Exploration of techniques for the creation of a 3D character

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Final Degree Work

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You'll be alright.
It's like tripping over a pebble in the road. This is no big deal.
The place you want to go is farther away from this. You'll be alright.
You can stand. You'll be walking forward again soon.
-Guts [Berserk]

ACKNOWLEDGMENTS

First of all, I would like to thank my Final Degree Work supervisor, Carlos Granell Canut for letting me embark on this project.

Secondly to my family for believing in me, sometimes more than others, and for letting me follow my passion.

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Abstract

The present document is the last assignment of the Design and Video Game Creation course at the Jaume I University in Castellón. The idea behind this project is to explore all the different techniques that can be used in the creation of a 3D character and, with all the various results, make a comparison between them, present all the pros and cons of each one and see in which situacion they should be used.

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1

INTRODUCTION

Contents

This chapter explains for what purpose this work was created, what was the motivation behind it, why I decided for this topic and how it has been developed.

1.1 Work Motivation

For a long time I have been interested in the artistic aspect of video games and, with the introduction of 3D programs in the career, I decided that I wanted to focus professionally on that aspect and focus my final degree work on something related to 3D modeling, which ended up as this project.

I believe that the field of 3D design has a great future. Every day new and very interesting technologies are being created that make possible the creation of spectacular works of art.

1.2 Objectives

- Develop a realistic character that can be used without any backlash in a video game.

- Use and explore the industry standard workflow pipelines and software.

- Explore all the professional techniques and methods utilized for the development of a high quality 3D model.

1.3   Environment and Initial State

The idea for this project came about a year ago when some of my classmates started to develop their final degree projects. As my internship was focused on the creation of 3D assets I decided that it would be a good idea to put everything I learned during that period in a new project, the creation of a 3D character.

Although in the degree there is a subject focused on character design and animation, I consider that this subject barely scratches the surface of how to create realistic characters for video games.

This project has been developed completely from scratch without any previously created assets to speed up the development.

CHAPTER

2

PLANNING AND RESOURCES EVALUATION

Contents

In this chapter the planning for this final degree work is explained, as well as the resources that I ended up using for developing it.

2.1   Planning

Below is a list of the different tasks required for developing this project. There's a brief description of each one, the time needed to complete it and the distinct techniques that can be used. All of the times for the tasks take into account all the information that should be searched in order to become acquainted and develop all the different techniques, named in the brackets, necessary to make each task. Is also worth noting that some tasks would be done multiple times, so the time needed is increased accordingly.

- **Gathering of reference materials (for each part of the project):** 5h. For each part of the character I will look at references to understand better how the structure of what I'm doing is like, a few examples can be: the anatomy of a human body, the flow and shape of the hair, the folds of the clothes...

- **Creation of the low poly body [modeling, sculpting]:** 12h. In every 3D project it is important to go from the general aspects of it, like in this case can be the shape of the character, to the more specifics, like pores, veins, scars. . . The

general features are done in the low poly model, which is a 3D model with very few polygons that can be easily tweaked.

- **From low poly to high:** 20h. The polycount increases as the model is being worked on, and more details are needed to define the shape of the character.

- **Sculpting the head, eyes, torso and feets:** 42h. Further refinement of the character shape.

- **Detailing [sculpt, texturing]:** 8h. Usually skin imperfections and pores, those details can be obtained in the sculpt software with brushes made for this task or by adding noise to the surface. Micro details can also be made via textures using the normal and high maps.

- **Hair [particles, cards, sculpt]:** 24h. This task is pretty self explanatory, it's basically creating the hair for our character.

- **Clothing [modeling, based on physics]:** 25h. As the name suggests, in this task I create the clothes for the character.

- **Retopology [manual, algorithm based]:** 20h. Retopology is the act of recreating an existing surface with more optimal geometry (see cite [24]. It's either made by hand, the artist creates all the new geometry following the high poly models, or by an algorithm that reduces the poly count to a selected one.

- **UV:** 22h. UV Mapping is the process of unwrapping the surface of a 3D model to create a 2D image onto which the model texture can be painted.

- **Bake details [Substance, Marmoset, Maya]:** 5h. All the information that the high poly model has, (like normals, ambient occlusion, curvature) is going to be baked into the low poly model in order to make it look like the high resolution one.

- **Texturing [painted in the model, procedural, created in Substance/texturing software]:** 26h. A texture map is an image applied (mapped) to the surface of a shape or polygon (see cite [18]). The texture maps define the color of the model, the roughness, the glossines, the transparency...

- **Rigging (body and face) [controls, UI]:** 22h. Rigging is the process of creating a skeleton for a 3D model so it can be moved and animated.

- **Animation [based on key frames, realtime]:** 13h. After the character is rigged it should be able to move and animated.

- **Posing and rendering [Unreal Engine, Marmoset, Substance]:** 5h. This stage focuses on creating visual images so the work can be seen and shared.

- **Integration in a video game engine:** 2h. This is pretty self explanatory as I just have to take everything that I have created into Unreal and see that everything is correct.

- **Creation of a sample scene:** 9h. A scene is created to test that the work created doesn't cause any issues.

- **Preparation of the final document and presentation:** 40h.

This section also includes a Gantt diagram Figure (see figure 2.1) and a chart that shows how the different workflows depend of each other. The white dots in the Gantt chart represent the weeks when work is done in that task. Is pretty clear that this project follows a cascade development. In the chart it can be seen that there's task that can be done independently of others, and ones that require several steps.

To further explain and provide a clear vision of the different tasks, I made a diagram that represents the dependencies that they have and when each one it's going to be made. This diagram goes hand to hand with the Gantt diagram that can be seen below. (see Figures 2.1, 2.2 and 2.3)

2.2   Resource Evaluation

The resources used were:

- Intel(R) Core(™) i5-7600 CPU 3.50GHz, 16.0GB RAM, GeForce GTX 1060 6GB.

- Canva, free online tool used for the creation of the Gantt diagram. (see cite [5])

- TeXworks, a tool used to make the LaTex document. (see cite [21])

- ZBrush 2021, used for sculpting, retopology and detailing. (see cite [16])

- Maya 2022, used for modeling, retopology, hair and rendering. (see cite [4])

- Substance Painter 2021, used for texturing. (see cite [2])

- Unreal Engine 4, the default videogame engine used in this project. (see cite [10])

- Marvelous Designer, used for clothes. (see cite [8])

- Marmoset Toolbag, used for rendering. (see cite [22])

- PureRef, used for gathering references. (see cite [14])

- HDRIHaven, free online website for HDRIs. (see cite [11])

- Mixamo, free online website for automated rigs. (see cite [1])

- I tested two other softwares (3Dcoat and RizomUV) for retopology and UVs respectively but I didn't like the workflow that I had to use so I ended up using Maya for those tasks..
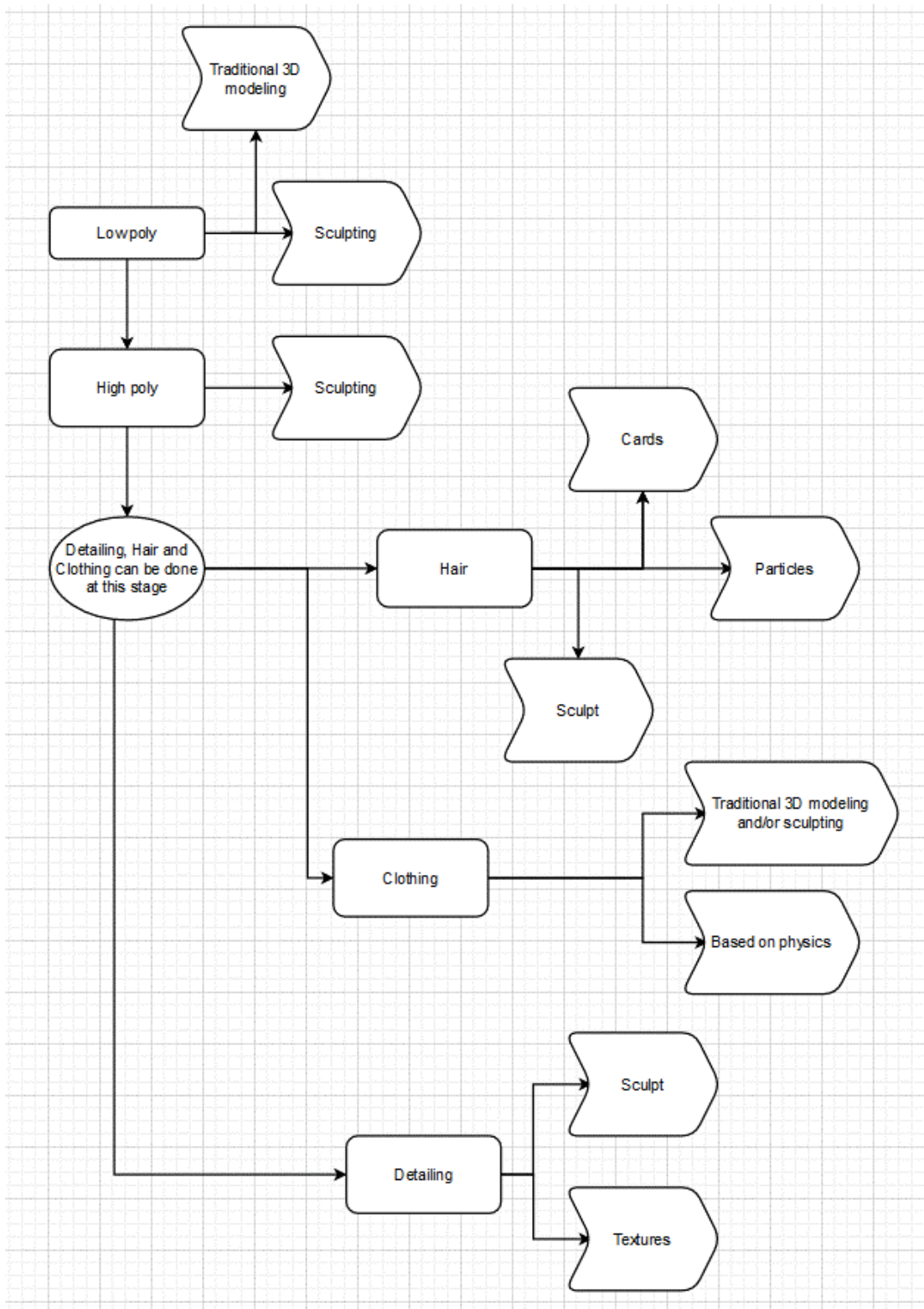
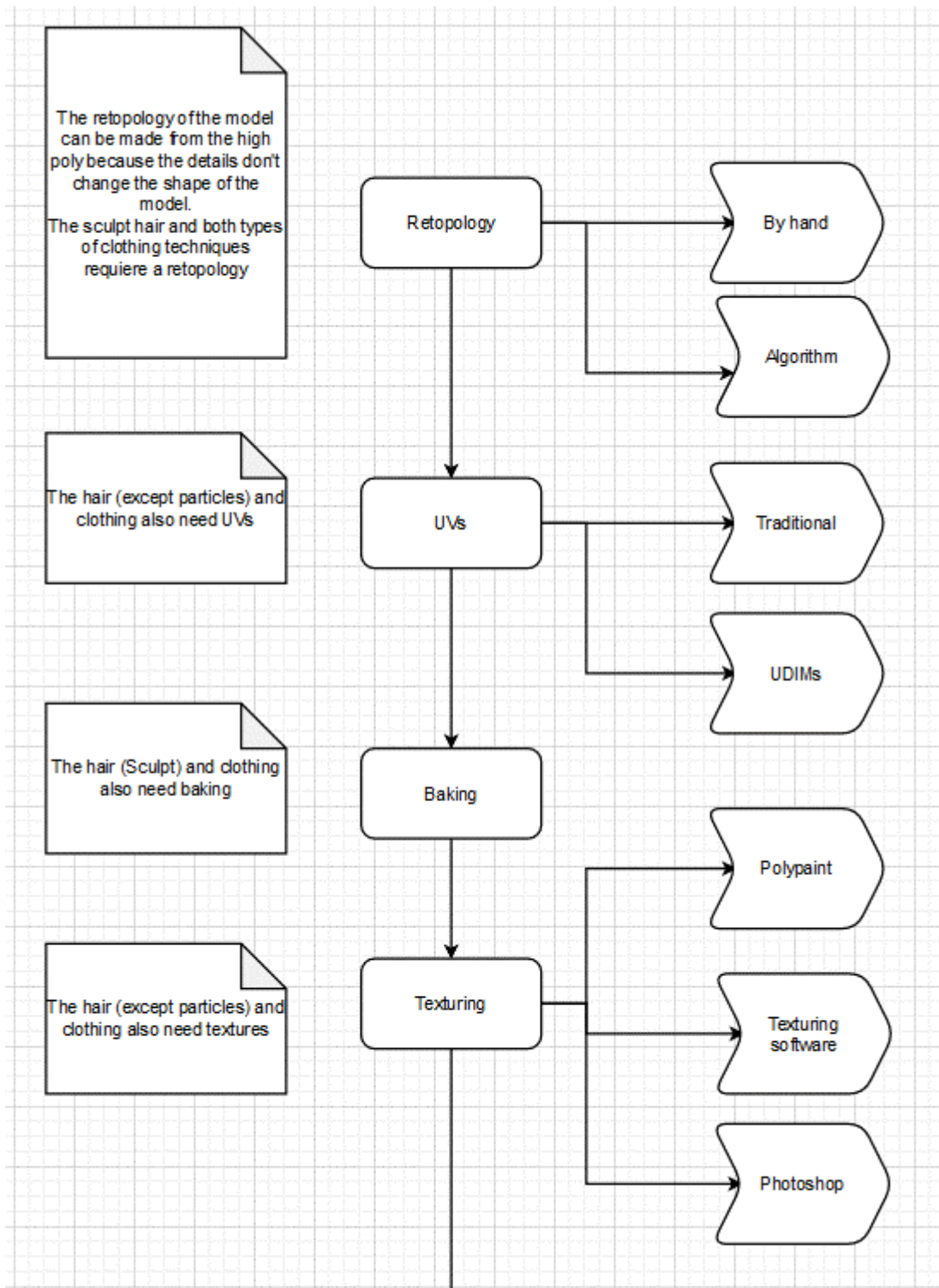Figure 2.1: Diagram explaining the general workflow of this project(made with Google Diagrams)

