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Verneri Kuusela

# 3D Modeling Pipeline for Games

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Verneri Kuusela

# 3D Modeling Pipeline for Games

The purpose of this thesis was to act as a guideline for anyone interested in 3D modeling and texturing for video games. It describes the different parts of modeling and texturing a 3D model from start to finish. It also examines the different methods of modeling and texturing. For the texturing aspect, this thesis focuses mostly on the hand-painted texturing style.

In the thesis, five environmental 3D models were produced for a mobile game intended for children, using different 3D modeling methods to find out which are the most suitable and effective practices for creating 3D models with hand-painted textures.

The 3D models were created with the 3D modeling software Blender by using poly-by-poly and box modeling methods. The sculpting method was used for concepting the 3D models and the textures were hand-painted with Blender.

As a result, the thesis shows that the 3D modeling pipeline is very strict with the order of work steps, but each of these work steps provides different possible workflows, which can be used according to the users’ preferences and skills.

Keywords:

3D, modeling, games, texturing, hand-painted

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Verneri Kuusela

# 3D-mallinnusputki peleihin

Tämän opinnäytetyön tarkoitus oli laatia ohje videopelien 3D-mallinnuksesta ja tekturoinnista. Opinnäytetyössä kuvaillaan kaikkia mallinnuksen ja teksturoinnin vaiheita, sekä tutkitaan niiden sisältämiä erilaisia työskentelymenetelmiä. Teksturoinnin osalta opinnäytetössä keskityttiin pääasiassa käsinmaalattuun teksturointityyliin.

Opinnäytetyössä tuotettiin lapsille tarkoitettuun mobiilipeliin viisi peliympäristön 3D-mallia, joissa eri 3D-mallinnusmenetelmiä käyttäen selvitettiin, mitkä ovat sopivimmat ja tehokkaimmat työskentelymenetelmät 3D-mallien luomiseen käsinmaalatuilla tekstuureilla.

3D-mallit luotiin Blender 3D-mallinnusohjelmistolla käyttämällä poly-by-poly- ja box-mallinnusmenetelmiä. 3D-mallien suunnittelussa käytettiin myös kuvanveistomenetelmää ja tekstuurit maalattiin käsin Blenderillä.

Opinnäytetyön tuloksena saatiin, että 3D-mallinnusputki on erittäin tarkka työvaiheiden järjestyksen suhteen. Jokainen näistä työvaiheista kuitenkin tarjoaa erilaisia mahdollisia työtapoja, joita voidaan käyttää mieltymysten ja taitojen mukaan.

Asiasanat:

3D, mallinnus, pelit, teksturointi, käsinmaalattu

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# List of abbreviations

| | |
|---|---|
| 2D | Two-dimensional |
| 3D | Three-dimensional |
| Asset | Media content in a game. |
| High-poly | A 3D model with a high polygon count |
| Low-poly | A 3D model with a low polygon count |
| Polygons | Straight-sided shapes defined by vertices and edges, with three or more sides |
| PBR | Physically based rendering |
| Retopology | Rebuilding a low-poly mesh on top of an existing high-poly mesh. |
| Topology | The wireframe of a 3D model |
| UV | Axes of the 2D textures, “U” and “V” |

# 1 Introduction

When 3D models are mentioned, usually people think about video games. 3D models are used nowadays in many different industries from movies and video games to engineering and architecture. Therefore, 3D artists are needed more and more everyday. Every 3D artist needs a 3D modeling pipeline to follow. The 3D modeling pipeline is a long process that consists of multiple steps (concepting, modeling, retopologizing, and texturing) which all have multiple work methods that can make 3D modeling overwhelming to some but it also gives more possibilities to artists with different interests.

This thesis aims to create a guideline for anyone interested in 3D modeling and texturing for videogames. The guideline's objective is to teach about the whole 3D modeling process and of it's different work methods, while also setting a 3D modeling workflow. The guideline should give an understanding of the whole 3D modeling process to people not familiar with 3D modeling, while improving the 3D modeling skills of those already familiar with the topic.

The thesis will be built of two parts: theoretical and practical work. In the theoretical part (Chapters 2 and 3), the whole 3D modeling and texturing process and their different work methods will be explored. Utilizing the information gathered from industry professionals, a 3D modeling pipeline will be set for the practical work. The practical work part (Chapter 4) will consist of the whole modeling and texturing process of multiple 3D models, by testing and using different 3D modeling methods, while also documenting the whole process.

The 3D models will be created for a game development company MiTale and their childrens mobile game Sanalanka Friends by following a strict 3D modeling pipeline used by industry professionals. The game has a simple cartoony art style and, therefore, the models will be hand-painted to achieve a fitting look. The hand-painted texturing style is known in fantasy-style games like World of Warcraft.

The research on the 3D modeling pipeline for games comes from professional sources such as the Fronzenbyte wiki which is a wiki page made by a Finnish game company Frozenbyte and Blender docs, which is the 3D modeling software Blenders manual. Frozenbyte wiki gives a professional view of 3D modeling pipeline, which can be useful for people already familiar with 3D modeling and Blender docs gives a more simplified view of 3D modeling that beginners can also use.

# 2 3D Modeling

3D modeling is a process that uses a computer software to create a representation of any surface or object in a simulated 3D space using vertices, edges, and faces. (Slick, 2020)

3D models are used in a wide variety of mediums like engineering, architecture, movies and video games (Petty, 2022, What is 3D modeling & What's it used for?). Most notable area of these are video games and movies because of the importance of the 3D models in them. For example, a movie like Avatar without 3D models would be a whole different movie. All the vegetation in the movie would be less impressive, there would not be any exotic creatures and so the audience would not buy the idea of the movie happening on another planet.

## 2.1 Concepting

3D modeling process begins with the concepting process. There are two starting points for concepting, either with existing concepts or without them. The 3D artist should always make their own concept regardless of whether there are already existing concepts. The concept works as a guideline to creating the final 3D asset. (Frozenbyte, 2021)

Research is the starting point to all concepting. First the 3D artist either discusses with the development team about what is wanted from the artist or the artist looks at the given concepts made by the concept artist, depending if there is or is not previously done concepts. With the core idea of the concept, it is time to look where the 3D model is going to be used as it should fit well to the level or environment by its colors and shapes. Another important factor is the story of the 3D model for example is the object old, rusty or crooked because it will affect the outcome of the concept and the final 3D model. For the actual concepting there should be some reference images. These images are used as ideas for the concept, but should not be just copied as they are. (Frozenbyte, 2021)

After the research is completed, the actual concepting work can begin by creating an image or a rough 3D model of the asset. The focus of the concept should be on the big forms, silhouette and proportions. The concept should have details on all levels and it should not be repetitive. The details give depth to the concept and also express the assets idea. (Frozenbyte, 2021)

Figure 1 gives a great idea of what the finished concept should look like and also it shows that there can be multiple concepts for a single asset.


Figure 1. Multiple concept arts for a vase. (Frozenbyte, 2021)

When the concept or concepts for the 3D model are completed, the concepts should be evaluated by the art director and with the art directors approval the modeling process can begin. (Frozenbyte, 2021)

## 2.2 Modeling

Modeling is the part of the 3D modeling pipeline, where the actual model starts to get its shape. A model is formed from vertices, edges and faces. Vertices are points that are connected together with edges to form flat faces. Faces are also called polygons (polys) that are separated to triangle polygons (tris) and quadrilateral polygons (quads). The modeling is done by using a 3D modeling software like Blender. (Slick, 2020) The modeling process is separated to

polygonal modeling and sculpting. Polygonal modeling is used in creating the base of the model or in creating very lightweight 3D models. Sculpting is used in creating more detailed 3D models and creating high-poly meshes that are used as low-poly meshes base and texturing.

