

What technique is most appropriate for 3D modeling a chair for a movie production?

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Abstract

Making 3D models with polygon modeling is the most common technique used for a 3D animated movie production, but there are also other good modeling techniques to work with. The aim of this thesis is to examine which of three chosen modeling technique is most appropriate to use for modeling a chair for a 3D animated movie production. I made three models of the same chair design and compared the results. The modeling technique used is polygon modeling, NURBS modeling and digital sculpting. A few factors were considered when I judged which one of the three techniques that was most suitable: The model's geometry, the workflow and the rendering (material and lightning).

The three chairs were rendered in the same scene with the same lightning and settings. The results showed that the model's geometry and how smooth it is to work with the modeling technique matter most for judging which technique is the most appropriate. In addition, the results show that how the light falls and reflects the surface depends on how the geometry was placed on the model rather than which of the other modeling techniques that was used.

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1 Introduction

In today's society most people have seen a computer animated movie and maybe some people have thought about how to make those 3D models. Some people wonder about different ways to make a 3D model and different 3D modeling techniques.

With today's technology you can make different 3D models in many different ways and using different software. Common software for 3D modeling could be Autodesk Maya and Pixologic ZBrush for digital sculpting.

This thesis is a project report where I make a 3D model to test and compare different modeling techniques and compare the results.

1.1 Background

In this section I write about 3D modeling techniques, terms and some of the digital modeling approaches used in this project report for modeling the chair.

- Geometry and Polygon-count.

Polygon-count is also known as poly-count (number of geometry). Vaughan (2012) writes that it refers to the amount of polygons on a 3D model. The fewer polygons you have on your 3D model, the easier it is to work with. Probably the most obvious reason to be mindful of a model's poly-count is the effect it has on rendering. The more geometry you have on the model the more time it takes to render an image. Vaughan (Vaughan 2012: Chapter 6).

- Topology: also called "Edge flow". In modeling terms, topology refers to the way a 3D model is constructed and how the polygons are arranged to build up its shape. Good topology makes for geometry that is easy to select, manipulate, and construct, and is even better for sculpting onto. (Vaughan, 2012: chapter 6).

- Render: Sanders write that render is used to refer to the process of creating computer-generated images from a series of mathematical calculations defined by a user's specifications. To "render" a digital scene, the software would take into account the user's settings for lighting, the various shapes of the models created in the digital space and how they reflect that lighting, and any other environmental factors as viewed by virtual "cameras"; all of this would be composited into a final image or video. (Sanders)

- Rendering: Slick writes that the process of converting a 3D scene from a mathematical representation of objects in three-dimensional space into a final polished two-dimensional image. Rendering is completed in a render engine, which uses surface material/textural information, digital lighting, and spatial data to calculate the final color of each pixel in the rendered 2D image. The final image is referred to as a render, or sometimes in animation, a 'frame' (Slick). In order to render a scene you can do it in 3D software like Maya e.g.

- Mental Ray: is a render engine. Livny (2008) writes that Mental ray specializes in generating photorealistic images, with an unsurpassed ability to re-create natural phenomena. It can also be used for creating non-photorealistic contour renderings (NPRs). (Livny 2008: chapter 1).

- Blinn Shader: When your model is done you can put on some texture (color) on the model. Andy Beane (2012) writes that a Shader is also called a material or surface. Blinn shaders allow for specular highlights (bright spots that appear on an object's surface when light shines on that object) and reflections. This shader provides good control of specular highlights for a range of effects, from a glossy look to high reflectivity. They can be used for many types of materials: plastics, metals, cardboard, and leather e.g. (Beane 2012: chapter 5)

- Alpha image: Amy Chopine (2011) describes that Alpha maps or masks are grayscale bitmaps (image) used to change the transparency of a texture. With an alpha map, you can make any part of your model completely invisible or partially transparent. Areas of the image that are black are totally transparent. (Chopine 2011:160-161)

1.1.1 The three 3D model techniques selected in this project

Polygon modeling

Palamar (2012: chapter 3) describes polygon in the following way:

Polygon geometry refers to a surface made up of polygon faces that share edges and vertices. A polygon face is a geometric shape consisting of three or more edges. Vertices are points along the edges of polygon faces, usually at the intersection of two or more edges.

The polygonal modeling is the most common modeling type; it is also very flexible to work with. You can work with both organic (character and animals) and hard-surface modeling (vehicle).

NURBS modeling

Palamar (2012: chapter 3) describes NURBS in the following way:

NURBS is an acronym that stands for Non-Uniform Rational B-Spline. As a modeler, you need to understand a few concepts when working with NURBS, but the software takes care of most of the advanced mathematics so that you can concentrate on the process of modeling.

NURBS is most commonly used for CAD (computer-aided design) and other industrial things. It can also be used to make 3D models in Maya. NURBS is good at hard-surface modeling. It can be vehicles (cars) and equipment.

Digital sculpting.

Vaughan (2012: p128) describes digital sculpting in the following way:

Digital sculpting is a method of modeling that is the closest an artist can get to traditional sculpting.

To work with digital sculpting you can really concentrate on the modeling itself, since you often do not need to care about the technical parts of 3D modeling. It is also a great technique to make organic models of humans and animals. The major disadvantage, of this technique is the model's topology (edge flow) that surrounds the model. The model's edge flow is very important when a model deforms in an animation, so a retopology is almost a requirement.

1.1.2 Digital modeling approaches

- Primitive modeling

Vaughan (2012: p 124) describes primitive modeling in the following way:

Primitive modeling, in simple terms, is combining multiple primitive geometric shapes (like boxes, spheres, discs, and so on) and modifying their shape to form the desired final object.

You start modeling by creating different primitive geometry. The cube, the sphere, the cylinder, the cone and the plane are some examples what you can start working with. You can start creating the shape of your model by placing several different shapes together in modeling robots, for example, primitive modeling is very useful because robots most often consist of many parts and primitive shapes. The advantage of primitive modeling is that you can efficiently build something together. The disadvantage might be that the model will look like it is made of several primitives. Unless you make a robot, this kind of result might not be what you desire.

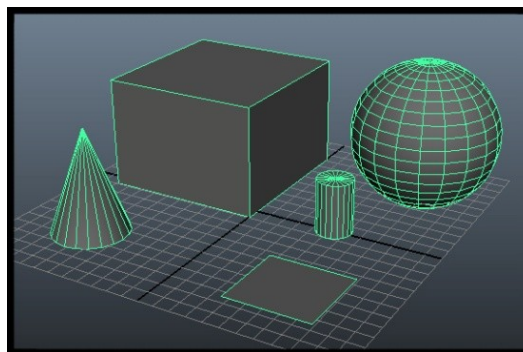


Image 1 A picture of different primitive shapes.