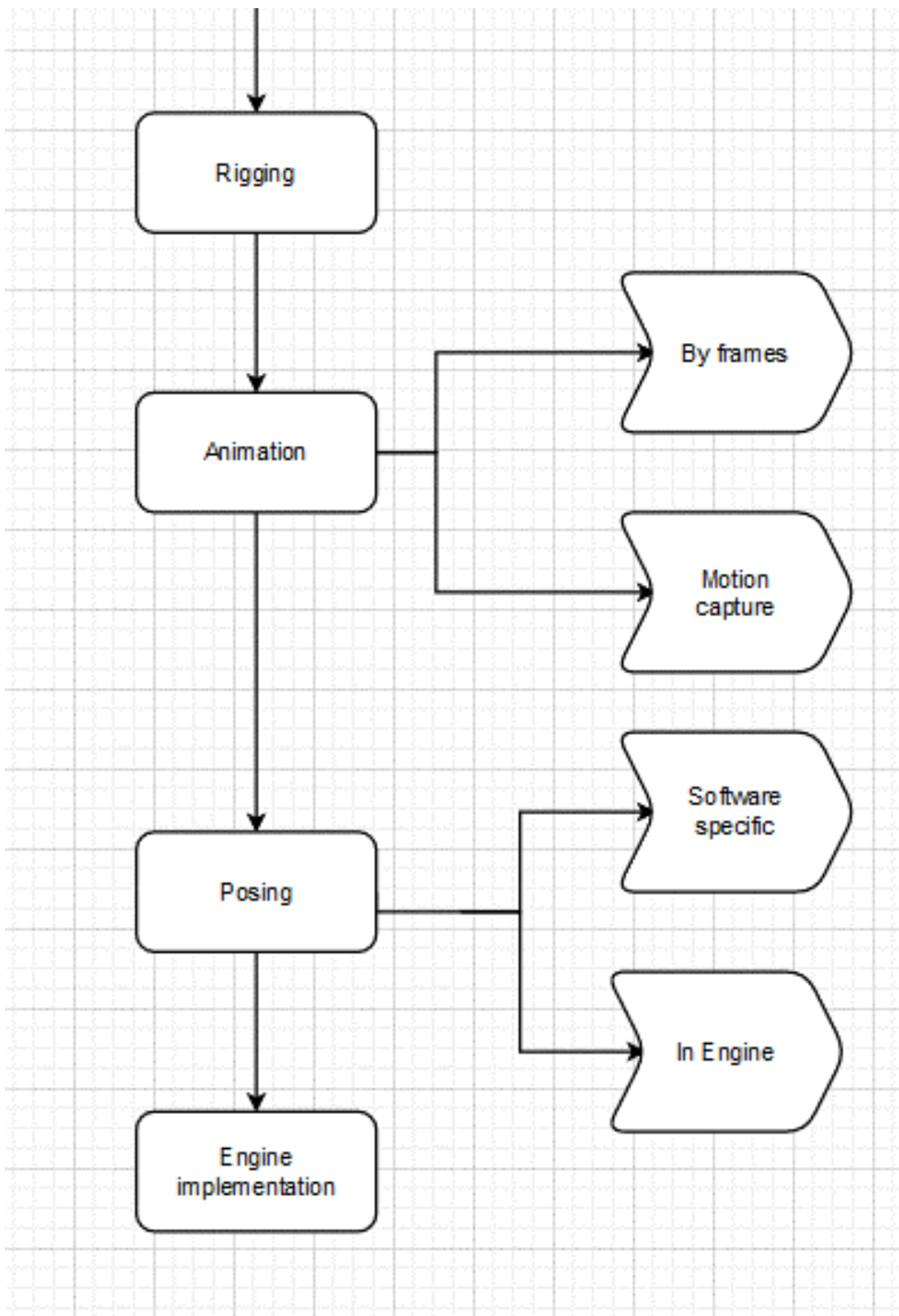Figure 2.2: Diagram explaining the general workflow of this project(made with Google Diagrams)

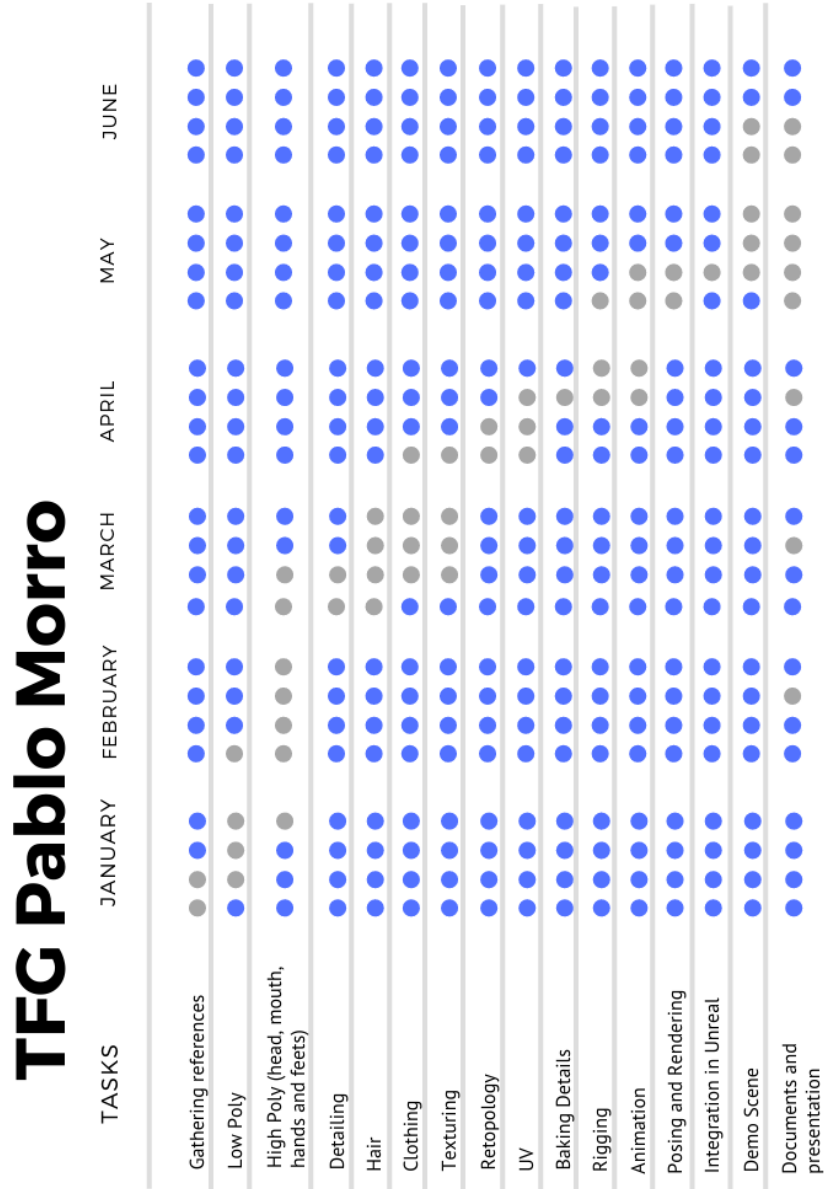Figure 2.3: Diagram explaining the general workflow of this project(made with Google Diagrams)

Figure 2.4: Gantt diagram for this project(made with Canva). The white dots in the Gantt chart represent the weeks when work is done in that task.

ARTISTIC DESIGN AND TECHNIQUES OVERVIEW

Contents

3.1   Artistic Design

This section focuses on the aesthetic vision that was given to the project at the beginning of its development, as well as which sections of it were the most interesting to me at the beginning of the final degree work.

One of the first challenges was to find a style (see figure 3.1) that I felt comfortable with and that would provide me with the opportunity to create an interesting and attractive project. In the end I ended up deciding to make a character inspired by feudal Japan, as previously mentioned she will be a samurai.

For the body (see figure 3.2) I'm taking inspiration from female athletes, such as mma fighters or powerlifters. I wanted her to feel like a warrior who has lived through many battles, since in many current video games, with a medieval aesthetic typical of RPGs, the characters look like models who are posing for fashion magazines. The face takes inspiration from various Asian models and actresses and my idea is that she has scars on her face and body that reflect her life.

For the hair (see figure 3.3) I want it to be in a bun and have loose strands, not too long, to give it a slightly careless look. I'm looking forward to this part since I haven't created hair before and I think it's very interesting.

Regarding the clothes, I'm still not sure what kind of clothes she will have. On the one hand I would like to create armor for her but I have the feeling that this way I'm going to use less new techniques. I will probably end up opting for some kind of typical Japanese outfit (see figure 3.4), such as a kimono, since I would like to try Marvelous Designer for the creation of clothes.

Figure 3.1: Character main style inspiration

Figure 3.2: Character main style inspiration

Figure 3.3: Hair style inspiration

Figure 3.4: Cloth style inspiration

3.2   techniques overview

I chose this project because there were a lot of techniques and creative processes that I wanted to investigate and develop.

The use of cards (see figure 3.5) (simple polygon shapes) for hair is one of them. Creating hair for video games is an interesting topic for me because there are limitations to creating realistic looking hair, as it is extremely difficult to render a large amount of particles in real time.