### 2.2.1 Polygonal modeling

Usually polygonal modeling is the beginning of all 3D modeling. It is also the most common type of modeling for video games due to being easiest to render and visualize by modern computers. With polygonal modeling the user builds 3D objects out of triangles or quadrilateral polygons also know as tris and quads. These components are completely flat and they consist of points also known as vertices and edges that connect vertices. (Spatial, 2019)

Polygonal modeling is commonly used to create a base for a model that will later on be sculpted to something more complex because refining polygonal models can be very time consuming when creating more complex 3D objects. The reason for that is the amount of polys required to create a complex model for example a human. A human model profile has a lot of round shapes that are usually very small and therefore require smaller polys and more of them and editing all those details by hand takes a lot of time. Polygonal modeling can be used in creating more simple 3D models that require less polys for example crates and barrels, or even in creating a high-poly model.

### 2.2.2 Sculpting

Sculpting is used in creating a high-poly model that is very detailed and therefore performance heavy. The high-poly model will not be used as the final model due to it’s high poly count. Instead the high-poly model is used in creating a low-poly model based on the high-poly model. This process is also known as retopology. The high-poly model is also used in texture baking, where the details of the high-poly model are transferred to 2D image texture maps. The 2D image texture maps

are later on used on the low-poly model. This way we can achieve a high detailed model that requires less performance from the hardware. (Frozenbyte, 2021)

The sculpting process starts from a base model created with polygonal modeling. In Figure 2 there is a base model of a tree on the left that was used as a starting point for sculpting a high-poly tree on the right side of Figure 2. In Blender the sculpting is done using different kinds of brushes that mostly either add geometry to the model or remove it. (Blender, 2022, Sculpting) The first main focus on sculpting is to create a general shape of the model. The resolution of the model should be kept as low as possible until the shape is accomplished. With the general shape done it is time to add subdivisions and begin adding details. While adding details it is important to keep an eye on what the model looks like from a distance, too small details look bad from a distance and can be unreadable. (Frozenbyte, 2021)

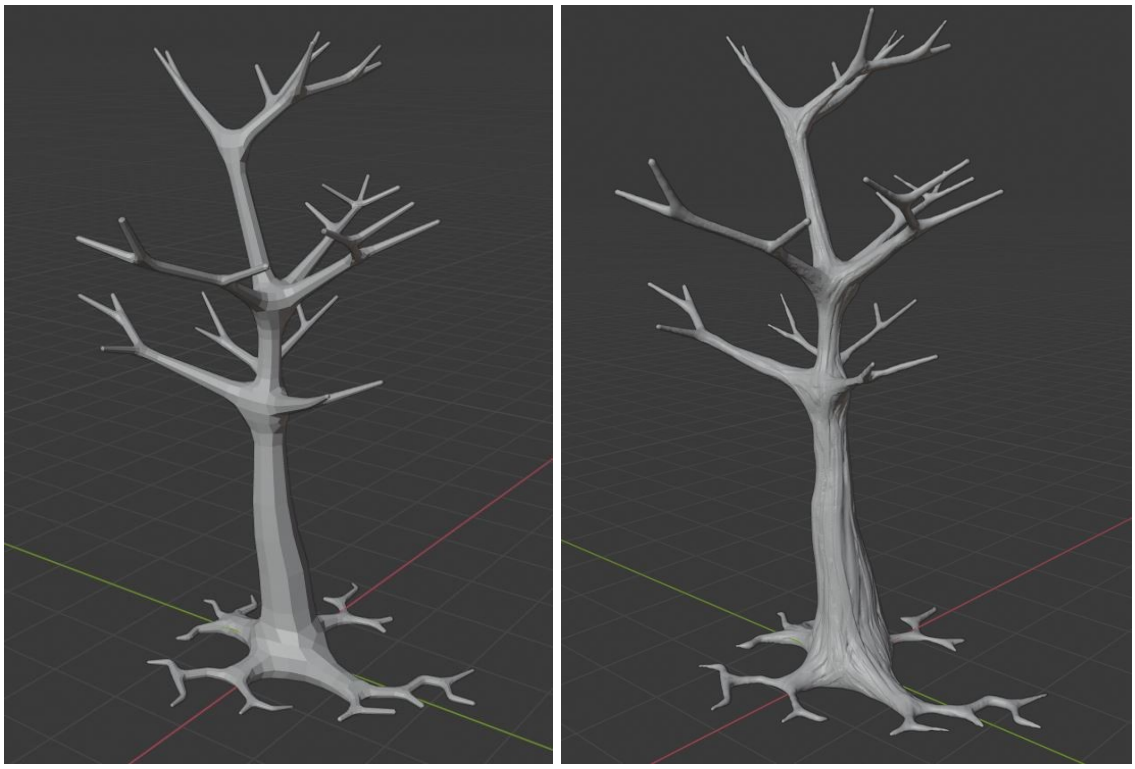

Figure 2. Base model of a tree and a high-poly sculpt made from the base model.

## 2.3 Retopology

After the sculpted high-poly model is finished, it is time to build a low-poly model on top of it. This process is called retopology. It is an essential part of the 3D modeling process as the high-poly models are usually not suitable for animating and they have too high poly count, which would require a ton of processing power from the game engine. The low-poly model is like a shell of the high-poly model that has its general shape and much lower poly count. The low-poly model is the final model that is used in the game; therefore, it should be well optimized and animatable.

The retopology process itself is done with either a 3D modeling software like Blender or with a 3D sculpting software like ZBrush. All of the modeling and sculpting softwares have their own workflow for retopology, but most of them have some kind of a dedicated retopology tool. Most of these retopology tools automaticly create a new topology based on the high-poly model. The outcome usually requires small handmade modifications depending on the model and the used software. For example, in Blender there are addons like RetopoFlow package that allows the user to quickly remesh a high-poly mesh that has the original models shape, but without the excess details. The outcome requires a bit of handmade fixes like moving single vertex that might cause small dents. (Petty, What is Retopology?)

Figure 3 shows a great example of the usefullness of retopology as the original dragon statues high-poly model had 871 000 polys as tris that was first remeshed to use quads intead of tris for a quad workflow and then remeshed to the final low-poly model that has only 5049 polys as quads.

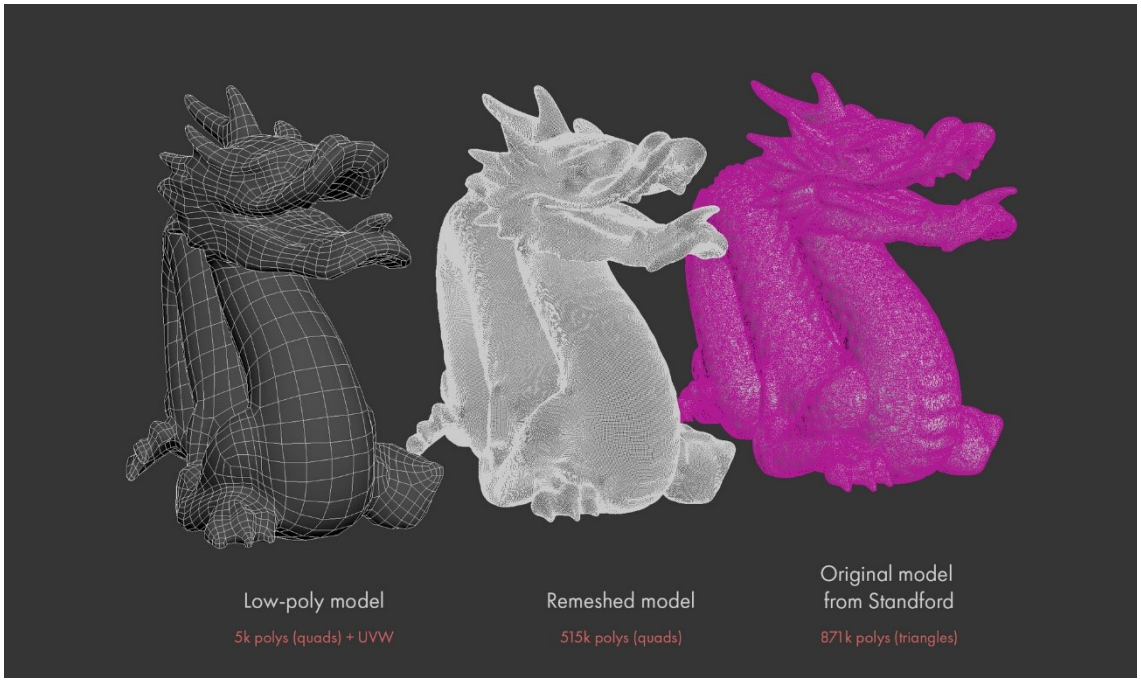


Figure 3. Retopology example. (Avduevsky, 2020)

# 3 Texturing

The last phase of 3D modeling pipeline is texturing. Texturing is the process of applying color, texture and material attributes to a 3D models surface. Textures are 2D images that are spread to multiple different functions like albedo, normal and ambient occlusion. Those 2D image files are also known as texture maps. The reason for using textures is that models with a ton of polygons require a lot of processing power, whereas textures require a lot less processing power and if done correctly one can not see the difference between a high-poly model and low-poly model with well done textures.