- NURBS curves modeling

Derakhshani (2012: p 180) writes in his book:

NURBS surfaces are defined by curves called *isoparms*, which are created with CVs. The surface is created between these isoparms to form *spans* that follow the surface curvature defined by the isoparms

By using curves with other tools you can easily create shapes. There are different kinds of curves and the one I use for the chair is a Bezier curve. Bezier curves have handles for adjusting angles and directions of the curve which facilitates the production and that is why I chose to work with Bezier curves in my project.

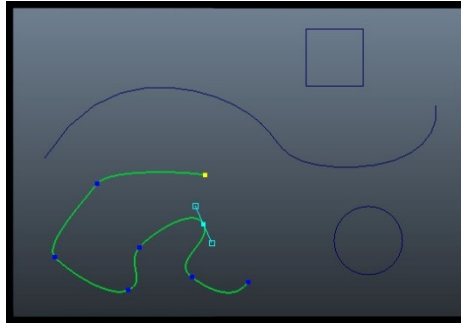


Image 2 Curves in Maya software. The highlighted curve is a Bezier curve.

- Digital sculpting using ShadowBox and clip brushes

ShadowBox is a tool in ZBrush that let you create an object by painting with the masking brushes on the ShadowBox walls. After using shadow box you can use different kinds of clip brushes to create the shapes and other tools and brushes ZBrush can offer.

Keller (2011: p 208) describes Clip brushes in the following way:

Clip brushes use the same stroke types as the mask and selection brushes—namely the rectangular, circle, lasso, and curve stroke types. They are used to slice away parts of the surface, but it is important to understand that they don't actually delete geometry; rather they squash the selected polygons so that they conform to the selected shape. Imagine taking a lump of clay and squashing it down on a flat surface; that's the basic idea behind how clip brushes work.

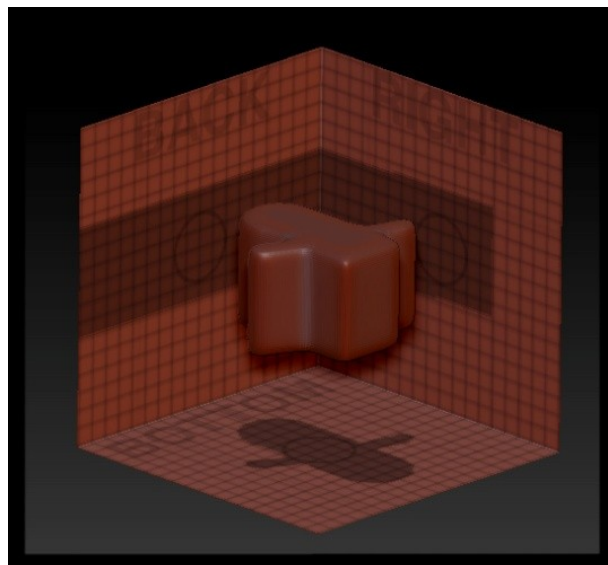


Image 3 A model created with ShadowBox in ZBrush.

1.2 Aim and questions

The aim of this thesis is to examine which of the three modeling techniques that is most appropriate to use for modeling a chair for a 3D animated movie production. The model is not to be deformed, but it is to be used by the character models in the movie.

Research questions

In this thesis the following research questions are central:

- What types of modeling techniques exist?
- What modeling technique is most appropriate to use for modeling a chair for a movie production?

1.3 Definition of the concept “appropriateness”

There are three factors that I take into consideration when I judge which modeling technique is more appropriate than the other: geometry, workflow and the rendering.

The geometry of the models

- How optimal is the model? How much geometry does the model have?
- The technical quality. Is the edge flow of the model correct (artifacts)? Does the geometry need any cleaning up? (Digital sculpting for example might need a re-topology).

Workflow of the modeling technique

- Does the modeling techniques require many steps to make the model?

The rendering.

- Do the lightning look well on the model? Are there any artifacts?
- What is the time to render?

1.4 Method

Three models were made of the same chair design. The three chairs were rendered in the same scene with the same lightning and settings.

These three modeling techniques were selected because they are among the more commonly used ones and which are suited to use for modeling the chair. Justin Slick describes on his site about different common modeling techniques. (Slick)

The techniques investigated are:

- 1) Polygon (primitive/box) modeling.
- 2) NURBS (curve) modeling.
- 3) Digital sculpting.

Software for the modeling techniques

Two different kind of software for modeling the chair were used. One of them is Autodesk Maya which is a 3D program that gives you complete control of your model. For the NURBS and the polygon modeling techniques I used this software. The second software is Pixologic ZBrush which is an excellent program to use for sculpting and organic modeling. For the digital sculpting modeling this software was used.

Object to be modeled

The chair below, (Image 5), is the model used. It is called the Septiembre chair.



Image 4 The *Septiembre* chair (photo by Miguel Angel Iranzo Sanchez).

The breakdown of the Septiembre chair

To make it easier to model something it is a good idea to analyze the picture first. We need to know how many parts the chair consists of to decide, which approach to use. This chair consists of only one part. The question is how to work with this chair. Depending on the modeling techniques to be used the approach will be different.

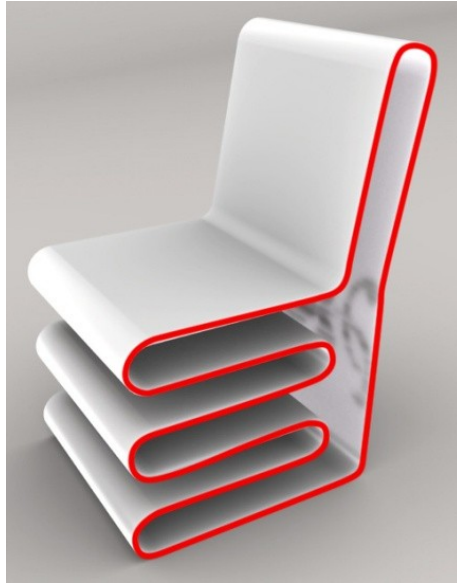


Image 5 The breakdown of the chair for modeling.

1.5 Limitations

Besides putting on a base material, no other texture will be applied. Another limitation is that a mix of different modeling techniques is not used in this thesis.

2 The production process

2.1 Polygon modeling

Tools explained and used:

- The bridge tool: creates geometry between two pieces of geometry. This may be used for different purposes and, for example with this chair it is used to create the half circle shape between two pieces (Image 7).
- The insert edge loop tool: adds more edges to your model by working with more geometry and creating the details on the model. For this chair it is going to be used to sharpen the edges of the model (Image 8).
- The smooth mesh preview: makes it possible to see how your model looks like with smooth added.