Figure 3.5: Hair cards example

In the creation of realistic characters, micro-details (see figure 3.6) are usually used to create pores, wrinkles, texture and skin imperfections... giving the model more realism. Although I have practiced creating busts before, I have never reached this part of the process so I hope to learn a lot by exploring this technique.
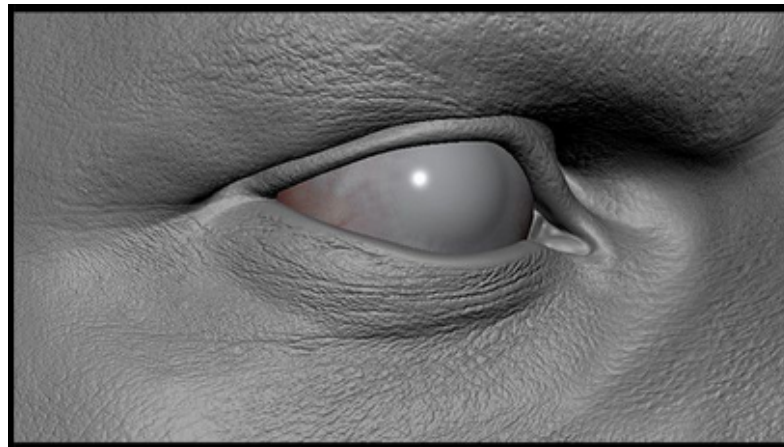

Figure 3.6: Micro-details example

Clothing is another interesting field, specifically the Marvelous Designer (see figure 3.7) software as it uses physics to simulate the effect that a fabric would have on a surface. This software is currently widely used both in the video game industry and in the special effects industry, so improving my skills in this regard I see something very positive in the future.
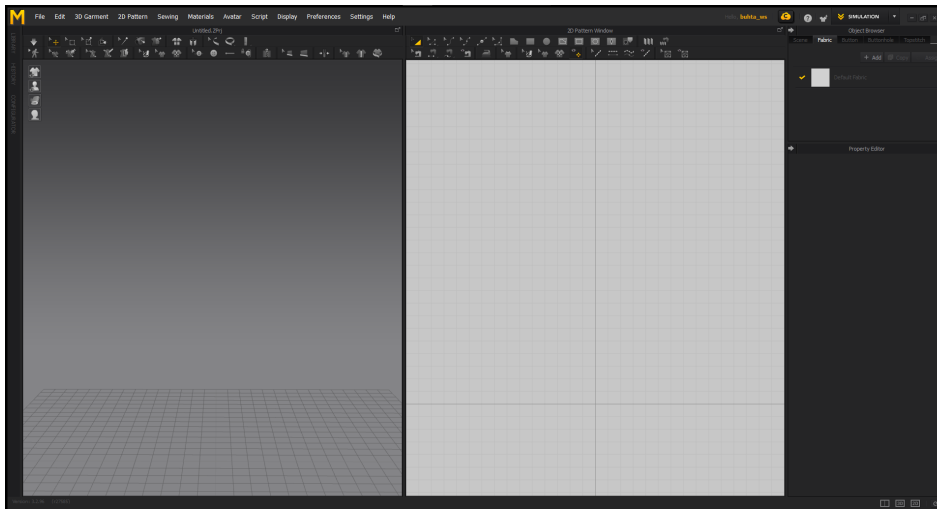
Figure 3.7: Marvelous Designer interface

The rigging stage is the one that scares me the most because I barely have knowledge about how to make a good rig (see figure 4.35) for a character and it is a very complex work that requires a lot of time to get a good result.
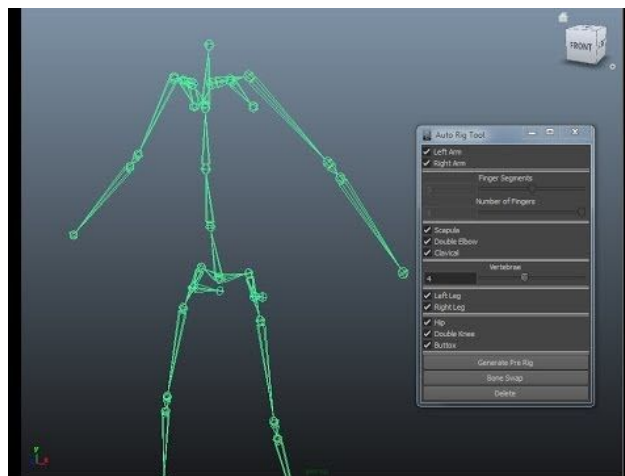

Figure 3.8: Rig example

Finally it remains to integrate all the work done within a game engine, although in the career we have used Unity I want to use Unreal Engine (see figure 3.9) for this project because it is a very powerful engine and is used in many blockbusters, whether triple A video games, movies and even series. Learning to use this engine will help me to be a better and more versatile artist.
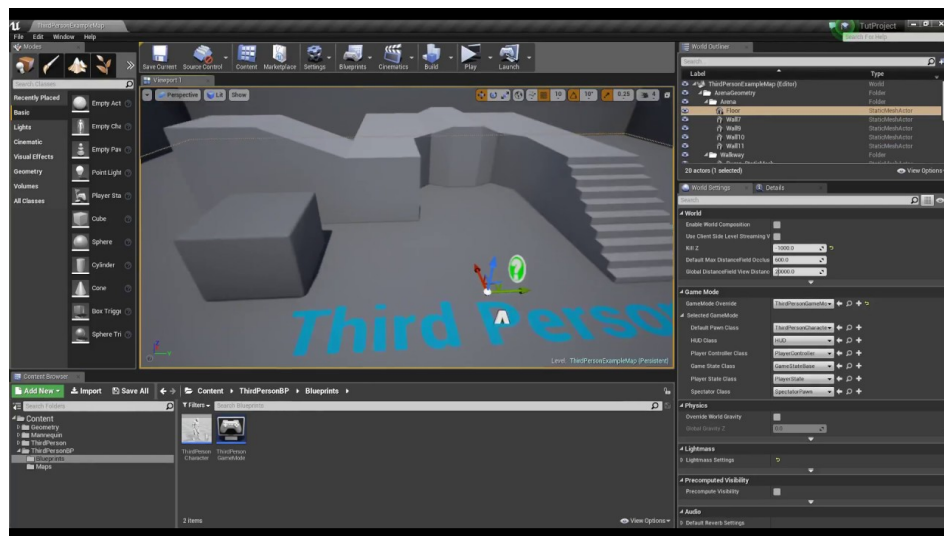
Figure 3.9: Unreal Engine interface

WORK DEVELOPMENT AND RESULTS

Contents

This chapter explains how this project has been developed, what hardships were encountered and if some tasks ended up changing from the original planning and idea.

4.1 Work Development

The explanation follows a chronological order and it's divided into segments, each one addressing one task. These segments provide an exposition of all the different techniques I have encountered and used, as well as an overview of their pros and cons. But first, where do we start?

4.1.1 References

One of the most important steps in every project is the preproduction, defining a clear path to follow is a key factor in the success of the project. What's the preproduction like when creating a 3D character?

The final objective and the time available must be defined before starting the project. Depending on the type of game to be developed the character overview will be very different. As the objective of this TFG was to discuss as many techniques as possible, the approach has been different from the one that would have been taken in a video game.

The first step is to define the artistic style to be followed, this is a process that should be done by the art director, with the defined style you should start creating a reference board (see figure 4.1). This board should reflect what is the idea behind the character, in this TFG a female samurai was chosen. When the idea is clear, references will be collected starting with the most general parts, such as aesthetics and general anatomy, and will move forward looking for more specific references like mouth shape, eye color, muscle definition. . .

It is important to have a clear overview to avoid having to make major changes and waste time that could be spent on improving the character. The specifics of the character can be added or changed if it will improve the character and if not much time is going to be spent on it.

When all the ideas are clear, we will start building the character following the same methodology as before, we will go from the general to the specific.
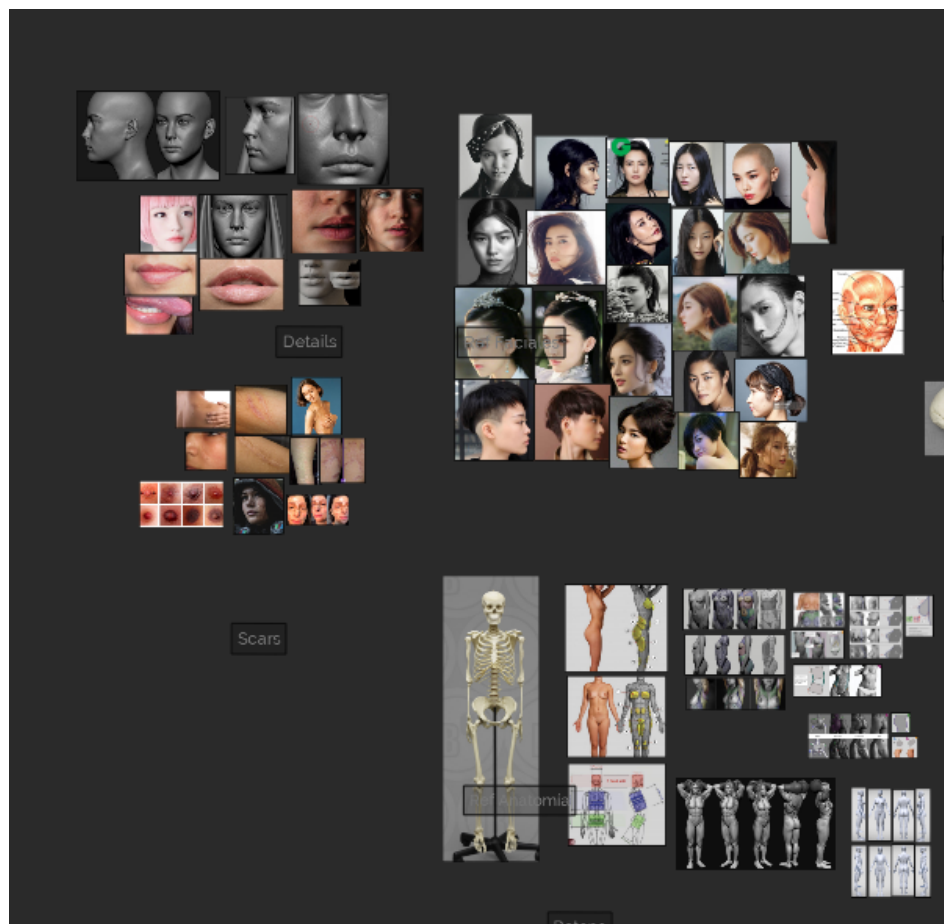

Figure 4.1: Reference board(made with PureRef)

4.1.2 Low poly

When a clear direction is taken is time to start the model, the first step is creating a low poly model (see figure 4.2). It can be done in two ways:

- **Traditional modeling**. This was the approach taken in the VJ1226 - Character Design and Animation subject. Consists in creating a very basic model by extruding, scaling, moving and rotating geometry, like it's done for hard surface modeling. For me this method has a lot of drawbacks and not many advantages, for instance it is harder to keep a good polycount density (meaning that the polygons will be distributed equally across the mesh) or a good edge flow. This is one of the most important aspects because a bad edge flow in the low poly stage can cause problems further down the development, in the high poly phase if the model is subdivided a bad edge flow can cause certain polygons to have more edges than others. I also found this process to be really tedious and time consuming.

- **Sculpting.** Sculpting allows for a more free form deformation and greater changes to the overall structure. Sculpting software tries to mimic the feeling of traditional clay sculpture so it's easier to create natural looking meshes. This phase starts with a low poly mesh (it can be a sphere, a cube. . .) that is going to be shaped like the figure of a real person with a brush. The advantages of this workflow are the greater control that the artist has over the mesh and that most 3D sculpting softwares include the option to change the current polygon density, which translates to a gradual increase in the polygon count as well as an increase in detail.

It should be noted that in this phase we are basically doing a rough sketch of what our character will be like. If the technique chosen for this stage is sculpting it can be kind of hard to separate from the next task, which is creating the high poly model.
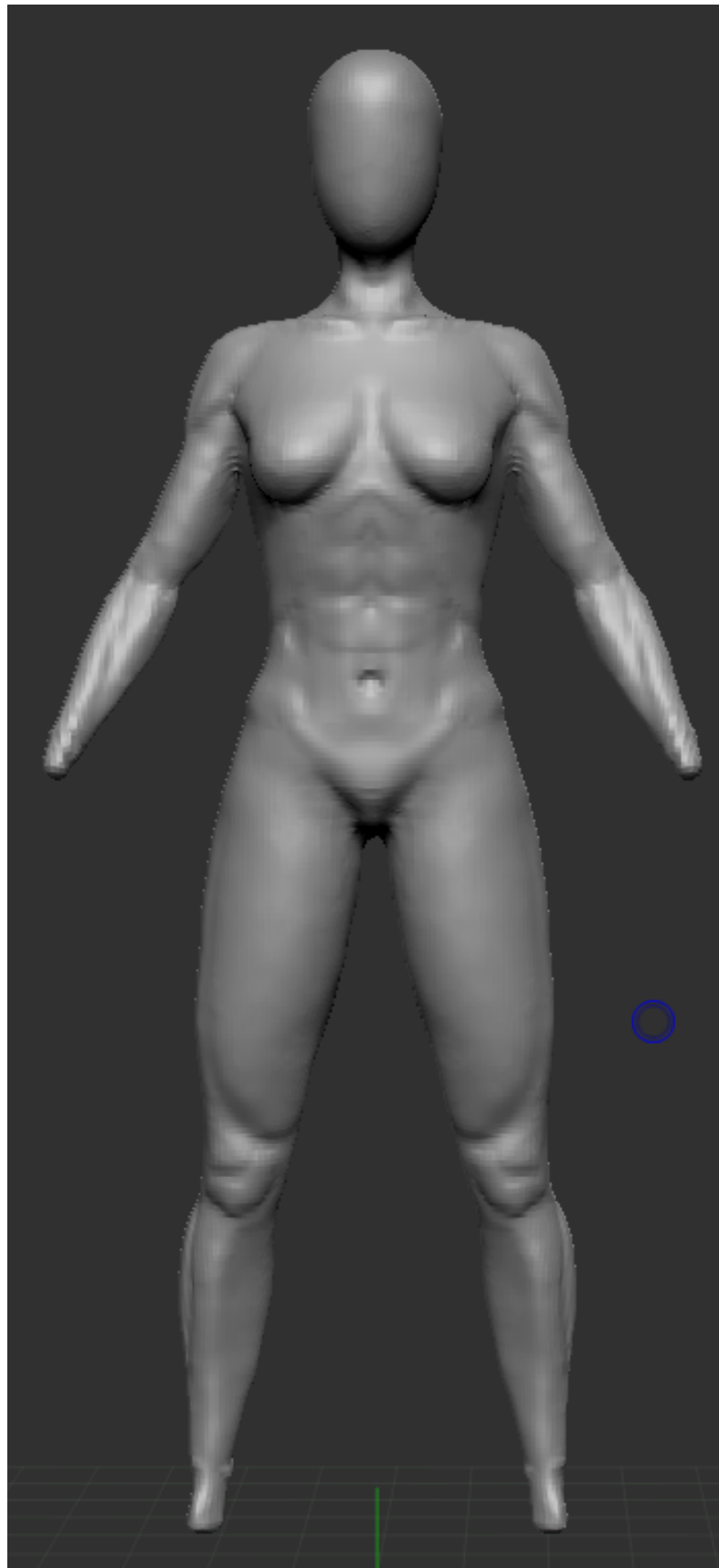
Figure 4.2: End result of the Low Poly model

4.1.3   High Poly

The high poly model was made exclusively in sculpting software, ZBrush, and the process
is pretty similar to what was previously stated in the low poly phase, the main difference
is that we are going to be focusing on the specific parts of the model. In this method
the polycount is increased as more refining and tweaking of the model is needed to bring
the character to life.