There are different methods for texturing that are used depending on the artstyle of the videogame and the artists preference. There is PBR texturing, which is used in creating more realistic textures commonly used in new games, and diffuse texturing, which is used in older and fantasy styled games.

PBR texturing uses multiple texture maps that have been baked from a high-poly model, like a normal map, or painted, like an albedo map. A normal map forms small details like dents to an objects surface without changing the objects geometry, while an albedo map defines the objects color. Diffuse texturing utilizes only one diffuse map that has been either painted by hand directly with lightning and shading information or using a photo reference. (Denham, 2022, Texture Maps: The Ultimate Guide For 3D Artists)

These methods will be discussed separately in sections 3.2 and 3.3.

## 3.1 UV mapping and Map baking

Before the actual texturing process of a 3D model can begin, there needs to be an UV map of the 3D model. An UV map is a 2D representation of a 3D models surface. Think it as a perfectly fitting wrapping paper for a 3D model. UV map works as a 2D information of a 3D object so that a 2D texture can be wrapped around the 3D object. (Denham, 2022, What is UV Mapping & Unwrapping?)

The process of creating an UV map is called UV mapping. UV mapping is done by marking edges of a 3D model as seams. Seams should be placed in edges that are less visible or where they would appear naturally like at the edge of a swords blade. Therefore UV mapping hardsurfaced models is easier than organic models like humans. For UV mapping a human model, it is important to place seams where they are not visible, for example on the sides. Usually on organic models all of the seams can not be hidden. This is where texture painting comes handy as most 3D modeling and texturing softwares have a texture paint tool that can be used to paint on top of the seams to hide them. For example in Substance Painter, there is Tri-planar projection tool that fills the model with desired patterns or noise without visible seams. When all of the seams are marked, it is time to lay out the UVs. The UVs should be laid so that there are no overlappings because that will cause textures to overlap aswell. There should also be atleast 5 pixels separating UVs or there might be texture bleeding. The amount of details define the sizes of the UVs, more details require more space. (Pluralsight, 2014, Adobe, 2021)

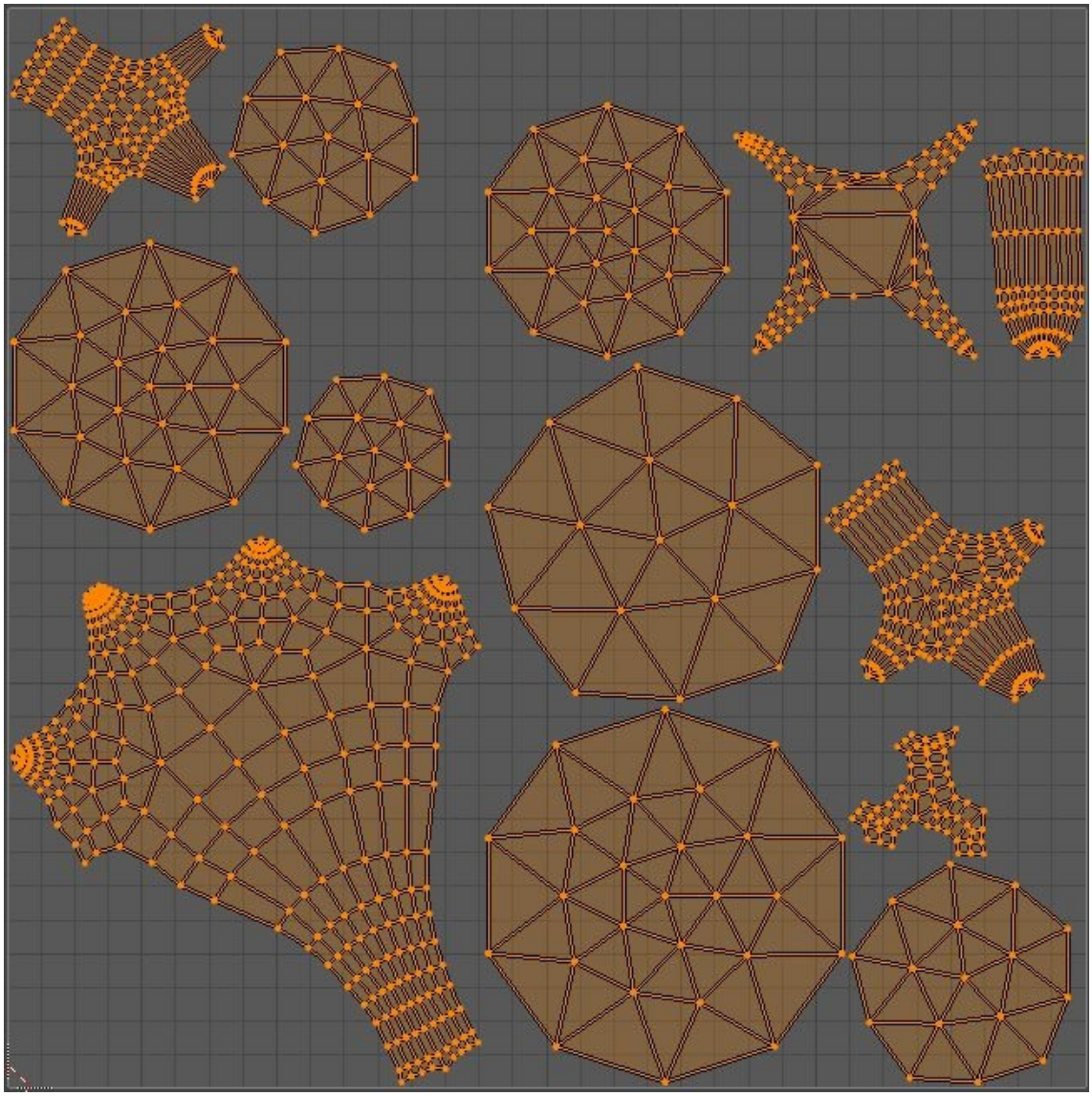

Figure 4. UV map of a small tree.

With the finished UV map it is time to move to map baking. Map baking is the process of converting 3D models details into 2D texture maps. These maps include for example normal and ambient occlusion maps. Idea is to transfer a high-poly models details to a low-poly model. Map baking is used in most 3D models, even in a hand-painted model the diffuse map is done by painting ontop of an ambient occlusion map. The actual baking is done with a baking tool from a 3D modeling or texturing software. These tools cast rays from the low-poly model towards the high-poly model and record the details of the high-poly model to a texture map with the low-poly models UVs. (Polycount wiki, 2021)