This chair is made with primitive modeling, made one box with the right thickness (depth) and height then I duplicated it and placed them where they needed to be (Image 6).

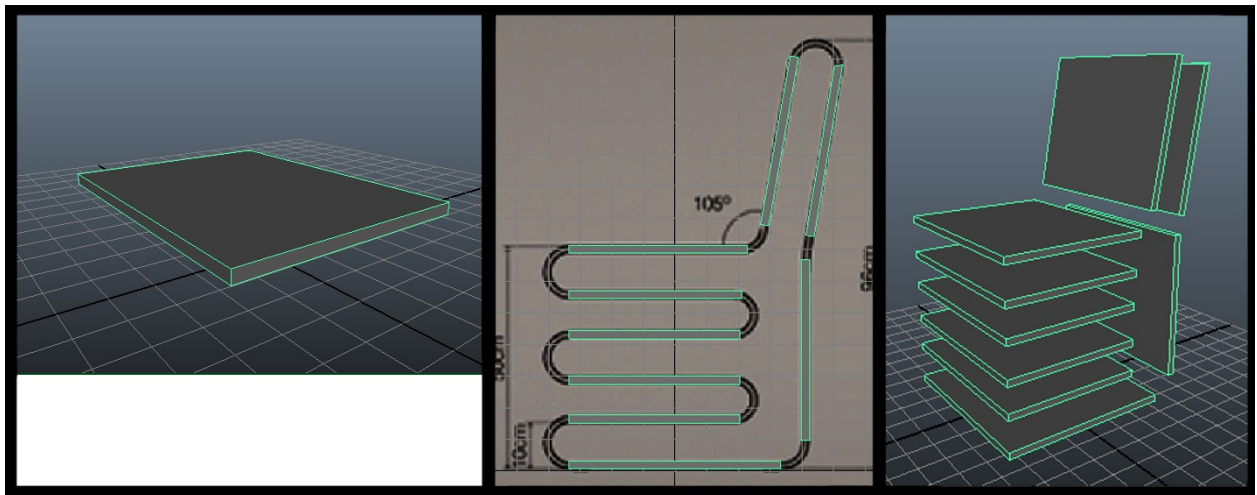


Image 6 Images of the different stages of modeling

After placing out the basic shapes the gaps were closed with the bridge tool. But first I deleted the faces from where the new geometry is to be created from (Image 7, left image). Then I selected the edges around the deleted faces, two gaps at a time (Image 7, middle image) and used the bridge tool, repeated it till all the gaps were filled (Image 7, right image).

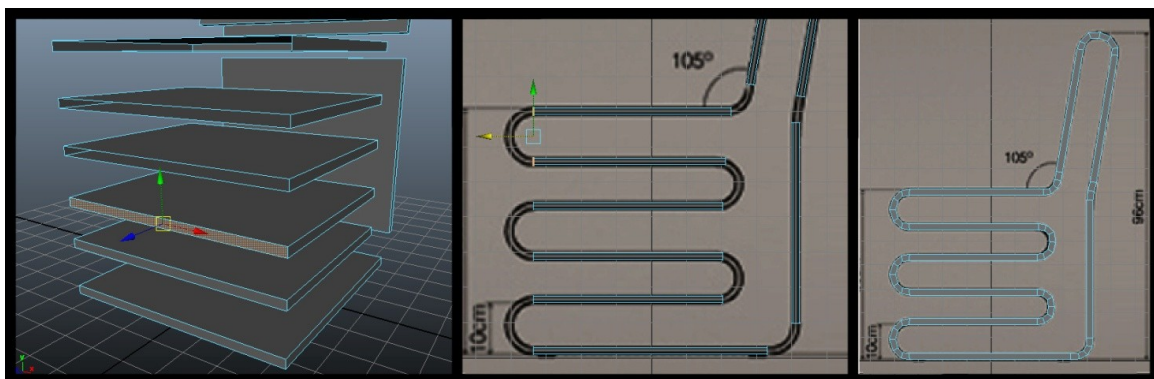


Image 7 Picture showing the process of using the bridge tool, creating the half circle geometry.

Then it was time to put “Smooth mesh preview” on to see how it affected the model. It would lose shape (Image 9, left picture). To get the final shape with sharper edges with smoothness on the object, the edges needed to be sharpened.

In order to achieve sharper edges, more geometry was needed. Edges were inserted with the “Insert tool” along edges that needed to be sharpened (Image 8).

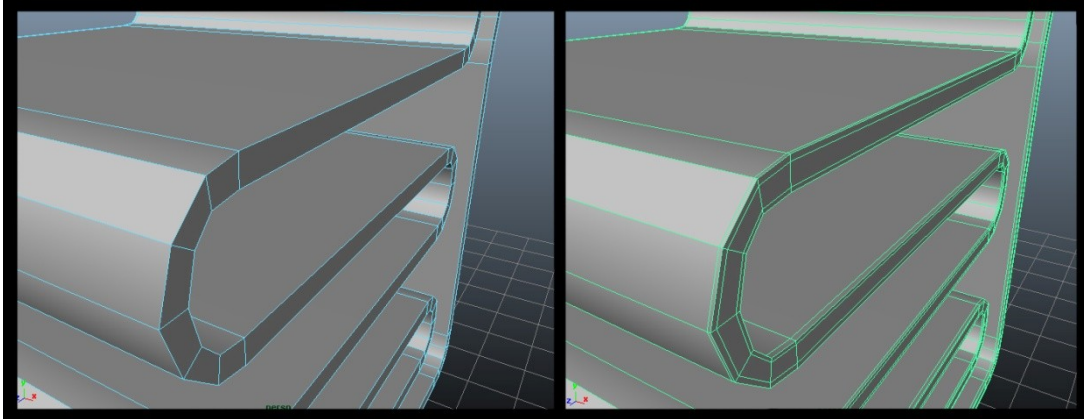


Image 8 Close-up picture of before and after with more edges added.

In Image 9 we can see the results of adding more edges to achieve sharper edges.