The usual way of increasing the geometry is with the *DynaMesh* option in the Tool
menu, (*DynaMesh* is a tool in ZBrush that allows you to change a model's shape and
then immediately recalculate an optimal topology for the new mesh (see cite [17]) (see
figure 4.3).
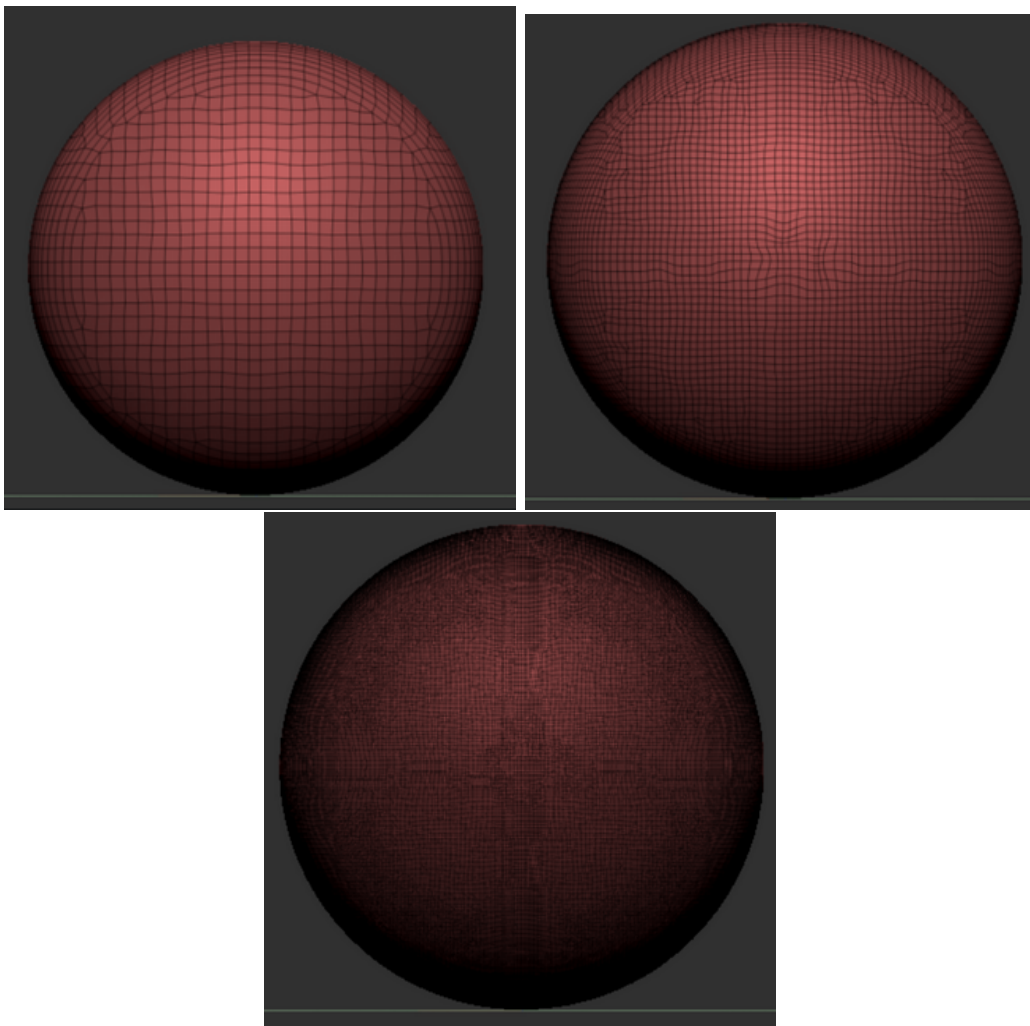
Figure 4.3: A sphere that has been dynameshed to a resolution of 32, 64 and 124.

More resolution is needed in a specific area of the mesh:

- **SculptrisPro.** This is something that can't be achieved with *Dynamesh*, lucky there's a tool named SculptrisPro that divides a specific area of the mesh in triangles allowing for more resolution in that area (see figure 4.4). The problem with this method is that the mesh can't be subdivided as it is no longer made of quads, so a retopology is needed afterwards. There's a video by Pixology Japan where a FromSoftware character artist explains this workflow (see cite [12]).
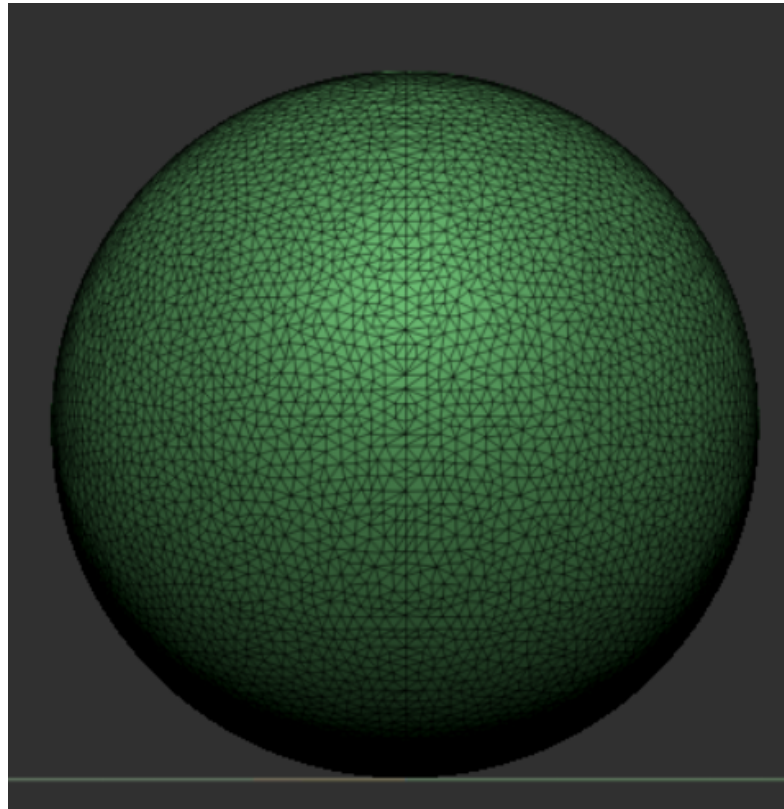
Figure 4.4: Mesh with SculptrisPro

- **Splitting the mesh.** Another approach consists in dividing the mesh in parts and subdividing each one the number of times that we see fit. This is a super useful workflow because instead of subdividing the entire mesh, which will rapidly take the polycount to millions, only a small area will be affected. Another good point for this technique is that it minimizes the impact that high poly meshes have on low specs pcs. Because the original mesh has been separated, it is not necessary to view the entire mesh, nor to view it at the highest subdivision level, taking all of this into consideration the number of polygons in the viewport will be way lower and the final look will be the same. Here's a good example of how to use this workflow (see cite [6]). (see figure 4.5)
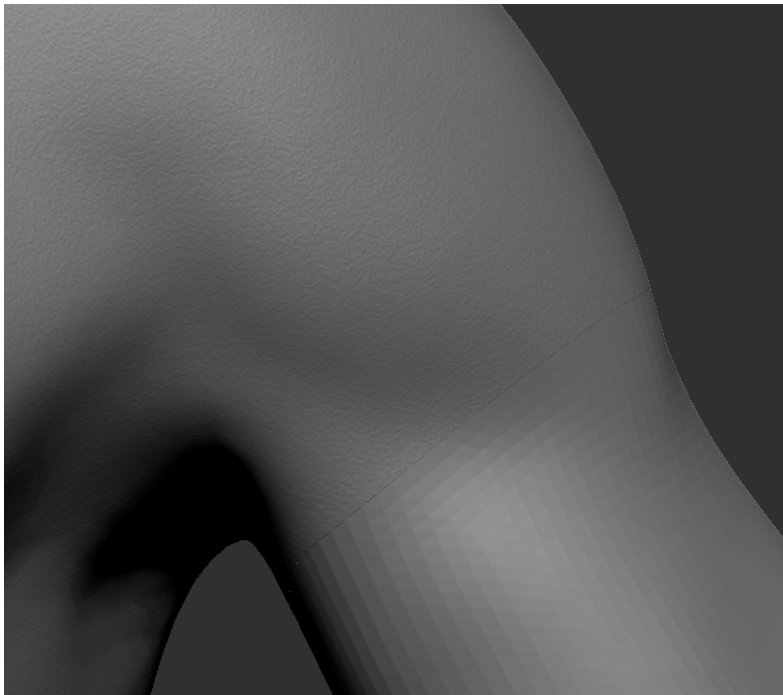

Figure 4.5: Mesh sliced workflow

- **HD-geometry.** There's an approach similar to the one stated in the first point, *HD-geometry.* It allows the artist to subdivide parts of the mesh to up to 1 billion polygons. its behavior is similar to the one mentioned above, since it adds geometry to a specific part of the mesh. A particularity of this technique is that it works in a circular way, the part of the mesh that falls inside the circle will be subdivided and the rest will be hidden. I haven't been able to find much information regardless of when to use this technique, nor did I consider it to be really useful in my case, but I'm sure it will be helpful to some people so I mentioned it just in case (see cite [15]). (see figure 4.6)
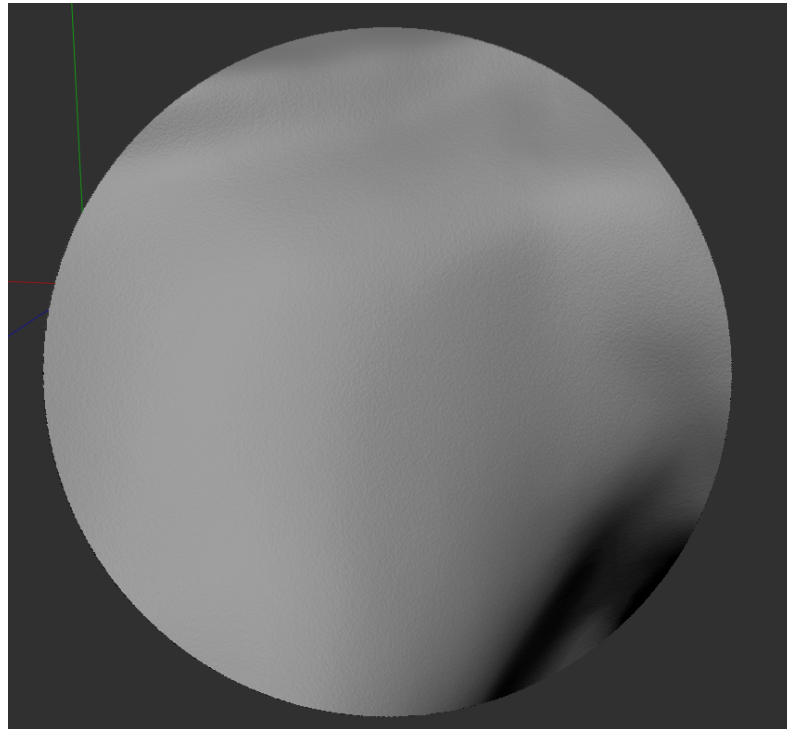
Figure 4.6: High poly model with hd-geometry turned on

In addition to the techniques mentioned above, scans of people can be used to speed up the process and achieve a more realistic final result.