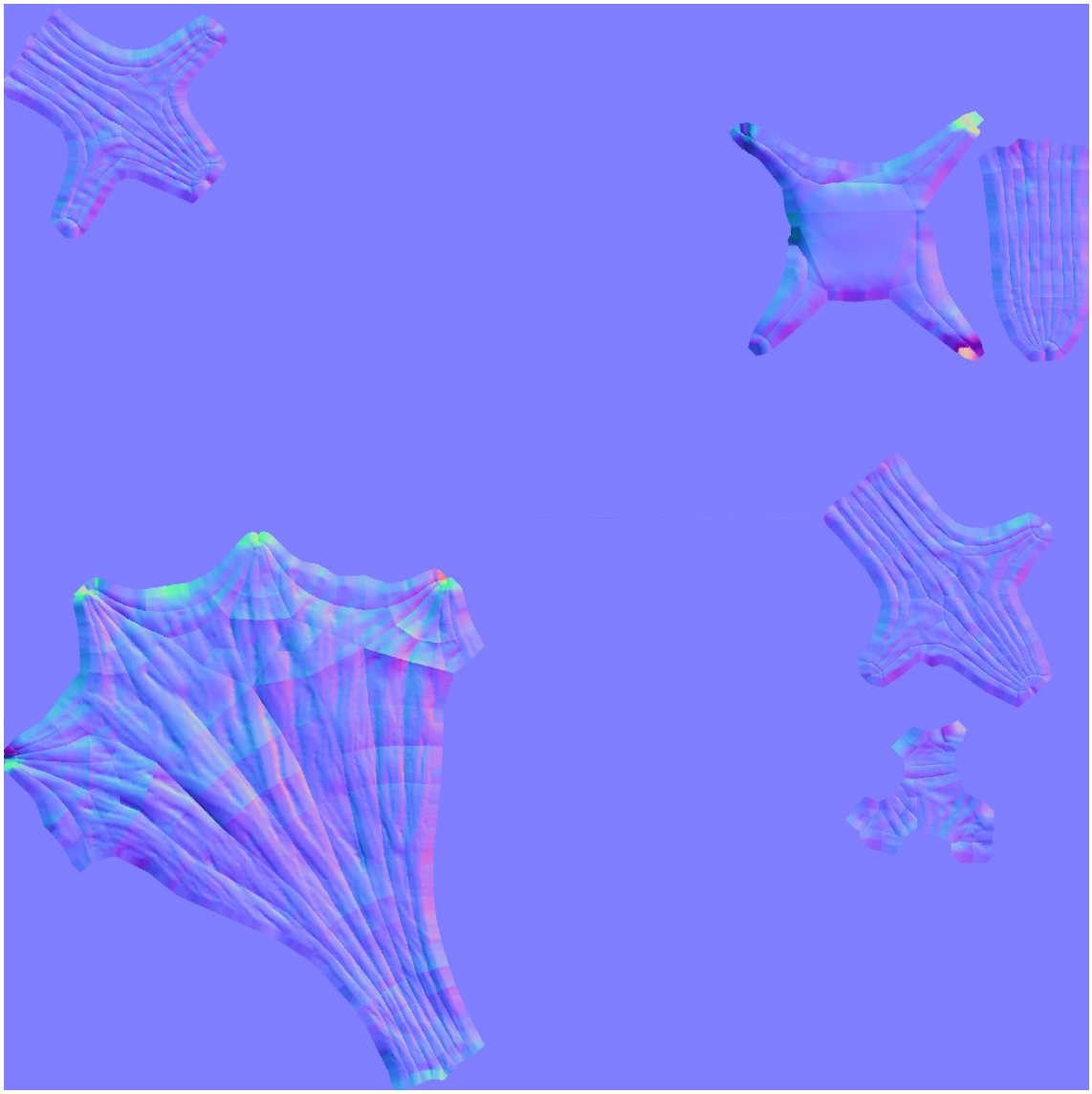

Figure 5. Baked normal map from a high-poly tree for a low-poly tree.

## 3.2 PBR textures

Creating more realistic textures for 3D models require PBR textures. PBR is short for physically based rendering. The idea of PBR is to utilize multiple different texture maps to control the properties of a material and how it reacts to light. (Mesquita, 2021) The realism that PBR textures provide come from the methodology and algorithms that are passed on physically accurate formulas. For that reason PBR textured models can be made by multiple artists and they will

still look consistent. The difference of artist can be seen on the level of details that are used on the material. (McDermott, 2018)

The most common softwares for PBR texturing are Substance 3D Painter and Substance 3D Designer. PBR texturing is split into two main workflows, metal / roughness workflow and specular / glossiness workflow. Metal / roughness workflow utilizes base color, metallic and roughness maps, while specular / glossiness workflow utilizes diffuce, specular and glossiness maps. The PBR shader will also use maps like ambient occlusion, normal and height maps. A shader is a program that utilizes a computers graphics processing unit, also known as GPU, to render graphics data. Both of these workflows have their own pros and cons. Most notably metal / roughness is easier to use and requires less memory, but has more apparent white edge artifact, while specular / glossiness has less noticeable dark edge artifact, it requires more practice to work with and also more memory. (McDermott, 2018, Hergaarden, 2011)

The difference of PBR and hand-painted textured models can be seen on Figures 6 and 7. The most major difference is how the PBR model reflects the light, while the hand-painted model has no glossiness.

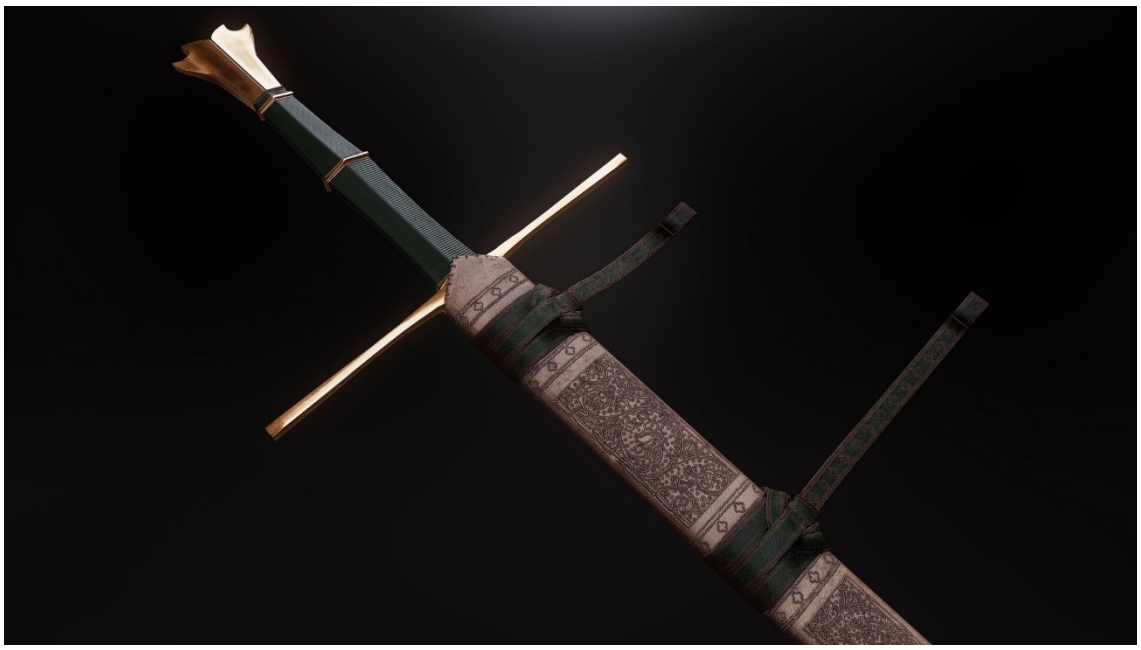

Figure 6. PBR textured longsword (Malarski, 2020)

Figure 7. Hand-painted orc sword (Konovalov, 2019)

### 3.3 Hand-painted diffuse textures

Hand-painted diffuse texturing is used on creating cartoony or fantasy styled textures. Hand-painted diffuse textures are done with a 2D painting software like Photoshop, with a 3D modeling software directly like Blender or by a texturing software like Substance Painter. Working with a 2D painting software, the artist will paint directly on a 2D texture image. While 2D painting softwares have a lot of different kinds of tools for painting, the painting is difficult due to the fact that it is hard to know where exactly the artist is painting on the model, especially small details. Painting directly in a 3D modeling software allows the user to see in real-time, how the model looks with the textures, but they lack the tools of a 2D painting software. But that is not a problem, because one can modify the hand-painted texture image in a 2D painting software and download it back in the 3D modeling software. Working with a texturing software has the same benefit of seeing the model get texture in realtime. They have more tools than a 3D

modeling software also, but one can not modify the image with a 2D painting software and download it back in the texturing software.