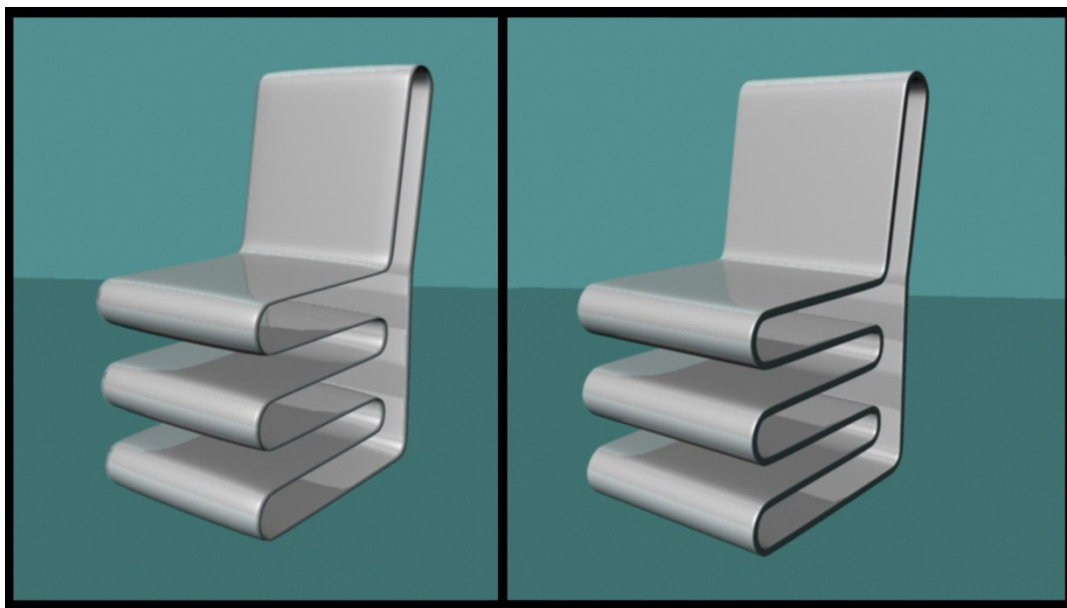


Image 9 Image showing the chair in Smooth mesh preview mode. The left picture shows the chair without added edges and the right with added edges. Since the chair to the right has more edges now it has also sharper edges.

Blinn shader (material) was added on the chair with a light grey color (Image 10), so we would get the lustre in the furniture, otherwise there is no texturing. The picture was rendered with the help of Mental Ray.

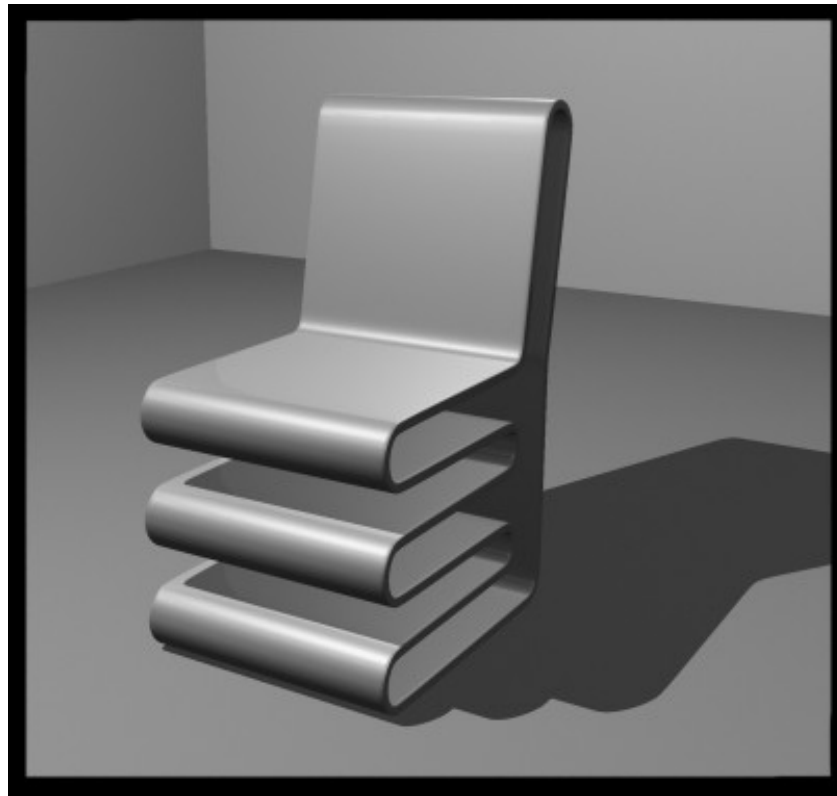


Image 10 The final render of the chair.

2.2 NURBS surface modeling

Term and tool explained and used:

- NURBS surface seams: Palamar (2012) describes in his book that many NURBS primitives have a seam where the end of the surface meets the beginning. Imagine a piece of paper rolled into a cylinder. At the point where one end of the paper meets the other there is a seam. The same is true for many NURBS surfaces that define a shape. The seam can occasionally cause problems when you're working on a model. In many cases, you can change the position of the seam by selecting one of the Isoparms (edges) on the surface. (Palamar 2012: chapter 3)
- NURBS extrude: Palamar (2012) describes that the extrude tool allows you to extrude a surface along a generated or predefined curve. Once created, the shape can be further manipulated by tapering the geometry along the curve. (Palamar 2012: Chapter 4)

To model this chair two Bezier curves were used, one for the shape of the chair profile, and one to be used with the extrude tool.

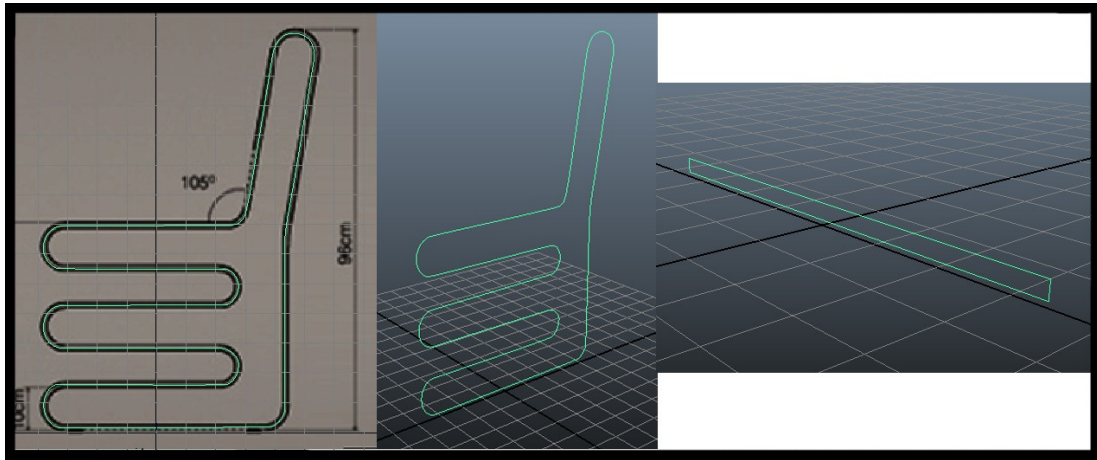


Image 11 Bezier curves.

