire object. Editing individual *vertices* allows for local changes and manipulations. *Faces* and *edges* on the other hand affect multiple vertices at once. Certain operations like smoothing the mesh or bevels are applied to the entire object or a selection of faces and edges.

The planar faces and hard edges make this type of modeling particularly useful for technical things and architecture. Given enough surface details, that is vertices, natural objects can be modeled as well. A big advantage of polygon meshes is also that they can be rendered directly with the GPU.

This type of modeling can also be used to create a certain artistic style: the low poly look. See Figure 2 for an example of low poly trees. Low poly models contain only a minimum number of polygons and can appear quite coarse. Sometimes this look is further emphasized with flat shading. Their main advantage is that the modeled objects have a low vertex count and are thus loaded and rendered more quickly. Alternatively, one can start with a low poly model and then successively add more and more detail until the object looks good enough.

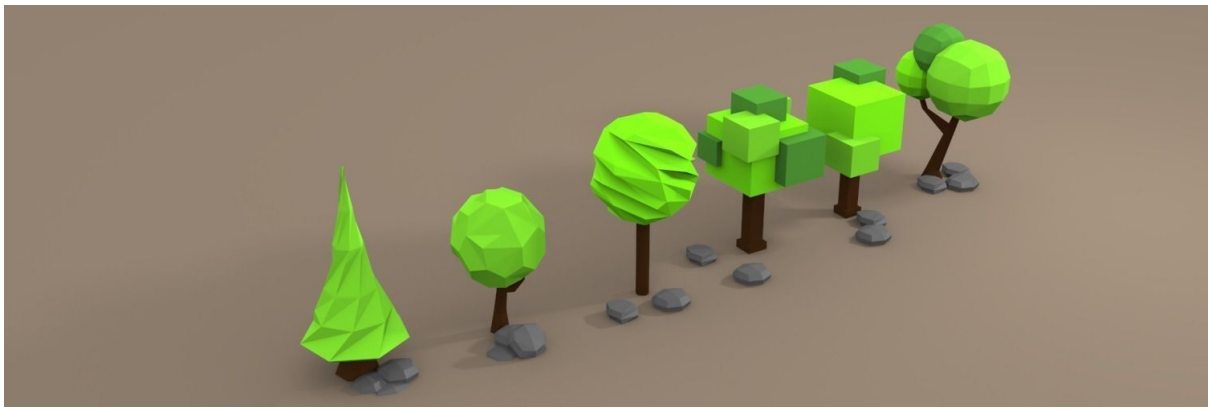


Figure 2: Low poly models of trees. Due to the low number of vertices the shapes are quite rough and less refined. Source: cgtrader.com.

3.1 Getting started

1. Familiarize yourself with Blender and have a quick look at the different windows and menus.
2. Start modeling by creating simple polygon primitives like boxes, spheres, and cylinders. Depending on the type of object, there are a number of settings which affect the object. In case of the cylinder there is a radius and the number of sections. The higher the number of sections the smoother the cylinder mesh will appear.

   See here for available Polygon/Mesh primitives in Blender.

   Adjust their position and orientation with the *Move*, *Rotate*, and *Scale* tools.
3. Try to edit the objects you created in the previous step using *vertices*, *edges*, and *faces*. Switch to *Edit Mode* by pressing ⇥ or the menu in the upper left corner of the 3D Viewport. In Edit Mode, you will get the option to select between editing vertices, faces, or edges in the upper left corner of the 3D Viewport. In order to modify the objects' position and orientation you need to switch back to *Object Mode* (see Blender Object Modes).

   Hint: You can toggle the view to wireframe mode to see the entire mesh instead of shaded front faces.

3.2 Modeling a coffee mug

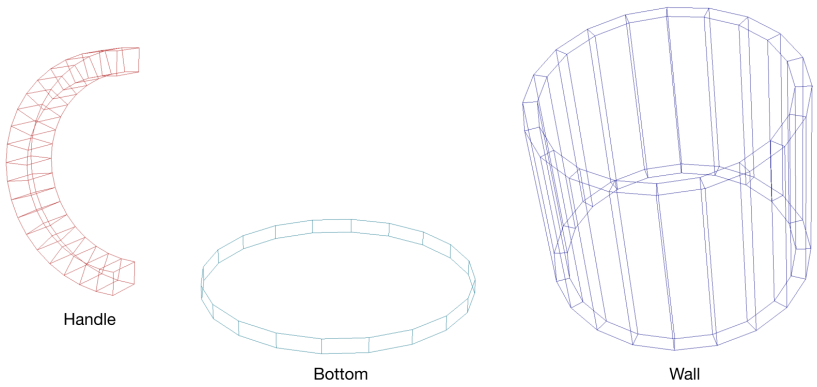


Figure 3: The separate parts of a low resolution polygon model of a coffee mug.