Handpainting diffuse textures is all about the balance of details and using different color shades. Models should have texture details in specific areas of the model, because if the model has too much details it will get overwhelming for eyes, especially in character models. Models should have less detailed areas where the eyes can rest and they will give more visual impact to the more detailed areas of the models. Texture details scale should be relative to the models size since too small details will become noise. The colors of a hand-painted model are important. A model should not have more than three main colors on it. Instead the artist should work with different shades of the three main colors to give the model more depth and detail. Using too many different colors on a single model can make it overwhelming and unnatural. (Valve, 2022)

Figure 8 shows good examples of using a color scheme with three colors and how much a simple value gradient can bring depth to a model. The gradient starts as dark from the feet of the models and lightens towards the top of the models. These models also have great examples of different detail areas to give the viewer visual interest without overwhelming details.

Figure 8. Examples of different color schemes on models. (Valve, 2022)

# 4 In Practice

The practical part of the thesis consists of modeling 3D models for a mobile game intended for children that has a simple and cartoony artstyle. Specifically the task was to model winter themed environmental 3D models and texture them. Since the purpose of this thesis was to work as a guide for anyone interested in 3D modeling and texturing, the whole process of modeling and texturing will be explained from concepting to texturing the model. A campfire site and an ice tile models modeling process will be explained, since different workmethods were used for the multiple parts of the campfire site and the ice tile. For texturing hand-painted texture style was chosen to improve hand-painting skills and to test, how much of a difference small color changes can do to a model.

## 4.1 Modeling the campfire site

The concepting of the campfire site started with researching the already existing assets for the game. The research gave an understanding of how much details different kinds of models have and how those details are made. For small environmental assets, details were made mostly with textures. The models in the game were textured with diffuse maps and therefore there was no need to bake normal maps for details. With that knowledge it was time to start searching for reference images of campfires and start working on a concept. For concepting Blender was used to create a rough concept of the models setup. The concept was started by creating a firepit made out of concrete blocks. The concrete blocks were curved and round edged to make them less harsh and to form a round circle. Then logs were placed to the firepit in a predetermined order from the reference images. Then a simple cooking rack was added, which was made out of wood with a hook that had a coffee pot hanging from it.

Figure 9. Concept of the campfire site.

The concept is very straight forward as the main focus was on pointing out, how the whole setup would look like, rather than spending time on figuring out the details of the objects. With the concept done, it was time to move to the actual modeling. The whole campfire sites modeling process was separated into four separate models: firepit, campfire, cooking rack and coffee pot.

### 4.1.1 Modeling a firepit

The modeling process started with the campfires firepit. For the modeling process Blender was used as the modeling software. Blenders original cube mesh was used as a starting point. Then by using polygonal modeling, the cube was modeled to look like a curved rectangle and modified more round. After that the model had already a bit too much tris, as it would be dublicated to have eight of them in total to create the whole firepit. The starting point was changed to a Torus

mesh, which is a round hoop like base model. Then the models bottom half was removed as the model had to be round only on one side and flat on the other. Now the model was a circle with three main faces. The circle was then separated into eight same sized sections that would represent the separate stones of the firepit. The separation was made by lowering the edges of all of the stones.

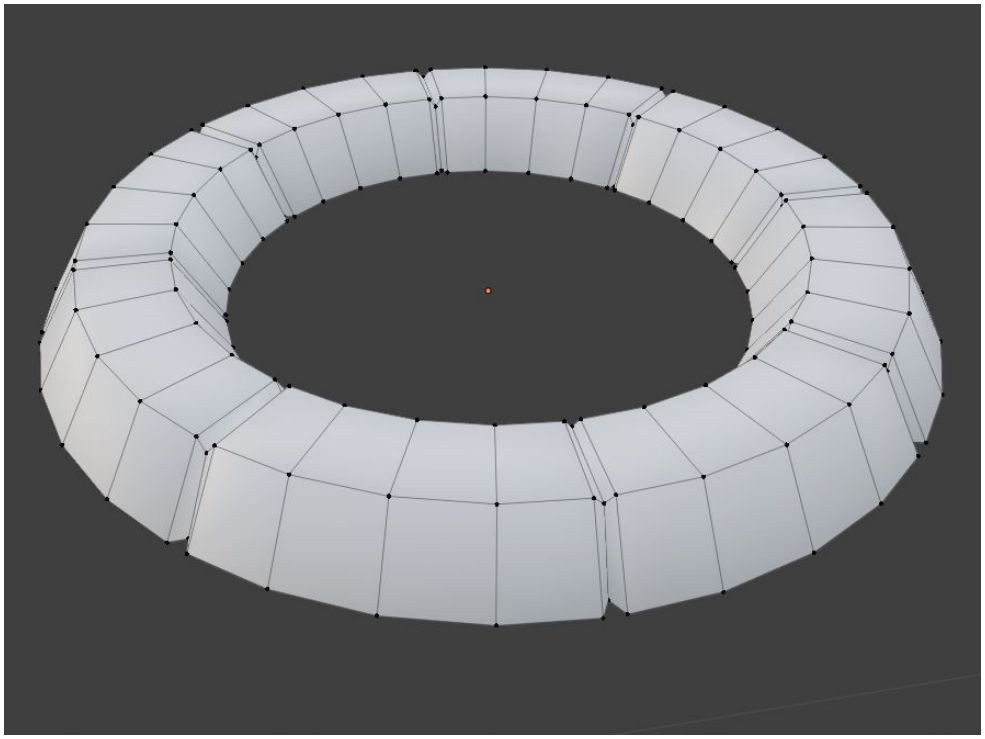

Figure 10. Model of the firepit before smooth shading.

At this point the model was still looking very flat, but that was quickly fixed with smooth shading. Smooth shading changes the shading of an object to look like smooth without adding or changing the geometry of a model. (Blender, 2022, Shading)

With the mesh of the model done, it was time to move into UV mapping. As the model was very straight forward, only one seam was needed going around the bottom of the model and unwrap it. As the model was just a low-poly base mesh there was no need for baking and therefore, the next step was texturing. Texturing was done by hand-painting in Blender. For this model specifically the focus was on, how much of a difference small color shade changes can do to a models

texture. First a gray main color was given to the model and, then the color between the stones were darkened to work a bit as a shadow between the stones. Then the inner ring of the firepit was darkened to act as the stones had some soot on it. With the soot added, it was time to give the stones more shades of gray to give it more depth and texture.

Figure 11 shows on the left side, how the model looked before adding shades of gray. On the right side of Figure 11 is the finished textured model that has way more details and depth to it, made by simple hand-painted color changes and shades. With the firepit done, it was time to move on to modeling logs for the campfire.

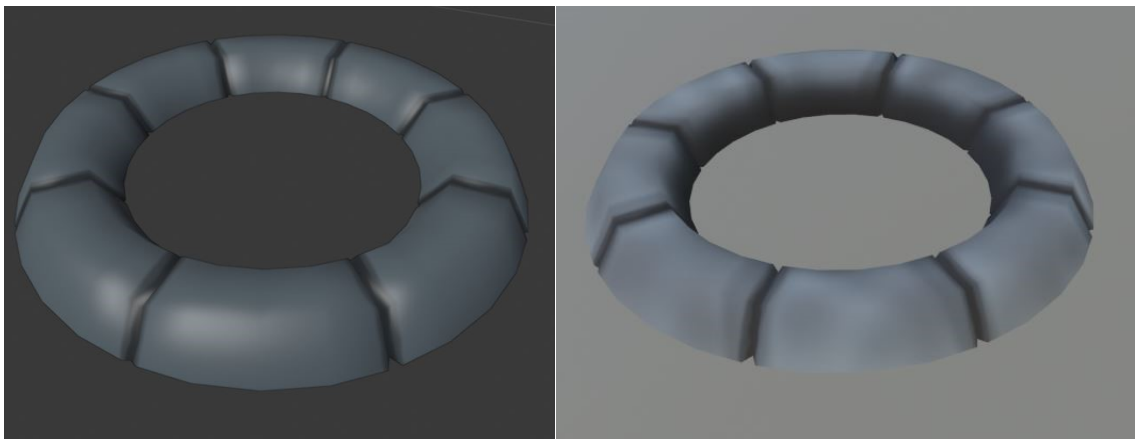

Figure 11. Texture of the firepit before and after adding details with different shades of gray.