From the curves the chair was created using extrude. In order to use extrude for this chair you first select the rectangle curve and then shift+ click the left mouse button to select the chair's profile curve and then use the extrude button.

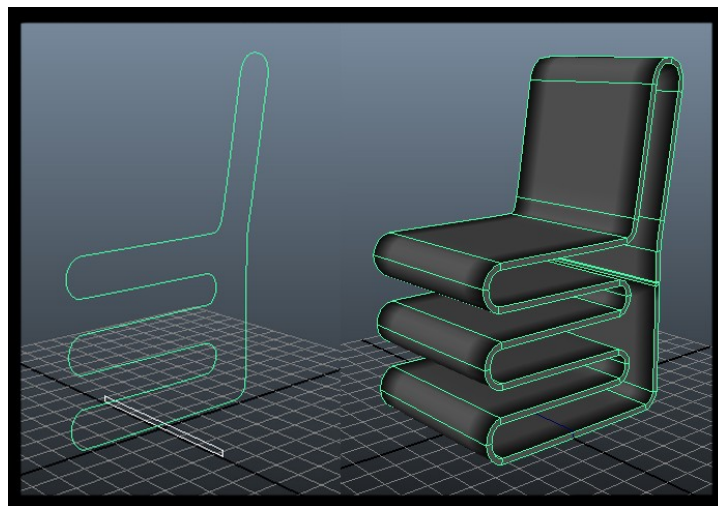


Image 12 From two curves to a chair using extrude.

If you were to look at your model with smooth mesh preview you would lose some of its sharper edges. To make a sharper edge for the chair you can insert a couple of Isoparms close to the other already existing edges (Image 13).

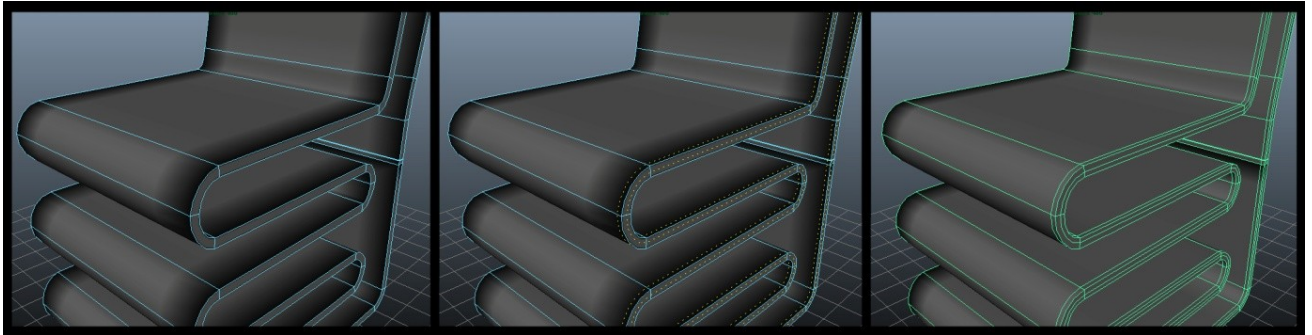


Image 13 Adding Isoparms to the chair to have harder edges. The left picture is before and the middle picture deploys Isoparms over the seat edges whereas in the right picture Isoparms has been added.

With the extra edges added to the chair it now has sharper edges. In this case the light reflected in the Blinn shader (material) has got even more spread out (Image 14).

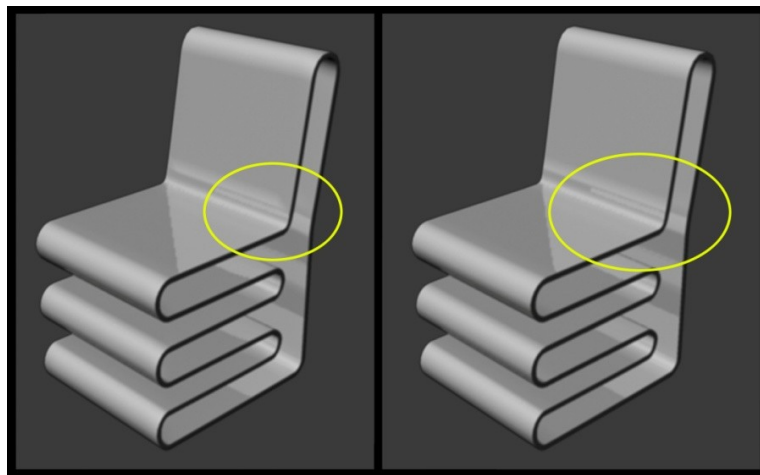


Image 14 Isoparms added to get harder edges, hard to see but it makes a difference.

Using NURBS leads to having seams somewhere on the model and since the chair is very hollow it is hard to hide the edge. There is probably a way to make the seams less visible, but not a way I know for now.

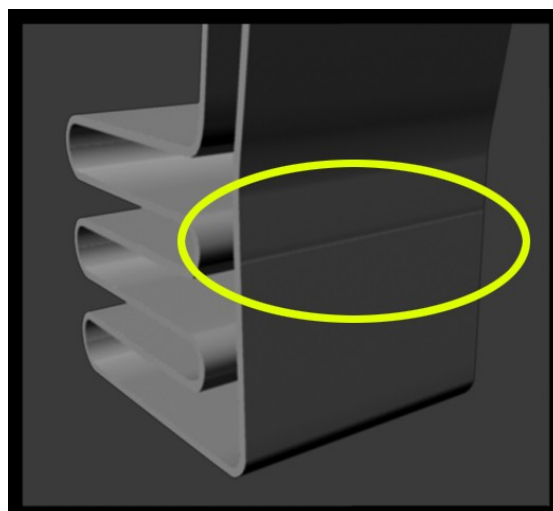


Image 15 The chair's seam is visible.

Discovered that the chair's surface needs to be adjusted and removed some of the chair's control vertices.

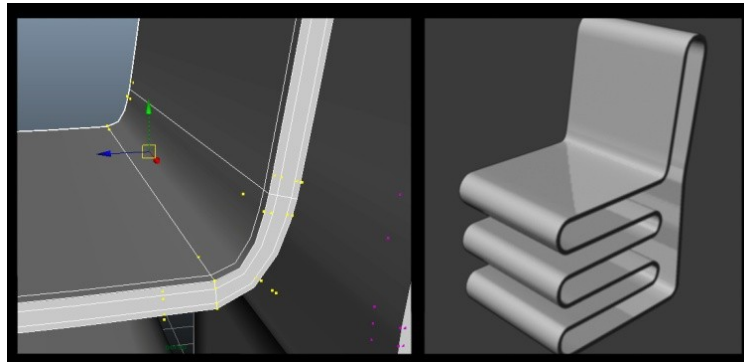


Image 16 Removed control vertices to flatten the surface.