Here's the end result of the high poly model (see figure 4.7).

Figure 4.7: End result of the high poly model

4.1.4   Detailing

When the high poly model is completed it's time to move into the micro details, such as pores, skin imperfections and stretches. . . It's also important to remember that this stage can be completely skipped if it does not fit the character model. Characters that are seen from afar or more cartoony looking characters would often overlook these skin details.

There's two main approaches in this stage:

- **Sculpt the details.** There's lots of brushes that are made for this purpose, it's up to the artist to place the details where he/she thinks they should be added. This technique can seem a bit tedious but it gives more freedom in the placing and type of detail that is going to be added. This technique can be combined with noise displacement, noise textures are used to move the vertices of the mesh and give it a small bumpy effect. (see figure 4.8)

Figure 4.8: High poly model with details

- **Add them with a texture.** To follow this workflow the character needs to be retopologized and with UVs. This technique makes use of normal maps to fake how the light bounces off the character. One positive aspect of this is that the texture can be procedural so it's easier to change the look of it. (see figure 4.9)

Figure 4.9: Details made with a texture

Once the details are added we can move onto the retopology, hair and clothes can also be done but I prefer to talk about retopology, UVs and texturing first because those stages also need a retopology, UVing and textures.

4.1.5 Retopology

As stated before, retopology consists of recreating an existing mesh with a more optimal geometry. It can seem like the retopology of a model is made when we need fewer polygons but that's not true, tools like *Dynamesh* are actually retopology tools and as we know *Dynamesh* can change the polygon density to the one that fits the most.

What do we need the retopology for? Right now our model consists of millions of polygons so it will be extremely difficult to get the UVs and texture that the model needs. There's a few approaches that can be taken to create this new topology:

Zbrush comes with a bunch of algorithmic retopology tools like *Dynamesh*, *Zremesher* and *Decimation Master*:

- **Dynamesh.** As we know Dynamesh is really easy to use and provides great results but it doesn't offer great flexibility for how the final mesh is going to look like. (see figure 4.3)

- **Zremesher.** It gives a lot of options on how we want the mesh to be retopologized, like keeping creases, polygroups, and it even has a brush that helps dictate the flow of the polygons. (see figure 4.10)
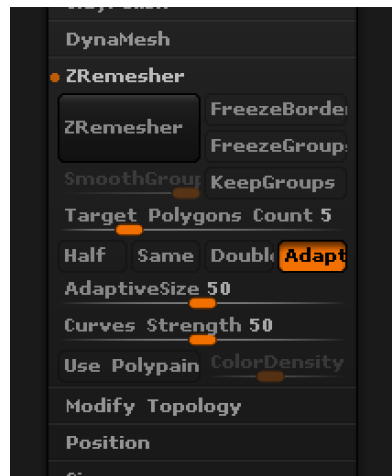
Figure 4.10: Zremesher panel options

- **Decimation Master.** As the name implies, it's a decimation tool (see figure 4.11). Firstly it triangulates the model and then it joins two vertices that are close, which removes one polygon, this operation is performed X amount of times. The first drawback that this operation has is pretty obvious, the entire mesh is triangulated so no subdivision can be applied. This technique can be used in tandem with the *Zremesher* and *Dynamesh* tools, this video explains how it can be used (see cite [12]).
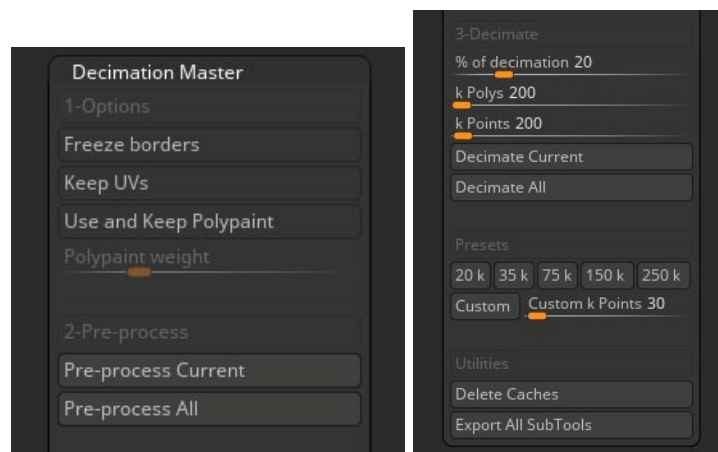
Figure 4.11: Decimation Master panel options

All of these tools have one thing in common, the polygon size across the entire mesh is pretty much the same. At first glance it can appear to be a good thing but when a

retopology is made so we can texture a model and use it in a video game, we need to get rid of as much useless topology as we can. So in the end the model has a higher polygon count in the most important parts like the face and hands.

Edge flow has been briefly talked about before but now it's when we need to be cautious about it. There are specific areas of the mesh that need a certain edge flow so the mesh can deform when it's animated without causing any issues, those areas are the shoulders, elbows, knees, phalanges (see figure 4.12)... Having a good edge flow is key if we don't want the model to cause any problem in the animation phase, so it's important to take some time in this process.

Figure 4.12: Hand edge flow

There's one way to get rid of the problems with the algorithm base retopology and that's manual retopology, of course it won't be as fast but it ensures that the model will present a good topology moving forward.

There's not much to talk about when doing manual retopology, it basically involves a high poly mesh that can be previously decimated, because there's no need to have millions of polygons for a retopology. Then we lay polygons on top of it to follow the shape and structure of the model. The way the actual modeling is handled can vary with each software.

As stated in the first segment it's important to have some reference (see figure 4.13) of characters made for games or animation so we can see how the edges flow and which parts of the model need more polygons.

For manual retopology Zbrush has a brush for that but I find it hard to use and it's also not well suited for my workflow.

Initially I retopologize the character with 3D Coat, it's a 3D software similar to 3DsMax or Maya, but because I did the UVs in a different software (RizomUV) the
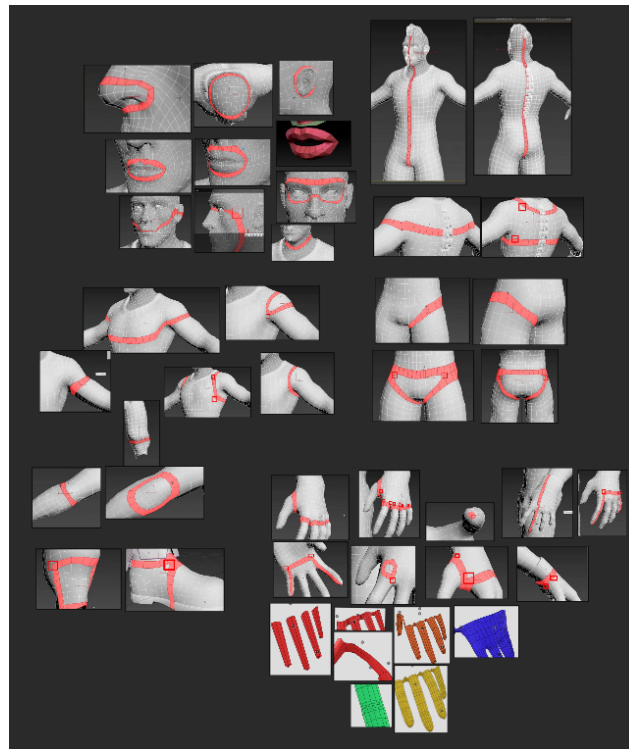
Figure 4.13: Reference board of the edge flows that the character should have

workflow was extremely slow when some changes were needed in the topology. Because of that I switched to Maya for the retopology and the UVs.

When the character retopology is done (see figure 4.13) we can start making the UVs. When working on the next step it is common to tweak the model topology and change something if we see fit.
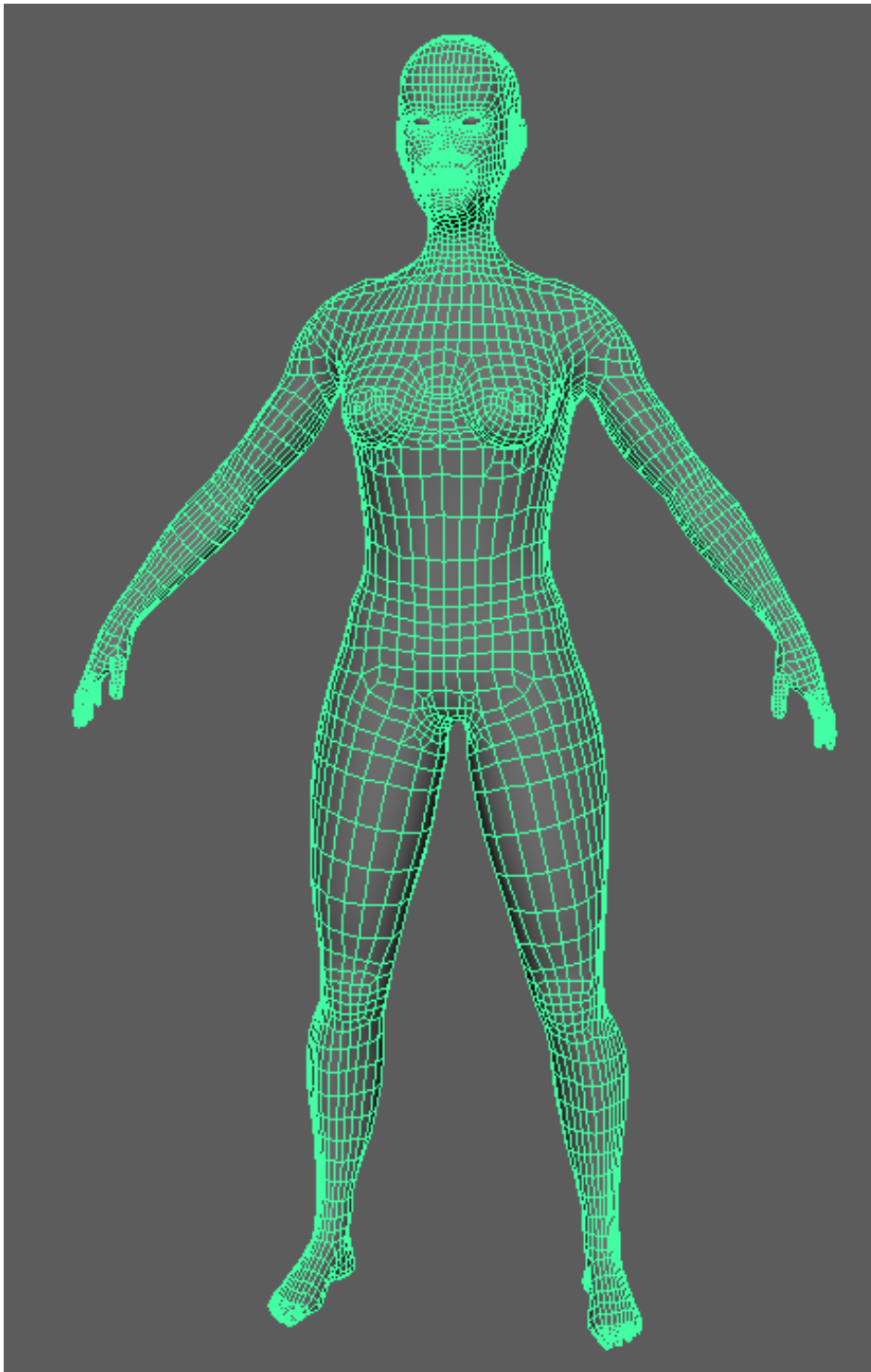
Figure 4.14: Final topology