### 4.1.2 Modeling a campfire

The 3D modeling process of the campfire was done by polygonal modeling and it was very straight forward. First a cylinder with eight faces was created to be a single log in the campfire. Then by dublicating the log and changing some of the logs width and length for variation, the form of the campfire was done. With the form of the campfire done, The logs were simply smooth shaded to make them look round.

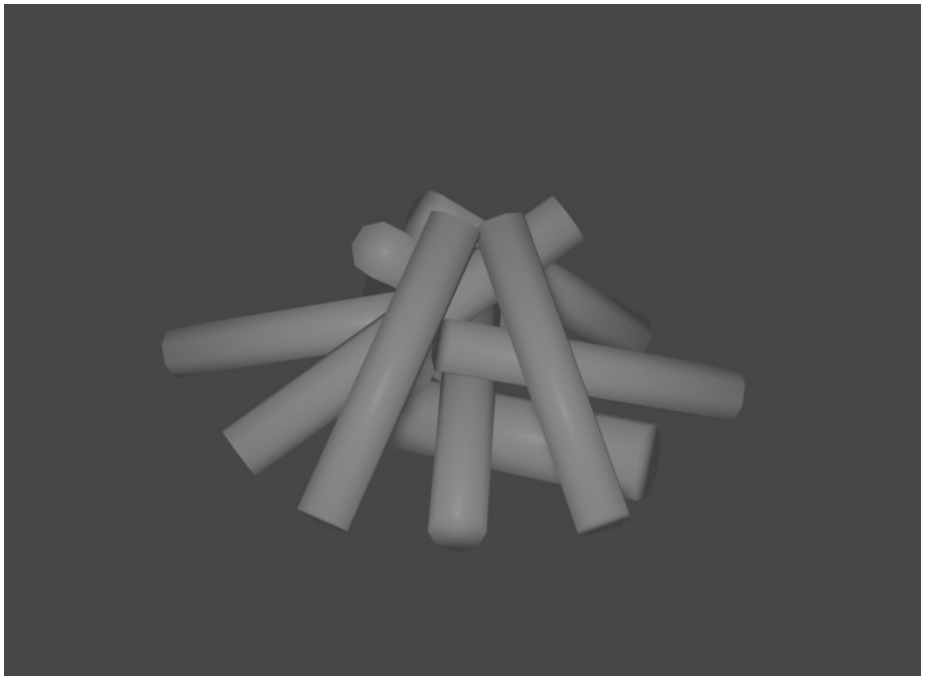

Figure 12. Finished model of the campfire.

UV mapping the campfire was done, by creating two UV maps from a single log. The logs UV map was done by creating seams to both ends of the log, separating the bark of the log and the ends of log. Then all the logs were separated to two different UV maps, half of them having the ends of the log on the left side of the UV map and half on the right side of the UV map.

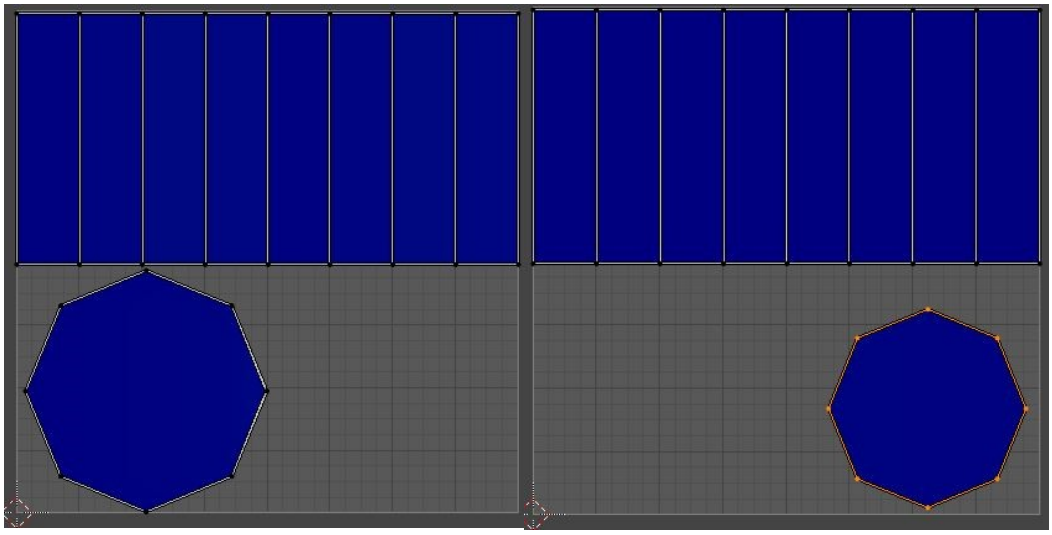

Figure 13. Both UV maps of the logs.

The reason for separating the logs to two different UV maps was texturing. This way a single texture image could be handpainted and used to create two different textures for the logs, saving a tiny bit of performance.

The campfires textures were done by handpainting the textures for the logs. First a brown color was selected for the barks main color. Then curved lines of different shades of brown were added to the bark, giving it nice details and overall color. With the bark texture done, it was time to move on to texturing the ends of the logs. Two different ends for the logs were made. One with a dark crack going through the end and one without it. First a light brown base color was added to the ends and some darker shades of brown to make the annual rings of the tree. Then some small cracks were added to give it a bit more detail. With the details done, the barks base color was added to the edges of the logs ends to represent the barks thickness.

Figure 14 and Figure 15 show, how important it is to see how the handpaiting looks on the model directly. If one would only look at the texture image (Figure 14), the barks texture does not really look good. However when it is seen on the object in real time while working on the texture, one can see how it really looks like (Figure 15). That is the reason, why texturing with a 2D texturing software can be difficult. The modeller can not see the end product while they are working on the models texture and they might remove details that simply look bad in 2D, while these details could look amazing in the actual 3D model.

Figure 14. Finished texture for the logs.

Figure 15. Campfire with textures.

### 4.1.3 Modeling a Cooking rack

With the campfire finished, it was time to start modeling the cooking rack. The wooden poles of the cooking rack were simply done by dublicating one of the campfires logs and making it thinner and taller. This way a lot of time was saved as there was no need to create a whole new model with a new UV map and texture. For attaching the poles to eachother, a rope model was created. The rope was modeled by creating two small torus meshes that formed a cross to act as a rope knot.

UV mapping the cooking rack was separated to two UV maps, as the poles of the rack used the already existing UV map and texture made for the logs. The second UV map was for the rope. The ropes UV mapping was done simply by cutting the torus in half with seams and adding seams to break the torus into a line.

The ropes texture was done by first adding light yellow base color to it. Then darker and lighter strokes of yellow were added to break the color a bit. After the ropes color was looking good, dark lines were added going around the rope. Those lines were supposed to represent the ropes separate threads and between the lines orange lines were added to represent the threads fibers.

The rope took so small portion of the texture map (Figure 16) the same texture map was used for the coffee pot aswell to reduce the amount of separate texture files.

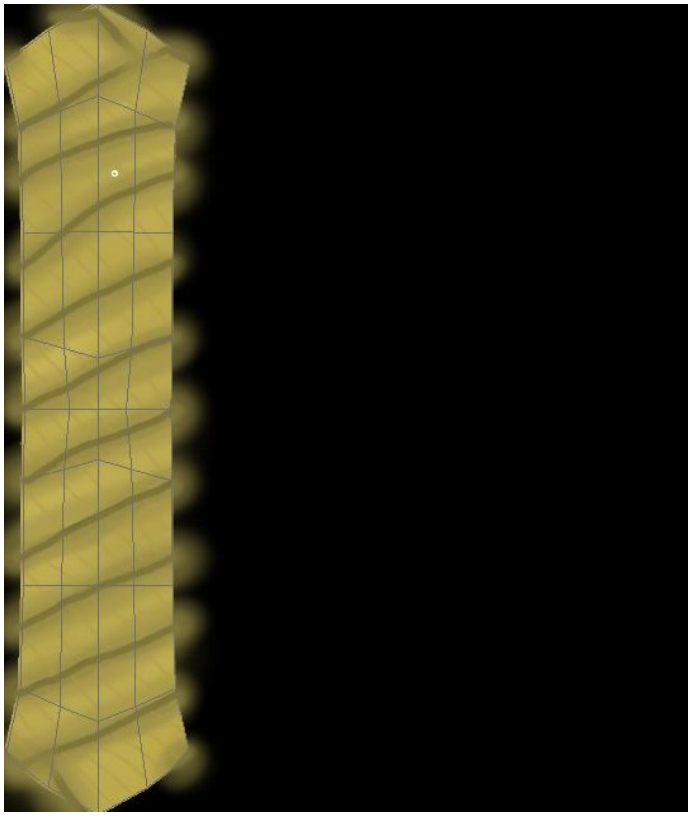

Figure 16. Texture map of the rope.