The final model with the Blinn shader (material) added in the same room and lightning as the polygon modeled chair. A comparison is now plausible.

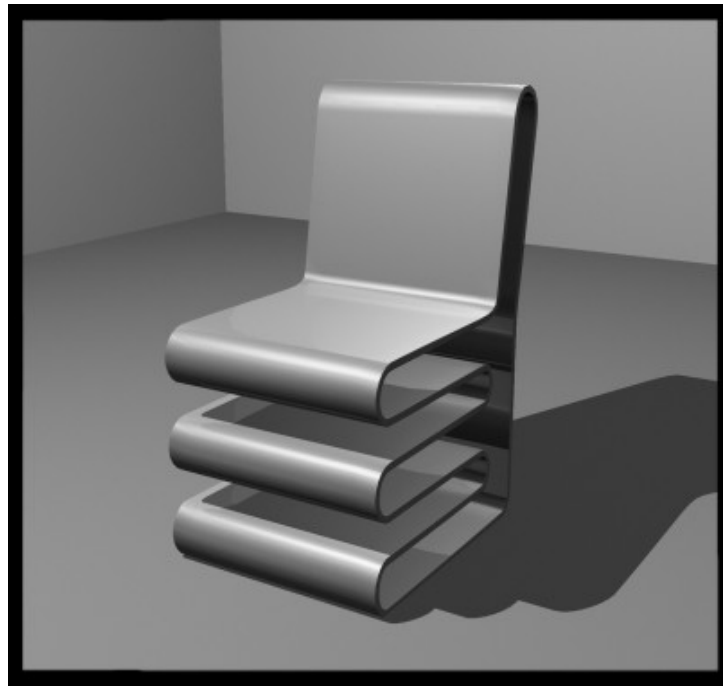


Image 17 Final render in Maya.

2.3 Digital sculpting

ShadowBox and clip brushes were used to make the chair. The first thing is to make the turnaround into an alpha image in order to make a mask from the image in ShadowBox (Image 18).

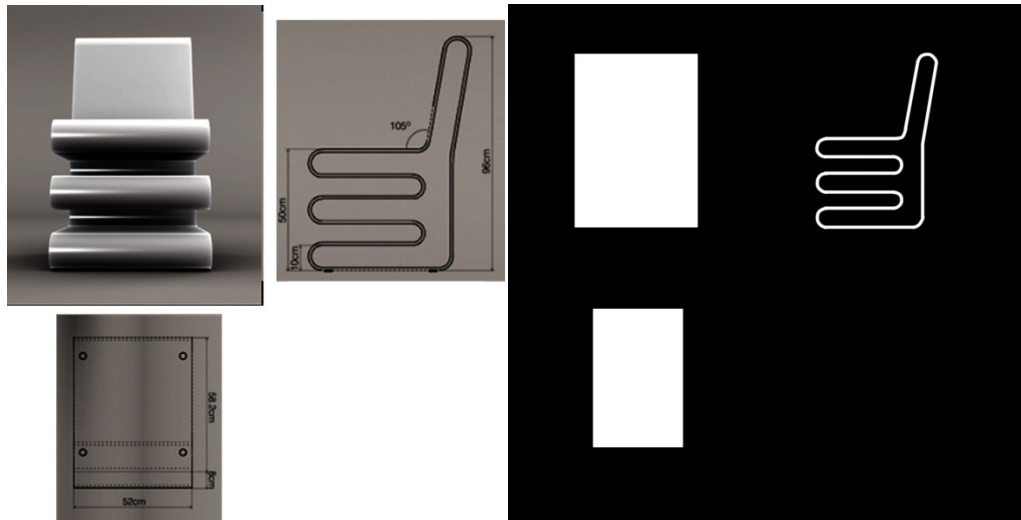


Image 18 To the left is the turnaround and to the right is the alpha.

In ZBrush I created a ShadowBox (Image 19 nr 1) and then in the “Texture Map” menu the alpha image was imported in to the ShadowBox (Image 19 nr 2). In the “Masking” menu I first pressed the “clear” button and then on “Mask by intensity” and then I went in to the “Texture Map” menu again and turned off the texture (Image 19 nr 3). In ZBrush workspace Ctrl+ click the left mouse button in order to invert the mask selection, when it inverted the mask selection a model was created (Image 19 nr 4).

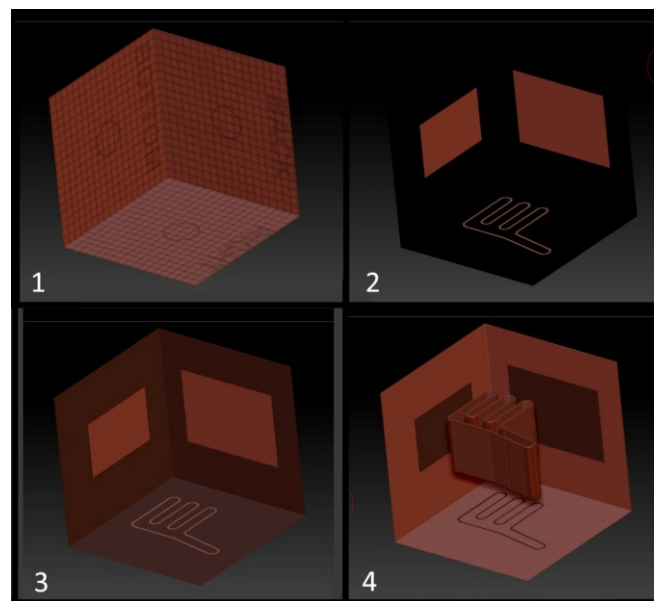


Image 19 The process of working with ShadowBox.

When the model was created ShadowBox was turned off. Since there were no sharp edges I used the clipRect tool (a clip Brush) to cut the soft edges (image 20 left image).