4.1.6 UV

UV Mapping is the process of unwrapping (see cite [23]) the surface of a 3D model to create a 2D image onto which the model's texture can be painted. To create the UVs the character is cut (see figure 4.15) in different places so it can be separated and unwrapped into a 2D tile (see figure 4.16). It's relevant that we take into consideration what those parts actually are, if we unwrap a head it will need more space into the 2D tile than if it is the sole of the feet. This is because we want more texture resolution on areas that are of importance.
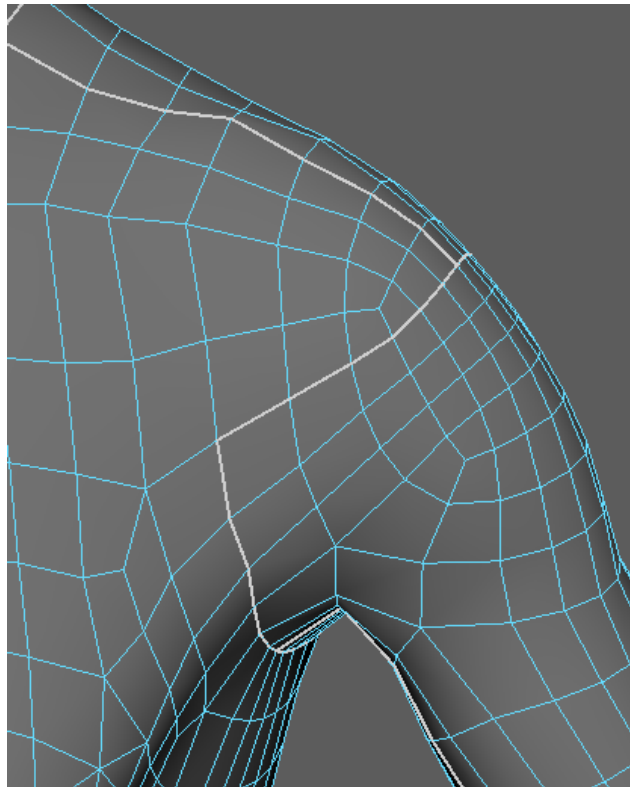
Figure 4.15: Visual representation of the cuts made in the model (the white lines)
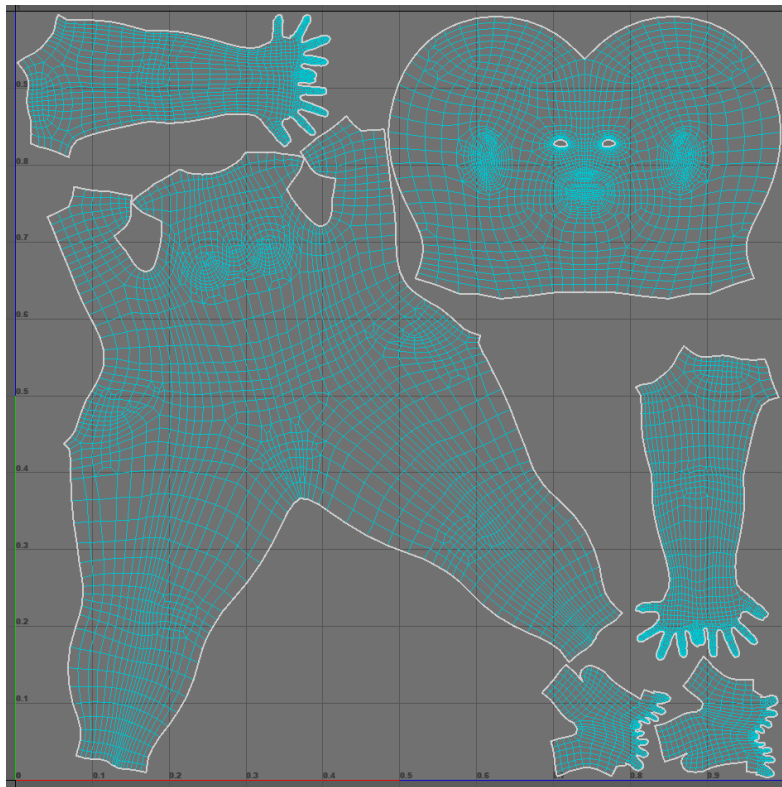
Figure 4.16: Single UV tile with the character UVs inside.

Almost every 3D software gives the option to automatically create UVs (see figure 4.17), based on the camera position, a planar projection, cylindrical, etc, but those UVs would probably have to be tweaked later.
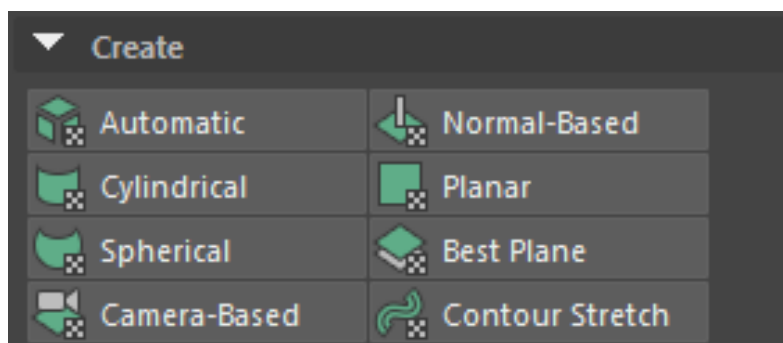
Figure 4.17: Menu for the creation of UVs

There also needs to be some consistency in the size of each part because if the texture had some kind of checkered pattern the size of that pattern would be inconsistent across the model. (see figure 4.18)
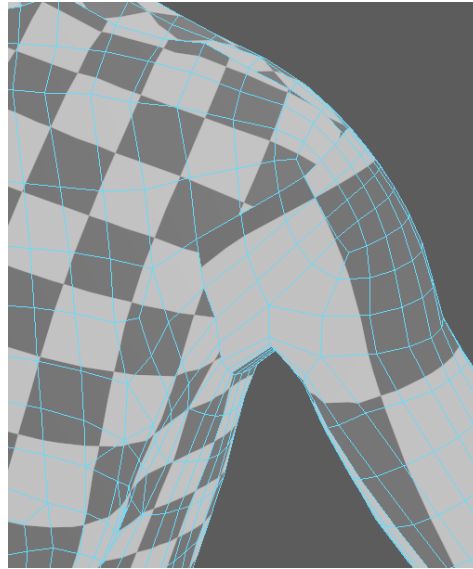
Figure 4.18: Inconsistency between the character UVs.

There's only one way of getting the UVs but the information can be saved in two different ways. The more detail we want in a part of a 3D mode, the bigger space it needs in the UV. The end result is a high-resolution image or a lot of materials, each material has its own UVs.

To solve this issue UDIMs were created, UDIM (see figure 4.19) is simply an automatic UV offset system that assigns an image onto a specific UV tile, which allows multiple lower resolution texture maps for neighboring surfaces, producing a higher resolution result without having to resort to a single high-resolution image. (see cite [9])
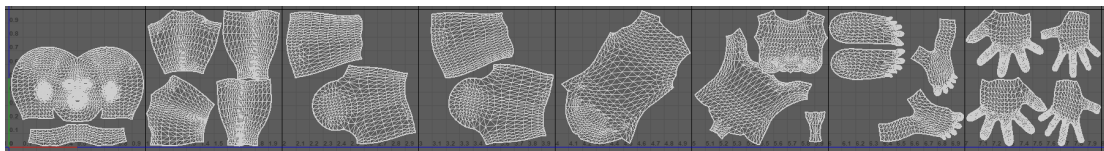

Figure 4.19: UDIMs tiles.

It can seem that UDIMs are the perfect solution but they come with a handful of problems.

- The first being that not all 3D softwares support UDIMs, Marmoset is one example, the model will take the first UV tile and repeat that texture across all UV spaces (see figure 4.20).

Figure 4.20: How UDIMs are viewed inside of Marmoset.

- The second is baking times. Each UV tile is basically one texture so the baking process needs to be made for each tile, greatly increasing the baking time.

UDIMs are mainly used in vfx where there are no limits in texture resolution, but it's of interest to keep an eye on them for video games as the engines develop and more technologies are added to them.

To create the UV I started using RizomUV but given that it was a different program than the one being used for the retopology I had to do a lot of back and forth between the two softwares so in the end I switched to Maya.

4.1.7   Baking

For the baking process there's really not much variations that can be made because it consists in taking all the information of the high poly model made earlier and transferring it into the retopologized one. Each baking software, in this case Substance Painter, takes for example the surface details variations that the high poly model has and it saves them into the UVs of the retopologized one as a normal map. Thanks to this process the two models look exactly the same but the performance costs that they have is incredibly different. (see figure 4.21)

Figure 4.21: Texture with the ambient occlusion information.

The baked information can also be used in the texture phase because there's modifiers (see cite [19]) that use the normal, cavity, curvature and occlusion maps to make calculations.

4.1.8   Texturing

Texturing consists of assigning properties to a model. It is at this point where we will decide if we want to have metallic parts, the roughness of the surface, if there are transparent parts or not, etc. The texturing process is very important because it can spoil an excellent model, but at the same time enhance more normal models.

The textures depend on the UVs that have been previously created so it is important that they are well done. There's two main ways of doing textures:

- **Procedural.** Softwares like Substance Painter or Mari give the artist a lot of freedom when it comes to texture creation. The fact that it's procedural creates a non destructible workflow that allows easy manipulation and control. One downside is that there's a higher learning curve than with painted textures (see figure 4.22).
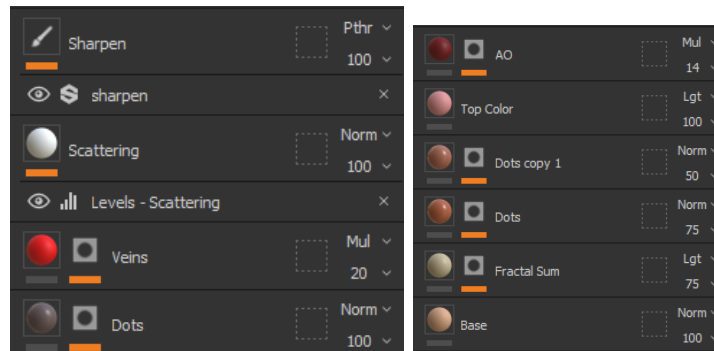

Figure 4.22: List of modifiers used for the skin if the character.

- **Painted.** Made in either 3D or painting software, the texture is painted by hand in the model or in an image. If 3D software is used, like Zbrush or Maya, one thing that needs to be addressed is that the color information is stored per vertex meaning that if more control is needed we will need a higher polycount. One advantage that this method presents is that the model don't need UVs for this process, so the high resolution model that we have in zbrush can be painted and rendered if we want to show what we made (see figure 4.23). Painting the texture in a software like photoshop is not something i would recommend because the workflow feels really slow.

Figure 4.23: Example of a painted texture, in this case the hair. Painted in Zbrush.

There is a way to make painted textures that uses scans to paint the colors and properties of the material to the object. XYZ texturing textures are often used for this workflow (see cite [20]).

4.1.9   Hair

The hair should be aligned with the overall art style of the character. For example, the hair of the character Mercy from Overwatch (see figure 4.25) was done in a completely different way than the hair for Ellie from The Last of Us (see figure 4.24).

Figure 4.24: Example of a hair cards in a videogame.

Figure 4.25: Example of a sculpted hair used in a videogame.

There's three main ways of doing hair:

Hair cards. Hair cards are used when we want our hair to look realistic and it's going to be used in a realtime engine. The process to create them it's the inverse of what we have been doing, we are going to start with the texture. Said texture can be obtained in a texturing software, like substance designer, and it's done in a procedural way. Another approach is to use particles, in this way we simulate strands of hair and we baked them into a 2D plane (see figure 4.26).

No matter which approach we take the final texture should have three main groups of hair types:
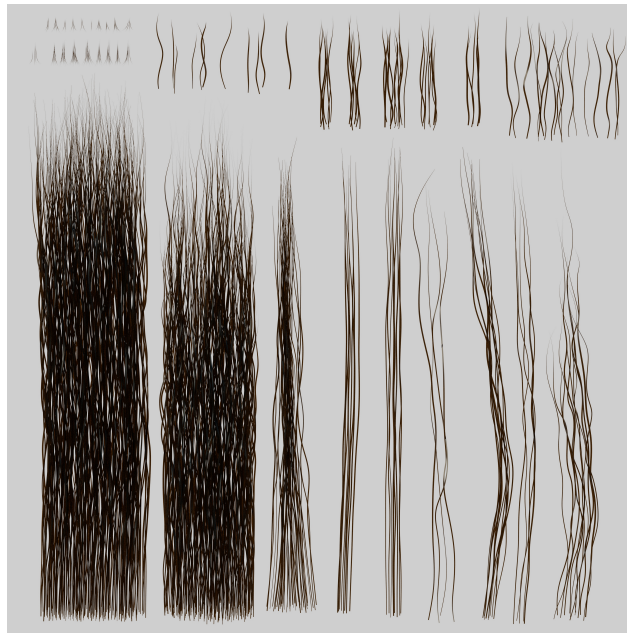
Figure 4.26: The hair cards texture, said texture was made using Xgen in Maya.

- **Main hair card.** Long clumps of hair that dictate the shape of the hair (see figure 4.28).

- **Break up hair.** Smaller clumps that go in a different direction than the main hair cards and adds volume and realism(see figure 4.28.

- **Flyaways.** A bunch of single strands that add volume to the hair (see figure 4.28).