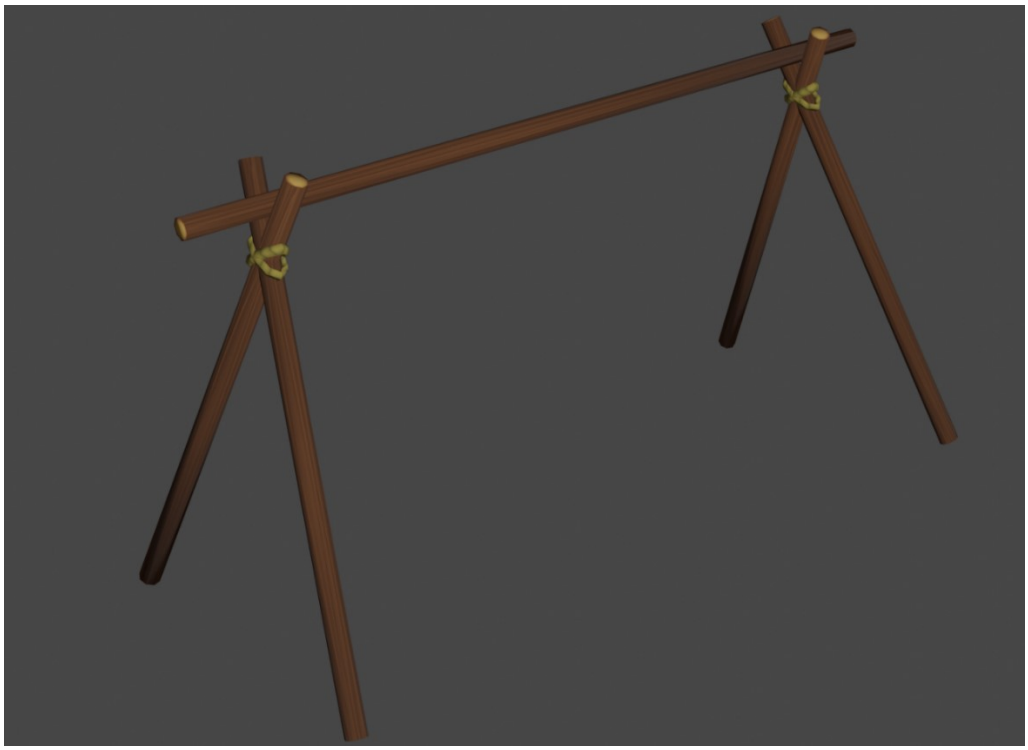

Figure 17. The finished model of the cooking rack.

### 4.1.4 Modeling a Coffee pot

The coffee pot was the last part of the campfire site. But before the actual coffee pot a metal hook was needed to be modeled to attaches the coffee pot to the cooking rack. The hook was modeled using Blenders extrude tool on a torus mesh to form a S shaped hook with one side having a smaller gap than the other side. Modeling the actual coffee pot started from a cube mesh. A bevel modifier was added to the cube to give it more quads to work with and to make it round. Then by moving single vertices, the final shape of the coffee pot was modeled. Next one side of the pot was extruded and again with moving single vertices a spout for the pot was formed. Then a lid for the coffee pot with a handel was formed from the top of the pot with poly-by-poly modeling. After that a cylinder mesh was added and refined into a metal wire connected to the coffee pot. The coffee pot was going to be hung from the hook with the wire.

The hooks UV map was made by splitting the hook in half with seams, just like in the ropes UV map. The coffee pots UV map was separated into four UV islands, spout, pot, lid and metal wire. This way the parts of the coffee pot with more details to paint would have more space in the texture map.

The textures of the coffee pot and the hook were painted on the same texture map as the rope, since the rope used a fraction of the whole texture map. Texturing both the hook and the coffee pot had the same principle, dark gray as a base color and black color on the bottom parts to represent soot. As the coffee pot was made from metal, some light color was added to it and also some blue to make it look more metallic. For the hook there was no need for these small details due to the size of the hook.

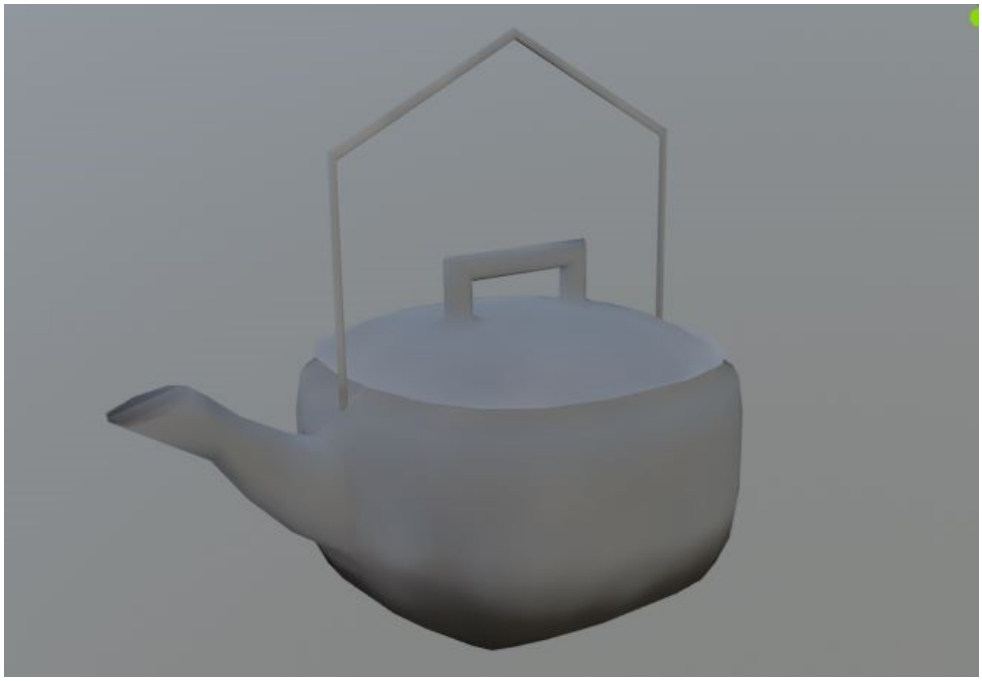

Figure 18. The finished model of the coffee pot.

Figure 19. Finished campfire site.

## 4.2 Modeling the ice tile

The ice tile models purpose was to be an environmental asset that floats in a body of water. Idea was to make it look like it has been separated from a larger piece of ice, but to still be that big it could have other assets on top of it. The model was made by using a cylinder as a starting mesh. Then with poly-by-poly modeling the tile was given its shape and then a smooth shading was added to it. The smooth shading removed the sharp edges of the tile. Smaller pieces of ice made from cylinders were added to give it more scattered and broken feel.

In Figure 20 one can see that the UV mapping of the ice tile and it's shards were made by completely separating the sides of the ice from the top and bottom faces. The reason for that was texturing. The texturing of the ice was done by first hand-painting a light blue base color to the whole model. Then to the top and bottom faces of the model a white color was painted to act as snow. The snow was painted by using lowered strength on the brush, that way the thickness of snow reduced to the edges of the ice. After the top and bottom faces were done, by utilizing the UV map the sides of the ice tile were painted light blue without painting the top and bottom faces of the model.