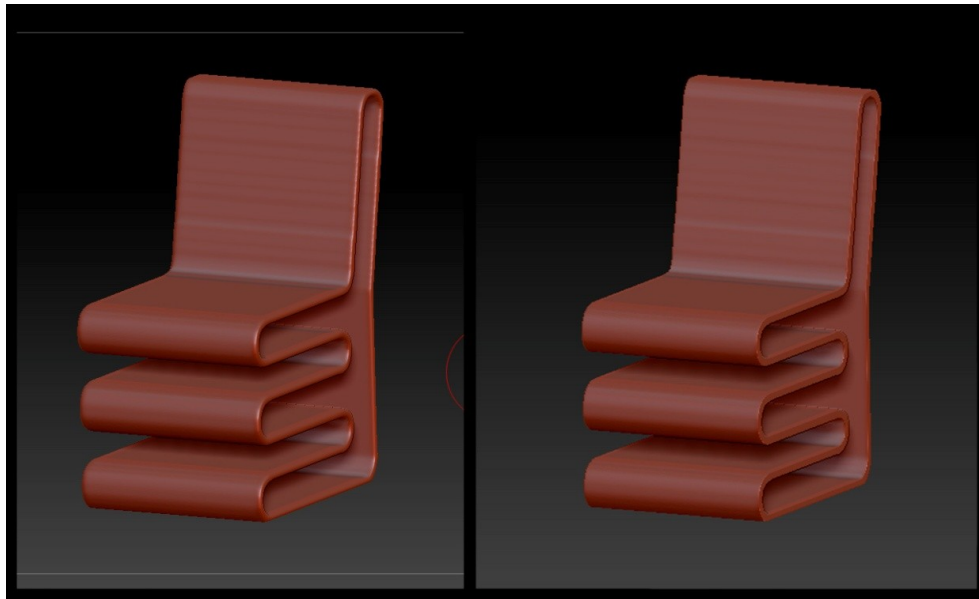


Image 20 Used clip brush to get sharper edges.

Creating a model in ShadowBox sometimes gives stripes on the model's surface. I used a smooth brush on the seatback to even it out.

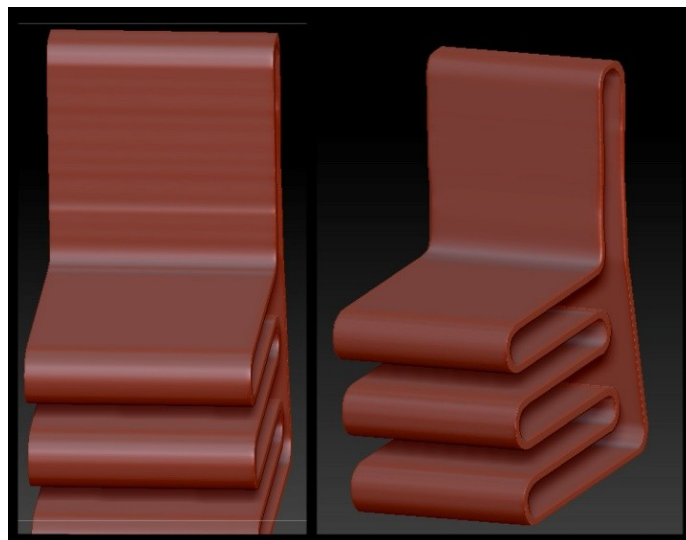


Image 21 Before- and after image using smooth brush on the seatback.

The number of geometry (poly-count) right now on the mesh is very extreme, 697.190 points (vertices).

By using DynaMesh the geometry was down to 37,405. It is still very high. For this project report I only needed to take the model in to Maya, put on a Blinn material and render it. But to be able to use this chair for a movie production reducing the geometry is almost a must, doing a retopology. A newer version of ZBrush a tool called QRemesher which will help you to reduce the geometry by using guidelines and then it changes the topology automatically. Using 3D Coat is also a good way to create a new topology. After smoothing the chair and reducing the geometry the border was not so sharp so I used the clipRect tool again to cut off the uneven border.

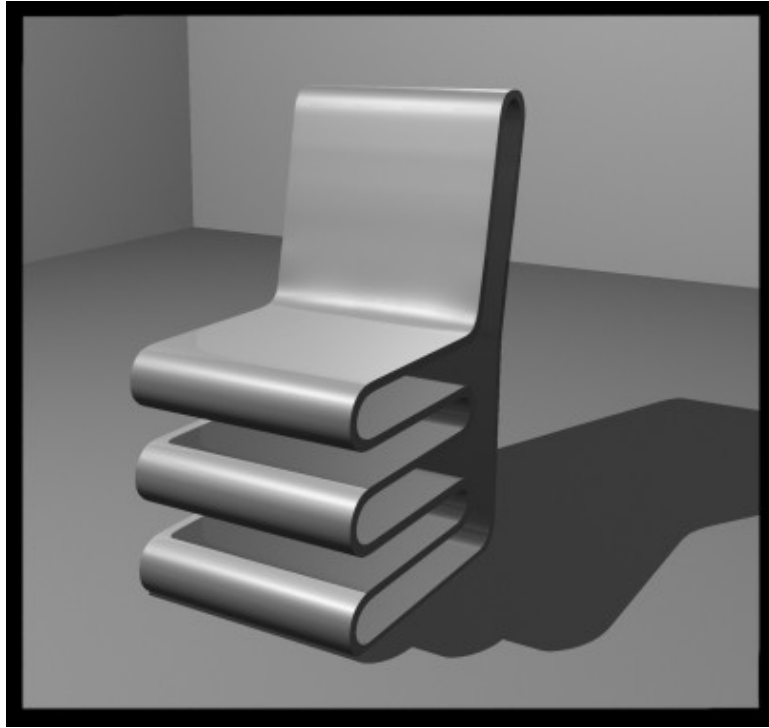


Image 22 Final render in Maya.

3 Analysis and Conclusion

3.1 Analysis

The analysis of the chair made with the three modeling techniques.

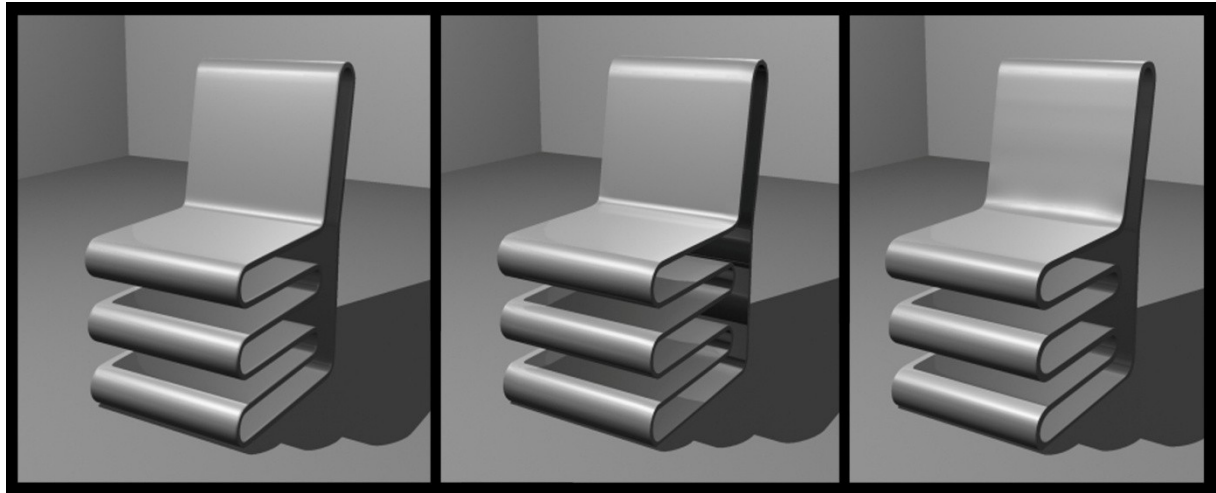


Image 23 The final rendering of the three chairs together. From the left: polygon, NURBS and digital sculpting.