When the textures are done we can create the geometry, 2D planes (see figure 4.27 and 4.28), that's going to use them and start placing them onto the model. (see figure 4.29)
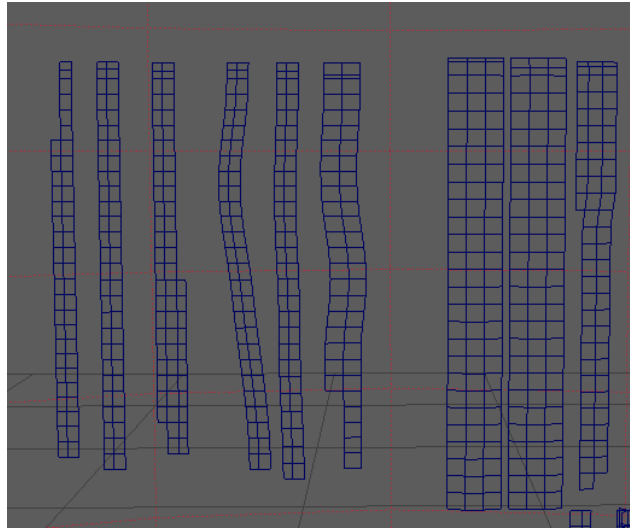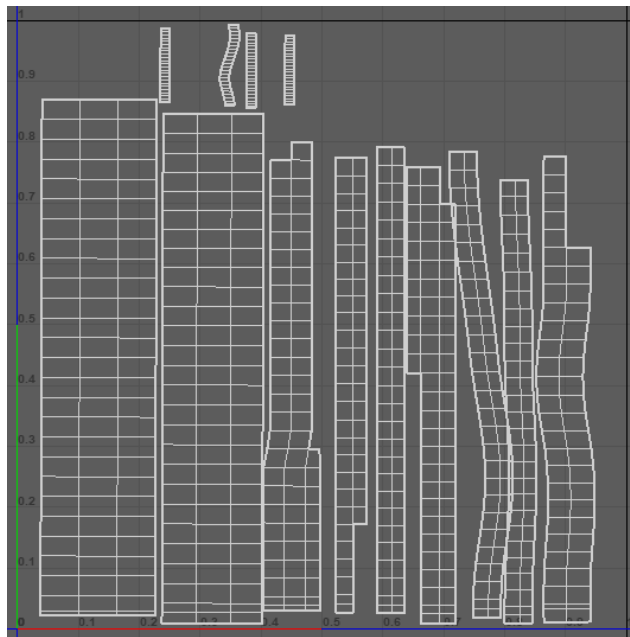

Figure 4.27: The hair cards geometry

Figure 4.28: The hair cards UVs

Figure 4.29: The final result of the hair cards

Sculpted hair. This technique is often used for more cartoony characters or for renders. There's two main ways of tackling this technique, the first one is creating geometry that will act as big clumps of hair and the second one is making those clumps as individual or smaller hair strands (see figure 4.30). If we want to use this hair in a video game a retopology, UV and texturing is needed afterwards.
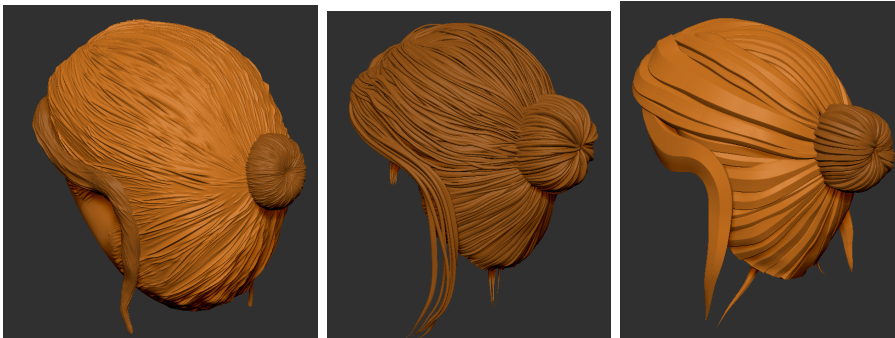
Figure 4.30: Three different ways of doing sculpted hair.

Particles. This method provides the more accurate results but has the highest performance cost. This approach simulates each hair strand and tries to mimic real life hair properties, it's often used for renders and vfx. (see figure 4.31).

Figure 4.31: Particle hair created using Xgen in Maya.

4.1.10   Clothes

For clothes we could make them with Marvelous Designer and try a methodology based on real life physics or sculpt/modelling them.

- **Marvelous Designer.** This software is really interesting as it mimics real life sewing. The artist creates patterns (see figure 4.32) in a 2D window and the program translates them into a 3D environment (see figure 4.33). The clothes are then simulated to emulate how they will look in real life. One advantage of this technique is that the clothes can be imported to a sculpting software and the folds of the clothes can be tweaked there.
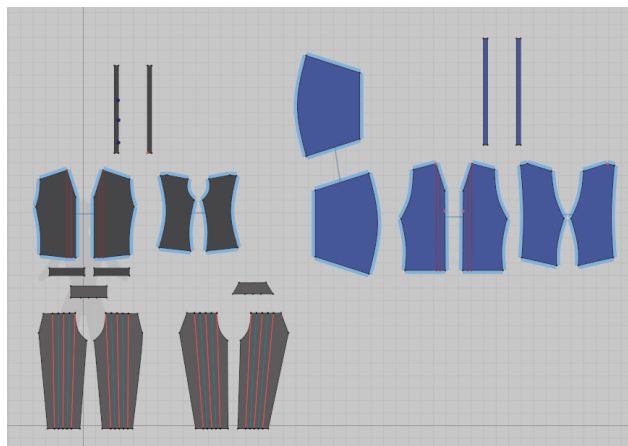
Figure 4.32: Marvelous 3D window with the clothes patterns

Figure 4.33: Marvelous 3D window with the clothes simulated.

- **Sculpting/modelling.** The workflow here is similar to the one used in the character, low poly model → high poly → details (if need it) → retopology → UVs → texturing.

With clothing it is up to the artist to choose which workflow he/she likes and obtains the best results with.

4.1.11 Rigging

Now that the character is finished it's time to create a rig so the character can be animated. The rigging process creates a skeleton (see figure 4.34) that will dictate how the character could be animated, maybe the limbs can stretch, the facial expression can be changed. . .
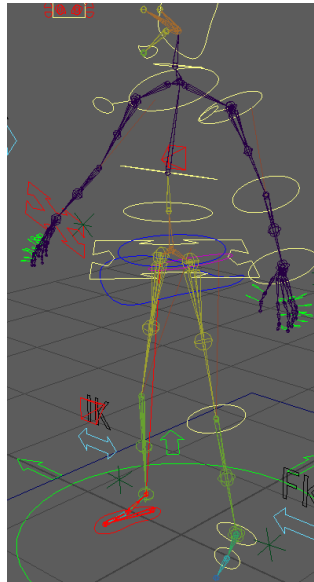
Figure 4.34: The skeleton created for the character

There's two ways of handling this process:

- **By hand.** It's the artist who's going to create the skeleton and the inverse and forward kinematics as well as the animation controls. A good practice to create the rig is to talk to the animator and see which kind of rig he needs the most. Different characters and productions require different rig systems, for example it is common in cartoon characters that the limbs stretch but that's extremely uncommon in realistic characters.

- **Automate.** A lot of softwares offers an automated rigging tool (see figure 4.35) that will look at the model and generate the necessary rig. This is really helpful for people that don't know how to rig or don't have the time for it. It comes with a disadvantage and it is that most automated tools only work for humanoid characters, so if the model needs a special rig it will most likely have to be done manually.
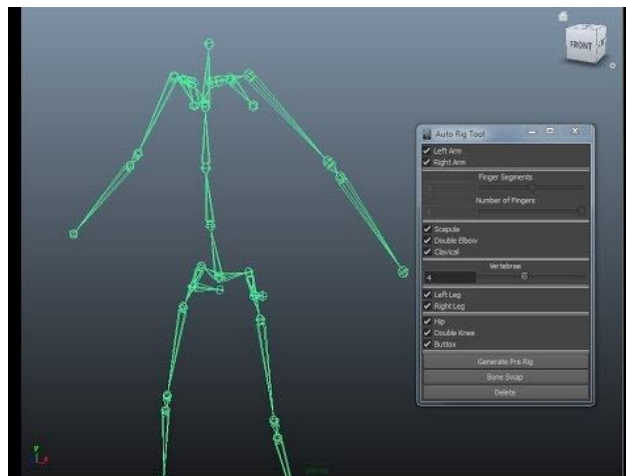
Figure 4.35: The skeleton created for the character

It should be noted that for any character to be animated, the skeleton must be skinned. This process consists of calculating which parts of the skeleton belong to the modeling we have. It is a process that can be done automaticaly in the software being used for rigging. The result will probably have to be retouched manually (see figure 4.36) so that the model deforms in a natural way. In manual form it is needed to paint a mask on the model (white has influence, black does not) to indicate which bone has influence on that part.
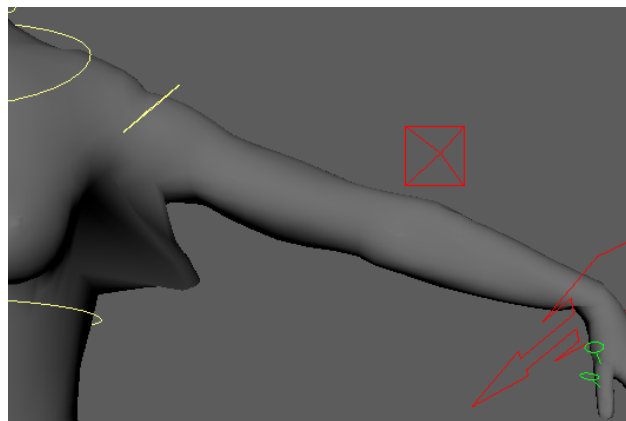
Figure 4.36: Character that needs the skinning phase to be retouched

The channel antCGi (see cite [3]) has an amazing series that covers rigging in depth so if you are interested in learning rigging or need some help in certain areas I'm sure it will help you.

I used the Mixamo webpage (see cite [1]). to create an automated rig for the character so I could export it into Unreal. While this page is incredibly awesome as it can be used

for rigging a character in minutes I recomend having a basic understanding of the rigging process as it will help you resolve all the different errors and mistakes that this webpage can create.

4.1.12   Animation

Sadly I couldn't do much in this field because I'm not an animator nor I have any previous knowledge about 3D animation. The best advice I can give to future animators is that the rigged model has some proper controls (see figure 4.37) so it's easier to animate, the animator shouldn't be moving the skeleton directly or even see it. One option to animate the character is to use already created animations and tell the model to use those animations. This video by the Unreal Engine Youtube page explains how to accomplish this workflow (see cite [7].
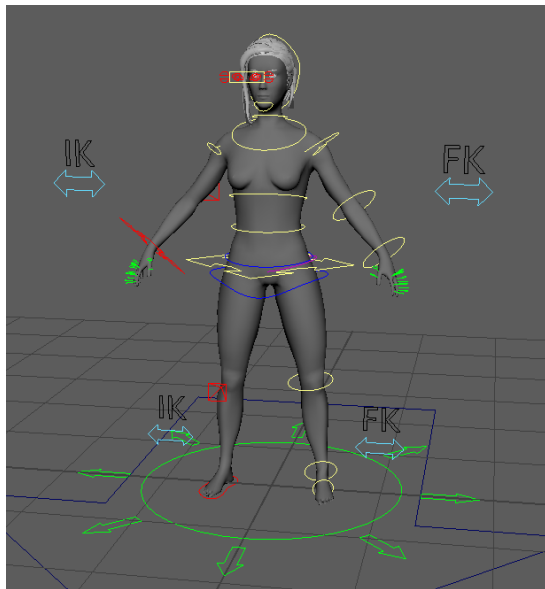
Figure 4.37: Rigging controls used to animate the character

One thing I investigated was the use of blend shapes, sadly my Maya file got corrupted and I can't show what I made. Blend shapes are deformations of a character body part, usually the head, and are used to make an array of expressions so the animator can quickly change between them as he sees fit. (see figure 4.38)
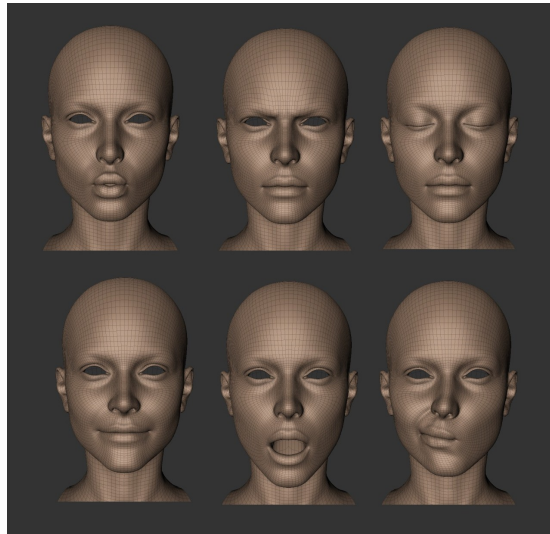
Figure 4.38: Tomb Raider blend shapes