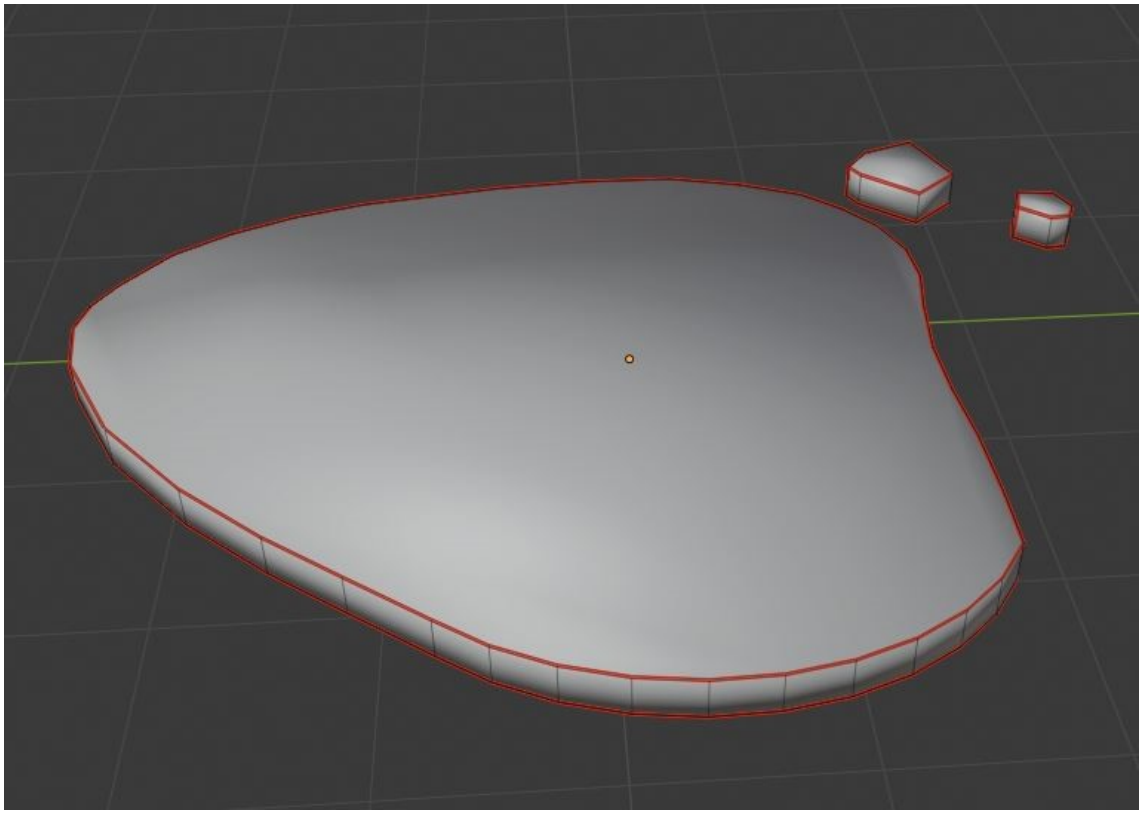

Figure 20. Model of the ice tile with UV mapping seams.

In Figure 21 and Figure 22 one can see the end result of the ice tile as well as the campfire site placed on the ice tile.

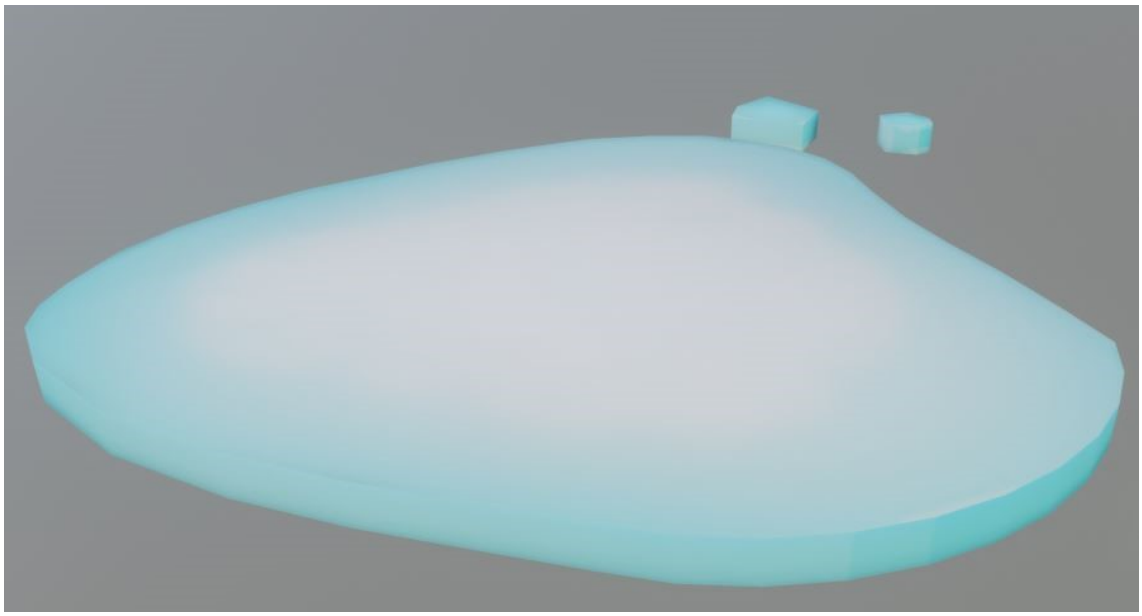

Figure 21. Finished ice tile model with textures.

Figure 22. The finished campfire site placed on the ice tile.

# 5 Discussion

The results from the thesis supports the fact that the 3D modeling pipeline for games is a long process that needs to be followed strictly, otherwise the end product will not be complete or it will have major flaws. However the 3D modeling pipeline offers flexibility by containing multiple different working methods on most of the steps that form the pipeline. The results were quite significant, due to the fact that there are not many complete collections of the whole 3D modeling pipeline, especially ones directed for beginners in 3D modeling.

The thesis theory has been formed from game development and 3D modeling industries professionals and by using that information, multiple 3D models were successfully modeled and textured. That provides reliability for the thesis results. Using more of the different 3D modeling and texturing methods, like sculpting or PBR texturing, would have expanded the focus area of the thesis and that way affected the results and their reliability.

# 6 Conclusion

This thesis's objective was to act as a guideline for anyone interested in 3D modeling and texturing for videogames. The guideline's purpose was to give an understanding of the whole 3D modeling process to people not familiar with 3D modeling and to improve the 3D modeling skills of those already familiar with 3D modeling. The guideline was formed by researching theory of the 3D modeling pipeline from industry professionals and by using that knowledge a 3D modeling workflow was set and five 3D models were successfully modeled and textured.

The 3D modeling pipeline for games is a long process that consists of multiple steps. These steps are followed in a strict order for a number of reasons, some of which are quite obvious, while others less conspicuous. Mainly, the reason for the work order is to have the best possible basis for the next step of the modeling process. While the order of the 3D modeling pipeline is strict, each of the steps in the modeling process provides freedom for the modeler to choose which tools or work methods to use. While some modelers might prefer to create their high-poly models using the poly-by-poly method, others would rather take the advantage of digital sculpting. The same goes with texturing; some prefer 2D painting softwares, like Photoshop, while others choose to paint directly on the 3D model in Substance painter. In the end, all that really matters is the end result.

This thesis has achieved its goal in being a guideline to anyone interested in 3D modeling and texturing for video games, since by following the theory formed from industry professionals five 3D models were successfully modeled and textured. This thesis has not fully unveiled the world of 3D modeling, but it is a good beginning. To further develop this topic, there should be different kinds of models that would focus more on the workflow of digital sculpting and retopology as well as texturing with PBR textures utilizing the map baking. Those workflows simply did not fit in this thesis's work project.

A 3D artist has never learned or practised enough. Mastering one modeling technique, like sculpting, will not make one a great artist. There is always going to be a project that requires the 3D artist to work with another technique,

something new to learn and experience, since the whole 3D modeling industry is constantly growing and expanding. Therefore, this thesis has been a great practice and a learning experience, but there is still so much more to learn and practice for the future.

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