In chapter 1.3 I discussed the concept “appropriateness” and the factors that I have taken into consideration when judging which of the three model techniques is most appropriate. The Analysis was structured into three parts: geometry, workflow and the rendering.

The geometry of the models

- How optimal is the model? How much geometry does the model have?
- The technical quality. Is the edge flow of the model correct (artifacts)? Does the geometry need any cleaning up? (Digital sculpting for example might need a re-topology).

| Modeling technique | Number of Vertices (geometry) | Cleaning up needed? | Artefacts |
|--------------------|---|---------------------|-----------------|
| Polygon | 660 | No | No |
| NURBS | About 600 - 800 (After convert to polygons) | No | Yes.(Seat back) |
| Digital sculpting | 37561 | Yes | No |

Table 1 Geometry statistics for the modeling techniques.

To count the NURBS model’s geometry I converted the model to polygons. Depending on the options you have when you convert the model to polygons, there will be different results depending on the number of geometry. The results of the NURBS geometry in the table above are roughly how much geometry it could contain.

Digital sculpting geometry is high because a retopology has not been made yet.

Workflow of the modeling technique

Since collecting more accurate data of the workflow is a challenge, an account is given of the advantages and disadvantages of using the different modeling techniques used for modeling the chair.

Polygon

- Advantage: It is very flexible to work with.
- Disadvantage: If you are not careful of where the geometry is placed, bumps and other details will be visible on the model's surface.

NURBS

- Advantage: You can easily create shapes with curves.
- Disadvantage: This chair is very hollow so you cannot hide the NURBS seams.

Digital sculpting

- Advantage: You can easily use ShadowBox and clip brushes to make the basic shape.
- Disadvantage: The loss of exact control that you have with ordinary 3D modeling was not for the better in this project. More pre-work (alpha image) was necessary before starting to work on the model and to achieve a completely flat surface is hard.

The rendering

- Does the lightning look well on the model? Are there any artifacts?
- What is the time to render?

| Modeling technique | Render time | Artifacts |
|--------------------|-------------|-----------------|
| Polygon | 3 seconds | No |
| NURBS | 3 seconds | Yes (Seat back) |
| Digital sculpting | 12 seconds | No |

Table 2 Rendering statistics for the modeling techniques. The models are rendered with smooth preview on.

The reason for the digital sculpting render time is so high is that a retopology has not been made yet. A model with less geometry does not take so long time to render.

3.2 Conclusion

The aim of this thesis was to examine which of the three modeling technique that is most appropriate to use for modeling a chair for a 3D animated movie production. To do this, three models of the same chair design were modeled. The techniques used were: polygon modeling, NURBS modeling and digital sculpting.

Working with polygon modeling is the technique that I am most confident with using of the three selected modeling techniques. Since polygon modeling is very flexible it was no problem to make the chair with polygons as a modeling technique for the chair.

When I began this project report I had only tested NURBS modeling a little bit. After I learned how to do it and much experimentation, I managed to finish making the chair with NURBS. When I experimented with modeling with NURBS I modeled another chair and I discovered that T-junction was really hard to work with and I could not figure out a solution to it.

When I began writing about different modeling techniques, I was very sceptical if digital sculpting could give the desired results. The chair that was modeled in reality is industry made which means the shapes are even. Digital sculpting is preferred to use when you want to make organic models that have irregular shapes. So that is why I was very sceptical of using it. I discovered there was a tool called ShadowBox in which I could use reference images to create a base mesh to begin to work from and continue to work with it. The problem with digital sculpting is the high amount of geometry that is used; some kind of retopology was needed to be able to use it in a movie production.

Once I learned how to model with NURBS, it is the modeling technology that is faster, than the other, to work with because there are relatively few sub-operations of modeling the chair, second place is polygon modeling. The modeling technique that takes the longest time to work with is the digital sculpting. There are many sub-operations and if you are using ShadowBox you need to reduce the geometry and it takes time to do that. When reducing the model's topology its edge flow could end up in disarray.

With the limitation I had in this project report it was noticeable that usually you work with different modeling techniques while you model. I had problems working with only NURBS; a good modeling combination could be to use a NURBS Curve to extrude polygon geometry. Even if it caused some problem it was still a good limitation for this project report in a way that I learned the limitations of the different modeling techniques.

To investigate the modeling technique that is most appropriate to use, the model's geometry and how smooth it is to work with the modeling technique are important, if there are many different tasks that need to be done. The use of ShadowBox for digital sculpting demanded some extra work because I needed to make an alpha besides the turnaround I had.

If we take a look at the geometry of the different modeling techniques, digital sculpting is the least appropriate modeling techniques for this chair because it has a very high poly count. This means you will have to make a retopology (which also takes time and more work) and the geometry itself can be troublesome. With polygon and NURBS you have an exact control of both your poly-count and the geometry (edge flow).

The time it takes to render a picture is about the same for polygon and NURBS. Since the geometry is still very high for the digitally sculpted model it is natural it will take longer time to render. How the light falls and reflects the surface depends on how the geometry was placed on the model rather than any of the modeling techniques you used.

Even though the results when comparing polygon and NURBS are similar I would consider polygon modeling the most appropriate for modeling this chair. I choose the polygon modeling technique before NURBS because the chair is so hollow you cannot hide the NURBS seams which will have an undesired result visually.

If I were to continue the research I would like to test subdivision surface modeling, one of the modeling techniques I was interested in doing in the beginning of the project. Andy writes in his book that Subdivision surfaces (or subDs) are a form of geometry that combines the flexibility of working with polygons with the rounded, smoothed shapes of NURBS. Subdivision surfaces are whole surfaces, and not patches as complex NURBS objects are. (Beane 2012: chapter 5). There are two different versions of subDs: the old one (as it is called) and the animation studio Pixar have developed their own subdivision called OpenSubdiv. It would also be interesting not to only compare the result between the two subDs, but also add these two modeling techniques to the project report.

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