4.1.13 Posing

Posing and rendering can be made in a wide variety of softwares so it's up to the artist to choose the one better suited for their workflow (see figure 4.39). If you want to create interesting poses and good looking renders I suggest checking renders made by artists that you like, as well as fashion and photography magazines to understand how and where to put the lights and which pose is the best suited for your character.
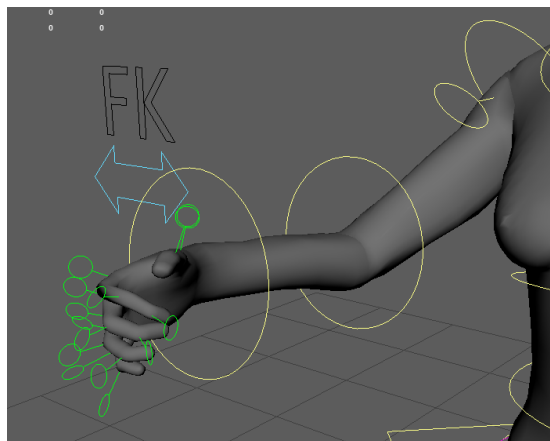

Figure 4.39: Character posed

4.1.14   Engine integration

There is not much to comment on this last section since it consists of importing everything previously created to Unreal Engine and checking that it works (see figure 4.40). I decided to import all the modelings first to Marmoset Toolbag and from there to Unreal since this way the textures will be assigned automatically and there is no need to touch Unreal's material editor.
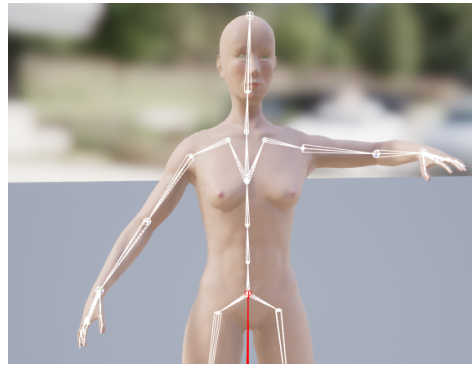
Figure 4.40: The character with the rig in Unreal

To check that everything worked I decided to create a scene where I would see the effect this character has on the performance of a game. To do this I duplicated the model created with a single texture and the one created using UDIMs until the frame rate dropped below 60, in total you can duplicate each one 128 times. The complete model I was able to duplicate it 96 times until the frame rate dropped below 60. If all the objects appear on the screen, about 352, the frame rate exceeds 30 fps.
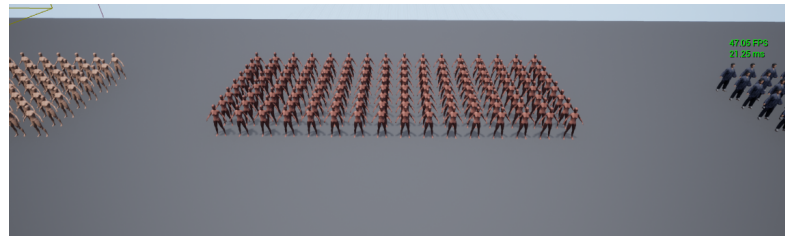

Figure 4.41: First Unreal scene

Although it may seem that these results are not quite good, it is quite the opposite because this character has been created imitating the main characters of any triple A videogame, so in truth there will never be such a large number of character entities in the same space. Normally the maximum amount of characters that are shown on screen at the same time does not usually exceed thirty, so the fact that it is able to appear more than 90 times before causing the frame rate to drop below 60 is a great achievement.

This was tested on a plain enviroment, what about more dense looking ones?

This scene has been downloaded from the Unreal marketplace and without any modification has an average of 90 frames per second. When adding the character there is no noticeable change to the frame rate. I can add the character more than 30 times to the scene and the frame rate varies from 60, in the worst case, to 80 which would be the average.

Figure 4.42: Second Unreal scene

To demonstrate that the character works in any type of scene I downloaded two more and the result was the same, the character works without any backlash.

Figure 4.43: Third Unreal scene

Figure 4.44: Fourth Unreal scene

4.2   Results

The initial objective of this final degree work was to obtain a realistic character that could be animated. At the end of the project this character exists and meets the requirements that I had raised but unfortunately I have not been able to animate it because I currently do not have the necessary knowledge to do so. Although I could create an animation where parts of the character went from place A to place B the result would have been quite mediocre, more like a check that the rigging is well done than an animation where the character is brought to life.

During this project I have created hair using different techniques, created clothes, as well as a rigg that makes the character animatable in its entirety. I had never done anything like this before and I am very happy to know that the final result has exceeded my expectations.

While it may seem that there are parts that have no disadvantage/advantage, this is because depending on the artist, and the way he/she works, there may be some techniques that seem essential to some and those techniques may be very slow or difficult to use for others. The important thing is to keep discovering ways of working and not to close yourself to new ways of doing certain tasks.

Here's a link with everything that I made for this project (see cite [13]).

With everything already explained, it is time to move on to the conclusions of this final degree work.

Let me know
Do I still got time to grow?
-Kanye West [Street Lights]

5

Conclusions and Future Work

Contents

5.1   Conclusions

Back when I was in college I wanted to know more about how video games are made, it seemed like a fascinating world that I would love to take a peek at. I chose this degree because it seemed like the perfect fit for me.

The first year of university was a bit hard, suddenly I had to learn a lot of technical things about computers, learn how to program, I even discovered that mathematics could be even more complicated. I failed quite a lot in the first and second semester. When the recovery period came, I failed a subject for the first time for the following year, Programming 1.

I remember coming home and crying, I had told my parents that this was the career I wanted, they had supported me and paid for it, I felt horrible. That summer I asked myself, am I good for this, is this what I want?

The following year we started modeling and I was fascinated by what could be done in a 3D environment, "this is what I want", "I want to do something cool", "I want to know more". From that point I always looked at the subjects that touched 3D with optimism, but whenever those subjects came what I received was a lot of useless and tedious information that did not teach me to be a better artist. To make matters worse, that year I had four subjects left for the following year.

I seriously thought about dropping out, but I didn't know what to do if I dropped out.

Should I go into fine arts? I'm not good at drawing, and it doesn't seem to be a career with many opportunities, so it might not be for me.

Do I do computer science? My brother has done that career and he has been doing well, besides I could be a programmer in a videogame company, but programming is not something I'm particularly good at.

I just decided to go ahead and see where I ended up, after all, I don't think I had a bad time in university. I've made new friends, I've had fun, there have been subjects that I've enjoyed and where I've felt like I was learning. Deep down there is still that feeling of wanting to make games or participate in their development.

Every time we had to make a game for a subject of the career we always ended up tired and with the feeling that we had to do it alone. But still every time someone saw or tested the game you had made and told you that it was good, you felt somehow comforted. "Look at that video game we made". I think it was that feeling that pushed so many of us into this career.

I did my university practices in a small escape room in Valencia, Mind Trips, that wanted to mix 3D environments with practical ones. It was a pretty cool experience and I learned a lot, but everything that I did was so distant from the things that I had to do in the degree that all I could think about was: why didn't anyone teach me this? Why did I have to spend so much time learning su much useless stuff? I had the exact same feeling making this TFG.

I'm doing things that are, and have been, a standard in the industry for years, why don't I know anything about them? I didn't expect to start this TFG with everything figured out but at least something to hold on to, I had to stumble around in the dark which cost me so many mistakes.

I did the character low and high poly twice, the retopology three or four times, which means that I had to do the UVs three or four times as well. I had to do the hair cards three times and twice it's textures, and when I finally moved into the sculpted hair I ended up doing it four times because I didn't know exactly what direction I needed to follow. The texturing was made only once, with a lot of adjustments, but I changed a lot of things in the retopologized model because things weren't looking good when the texture was applied to it. The rigging was done twice and I was lucky to find a free tutorial that covers that field entirely. And when I exported things into the engine the scales were wrong and it didn't look like it should, so I had to go back and make adjustments so it looked better. I wasted so much time and effort in things that weren't addressed in a Video Game Design and Creation Degree.

Although it may not seem like it, I enjoyed doing this TFG. I think I am a little bit good at it and I would like to see how far I can go.

Seeing reports of other years you can feel a sense of confidence that I have not acquired. There is so much I still have to learn and improve that it is a little scary. This is how I'm going to go out into the working world and I don't know if it will be enough. The road ahead of me is very long, I hope that later I can look back and say

that everything went well, that the future that awaits me is a good place.

5.2 Future work

I don't think that I will do anything more to the character once I send everything needed for the TFG. Well I'll probably make some renders so I can show my work but that's it, I started it in February after the final exams of January and have worked on it pretty much every day, not necessarily six hours every day but still worked on it.

After so much time has passed all I see are things that could be improved, don't get me wrong I'm proud of what I made, hell I made an entire character all by myself and learned so many things that proves to me that it was some time well spent.

But everytime I see what other people are making, all that comes to my mind is that what I made isn't good enough. I think that comparing yourself to others is really stupid, because you know nothing of those peoples or how they see their own art, I should compare myself to me back when I started this TFG. I wish I was the person that I am now, but still that feeling lingers. Am I good enough?

The only thing left for me in this degree is this TFG and an exam in Computer Graphics. This time will mark my sixth attempt, but the first one I only went to see how the exam was going to be, and if I don't pass it this time I don't think that I would be able to care about it anymore. After everything is done I still want to make more characters, more hairstyles, more clothes, I want to keep improving and keep moving forward but, where?

The next step should obviously be getting a job, but I don't know how. Everytime that one course of college ended there always was another one waiting for you, life was pretty much figured out for you. With university it's the same, there's some classes that you should go to every week and once one year is over another one starts. Soon university will be over and what will be waiting for me it's just a void, there's hundreds of companies that I wish I could work in, but, will they want me?

I know that I shouldn't worry this much about all this stuff, but I can't get the thought off my head that I'm not good enough, but still I made all this by myself, and there's lots of things in this project that I had never done before.

I can accomplish more things than I redeem myself capable of. If I was able to make this journey, I think that I will be alright.

Bibliography

[1] Adobe. Mixamo web page. https://www.mixamo.com/#/.

[2] Adobe.   Substance   painter   download   archive.
     https://www.substance3d.com/subscribe/.

[3] AntCGi. Rigging series. https://youtu.be/uzHn_4ByyjY.

[4] Autodesk. Maya 2022 download archive. https://www.autodesk.mx/.

[5] Canva. Canva web page. https://www.canva.com/.

[6] Lucas Cuenca. Splitting the mesh. https://youtu.be/VYsolWxO3yc.

[7] Unreal Engine. Unreal engine retarget animation. https://youtu.be/JkcJ5bjGPsg.

[8] CLO   Virtual   Fashion.   Marvelous   designer   download   archive.
     https://www.marvelousdesigner.com/product/download.

[9] The Foundry. Udim explanation. https://learn.foundry.com/modo/901/content/help/pages/uving/udim_

[10] Epic Games. Unreal engine 4 download archive. https://www.unrealengine.com/en-
     US/download.

[11] HDRI haven. Hdri haven web page. https://hdrihaven.com/hdris/.

[12] Pixology Japan. Sculptrispro workflow. https://youtu.be/T4tpoAxDg9Y.

[13] Pablo Morro. Tfg files. https://drive.google.com/drive/folders/1QR4swygTeWpV4Tjcbuk91XWqJ8TzDTe

[14] Idyllic Pixel. Pureref download archive. https://www.pureref.com/download.php.

[15] Pixologic.   Hd-geometry.   http://docs.pixologic.com/user-guide/3d-
     modeling/modeling-basics/subdivision-levels/hd-geometry/.

[16] Pixologic. Zbrush download archive. Pixologic.https://store.pixologic.com/zbrush-
     academic-license.html.

[17] PluralSight.   Dynamesh explanation.   https://www.pluralsight.com/blog/film-
     games/add-dynamesh-sculpting-workflow-flexibility.

[18] Steve Roach. Texture maps definition. https://en.wikipedia.org/wiki/Texture_mapping.

[19] Substance. Dirt modifier. https://docs.substance3d.com/sddoc/edge-dirt-159451230.html.

[20] Texturingxyz. Texturingxyz web page. https://texturing.xyz/.

[21] Texworks. Text editor used for the document. http://www.tug.org/texworks/.

[22] Toolbag. Marmoset toolbag download archive. https://marmoset.co/.

[23] Wikipedia. Uv mapping. https://en.wikipedia.org/wiki/UV_mapping.

[24] Jonathan Williamson. Retopology definition. https://cgcookie.com/course/introduction-to-retopology.

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