Now it is time to model a coffee mug. The coffee mug shown in Figure 3 consists of three parts; a handle, a circular bottom, and a thick wall. Keep in mind that there are many different ways to model such a cup and the following is just one of them.

1. Create a flat cylinder to model the bottom part. Rename the cylinder to something more reasonable. A good name allows you to find the object later on more easily than for example 'cylinder004'.

2. Continue with the side wall of the mug by adding another cylinder, deleting the top and the bottom, and extruding the walls outward (use the e hotkey when you have the faces selected). Don't forget to rename the object.

   Hint: You can use the orthogonal views from front, top, and side (use the numbers on the numpad on the keyboard) for more precise modeling and then easily switch back to the 3D perspective.

3. The handle can be modeled in different ways. Here, we start with a box (cube) and set its name to 'handle'. Set the number of height segments to about 60. Scale the box so that it resembles the handle of a mug.

   To bend the handle, you can add a *Simple Deform Bend Modifier*. Set the bending axis so that it aligns with the long side of the box and adjust the bending angle until it looks good. Move the handle into the correct position at the side wall.

   Check out this link for a quick tutorial: YouTube - Simple Deform Bend Modifier.

   Alternatively, you could begin with a single box and then extrude one face, rotate it slightly, and then repeat the process until you have created the complete handle.

4. You will quickly notice that moving the mug around is quite tedious and you need to select all three parts before applying a transformation. A better way is to select the parts and group them together (ctrl + p) with the parts selected. Think about which order you are selecting the objects and notice the different shades of the orange highlights.).

   Instead of moving the individual parts, you can now move the entire mug. You can even create groups of groups to organize your scene hierarchically. The *Outliner* (⇧ + F9) contains all objects in the scene, and allows you to manipulate the hierarchy by regrouping objects.

5. Save the scene so you can show it during the lab.

Hint: When rendering you scene into an image, you might need to add light sources. Otherwise the rendered image will be entirely black. Some modeling software will add default lights, others won't.

Regular light sources will not have an effect. If the scene appears too dark, try scaling up the light intensity.

3.3 Modeling using face extrusions

Another way to create more complex polygon meshes is to use extrusions. With an extrusion, you are pushing or pulling out part of your object. In mesh modeling, one can extrude faces, edges, even vertices. Here, we focus on extruding faces. When a face is extruded, additional faces will be added to its edges so that the face is still connected to the mesh (see Figure 4). Using face extrusions, an experienced modeler is able to roughen out quite complex objects and characters within a couple of minutes.

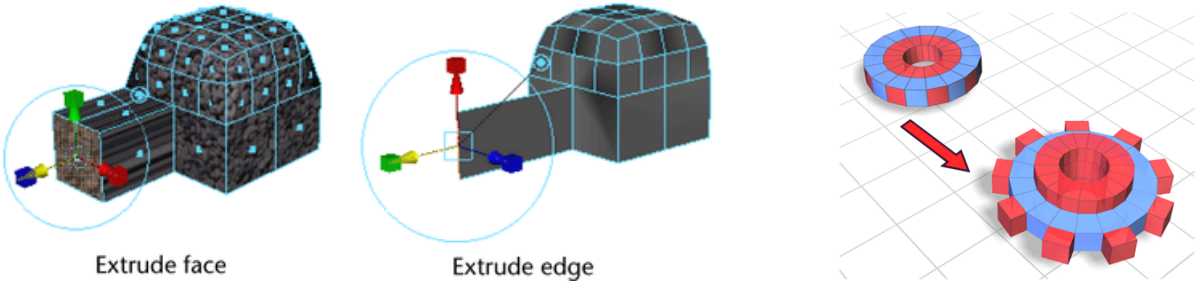


Figure 4: Face and edge extrusion is another powerful modeling technique for polygon meshes. It is also possible to extrude multiple faces at the same time (right). Source: knowledge.autodesk.com.

1. Create a polygon box/cube with two segments in each direction. Select a single face and experiment with *Extrude Faces*.

   What happens if you select multiple, or all, faces?

   Note that some tools allow you to adjust the scaling and rotation of the extruded face.

2. Think of a single, slightly more complex object, character, or animal. Create another polygon box/cube as the starting point for your modeling. This cube is now the starting point for your object. Try to model the object of your choice using mostly face extrusions. For example, extruding the faces at four corner points can easily become four legs.

   You can of course manipulate individual vertices, edges, and faces to tweak your object as you have done in the previous tasks.

   Hint: you can also *cut* (k hotkey) one or more faces of the polygon mesh to give you more options for the extrusion.

3. Save the scene so you can show it during the lab.