

Czech University of Life Sciences Prague

Faculty of Economics and Management

Department of Information Engineering



Bachelor thesis

Comparison of software for creating 3D graphics

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BACHELOR THESIS ASSIGNMENT

Ladislav Vondruška

Informatics

Thesis title

Comparison of software for creating 3D graphics

Objectives of thesis

Bachelor thesis is focused on problem of software for creating 3D graphics. The main objective is comparison of selected software based on chosen criterion with creation of project. Partial goals of this work are:

- characteristic of development PC 3D graphics,
- summary of usage of 3D graphics.

Methodology

Methodology of the bachelor thesis is based on study and analysis of specialized information sources. The practical part is focused on comparison of selected software programs for creating 3D graphics based on selected criteria with the subsequent implementation of the sample output. Based on a synthesis of theoretical knowledge and the results of own solution, the conclusions of the thesis will be formulated.

The proposed extent of the thesis

40 – 50 pages of text.

Keywords

graphics, 3D, maya, mudbox, 3ds Max

Recommended information sources

DE LA FLOR, Mike a Bridgette MONGEON. Digital sculpting with Mudbox: essential tools and techniques for artists. Burlington, MA: Focal Press, c2010. ISBN 978-0-240-81203-8.

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NAAS, Paul. Autodesk maya 2014: essentials. Indianapolis, Ind.: Autodesk, c2013. ISBN: 978-1-118-57507-9

PALAMAR, Todd. Mastering Autodesk Maya 2015. ISBN: 978-1118862513

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Prague on 13. 03. 2018

Affidavit

I declare that my bachelor work "Comparison of software for creating 3D graphics" was elaborated independently under the guidance of the bachelor thesis supervisor and using specialized literature and other information sources quoted in the thesis and listed in the list of used resources at the end of the work. My bachelor thesis further declares that I did not infringe the copyrights of third parties in connection with its creation.

In Prague on

Acknowledgement

I would like to thank Ing. Pavel Šimek, Ph.D. willingly providing the necessary information and advice for preparing the bachelor thesis.

Comparison of software for creating 3D graphics

Porovnání software pro tvorbu 3D grafiky

Summary:

This work is focused on problem of software for creating 3D graphics. The main objective is comparison of selected software based on chosen criterion with creation of project.

Chosen software is going to be compared on based criteria with subsequent implementation of the sample output. Based on a synthesis of theoretical knowledge and the results of own solution, the conclusions of the thesis will be formulated. Additional first partial goal of this work is also characteristic of development PC graphics, where each development step is analysed and then compared to previous step and one going after last one. Second partial goal is also summary of usage of 3D graphics, based on research through data where 3D graphics are used, where they were used but are no longer used and where they have potential to be used in future.

Keywords: Graphics, 3D, Maya, Mudbox, 3ds Max

Souhrn:

Práce je zaměřena na problematiku software pro tvorbu 3D grafiky. Hlavním cílem je porovnání vybraného softwaru na základě zvolených kritéria s vytvořením projektu. Vybraný software bude porovnáván na základě kritérií s následnou implementací výstupního vzorku. Na základě syntézy teoretických poznatků a výsledků vlastního řešení budou formulovány závěry bakalářské práce. Dalším dílčím cílem této práce je také charakteristika vývojové PC grafiky, kde je každý vývojový krok analyzován a poté porovnán s předchozím krokem a krokem následujícím. Druhým dílčím cílem je také shrnutí využití 3D grafiky, založené na výzkumu prostřednictvím dat, kde se používá 3D grafika, kde byla použita, ale již se nepoužívá a kde může být potencionálně použita.

Klíčová slova: Grafika, 3D, Maya, Mudbox, 3ds Max

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Introduction

Graphics have a long history that dates back to the 7th millennium BC, when first font entries were recorded on the turtles.

Another important step, a breakthrough, could be considered inventive book printing in the 15th century, mainly associated with Johann Gutenberg. In front of it was invented only block printing, which worked on the principle that the page had to be carved into wood, or even cast, and then it could be printed out. This was extremely demanding and costly because every single page had to be produced manually. It was Johann Gutenberg who had come up with the idea of creating a matrix of individual characters that could be reordered and re-used, which was faster, more efficient, and especially cheaper. Thanks to this, the ability to print not just books more simply, but other things, such as leaflets, posters, but also newspapers became possible.

It was thanks to this simpler way of printing that the graphics that enriched individual creations grew, and although it was still quite complicated to produce, it was the first big step for the graphics we know today.

For the next step, it is consider to be the creation of the computer that has propelled printing even further. It has made everything much easier, quicker, and also greatly reduced production costs. From the outset, of course, computers were used for completely different purposes than books, but over time computers developed from huge machines taking the whole room to similar-looking desktop computers to computers as it is known today. So, at the beginning of the 21st century and at the end of the 20th century, the computer is almost in every home, and it is possible for graphic designers to create what is known as 2D and then 3D graphics. That is, using different programs to create such projects. Most of the 2D and 3D graphic designers started as artists, before they moved to work with computers. During 21st century, most of the movies, games and much more are created just with usage of 3D graphics or with help of 3D graphics to enhance experience of the consumer.

Objectives and methodology

The theoretical part of the bachelor thesis will deal with the history and development of 3D graphics in the world. Subsequently, the development from the beginnings to the present and the theoretical consideration of the development into the future will be presented here. The practical part is focused on the comparison of selected software programs for creating 3D graphics based on selected criteria with the subsequent implementation of the sample output. Based on the synthesis of theoretical knowledge and the results of the own solution, the conclusions of the thesis will be formulated. Once a sample is created, each individual selected program will be evaluated per the criteria, such as the identification of the benefits and drawbacks of the creation, the achievable result and the potential additional potential.

Methodology of the bachelor thesis is based on the study of specialized information sources, which includes the study of specialized literature, which deals with the creation of individual programs, individual procedures and the advantages of individual programs, through literature focusing on 3D graphics in general, animation in certain programs, and choice of materials, use and realism of lights and so on.

Theoretical part

1.1 Raster Graphics / Bitmap Graphics

One of the most basic and widespread types of 2D graphics known as Bitmap/Raster Graphics. The entire 2d image is composed of individual pixels. Those pixels that make up the picture just above the grid. This kind of graphics has its advantages and disadvantages. The main and indisputable advantage is that it is very easy to create and then save the image. Cameras, scanners, but also TVs are using this kind of graphics to store and display. Among the drawbacks is memory demanding, especially in case of higher resolution. Furthermore, the change in size leads to a deterioration in quality. In the case of shrinking and subsequent magnification, the grid changes, so the resulting product will be in much poorer quality than originally. Most used and well known programs to create Raster Graphics / Bitmap Graphics are: Photoshop, Gimp, Paint Tool Sai. In 3D graphics, Raster/Bitmap Graphics helps to develop a 3D model, mostly cause via art by artist who is able to create a vision of some object which is needed. [2, 19]

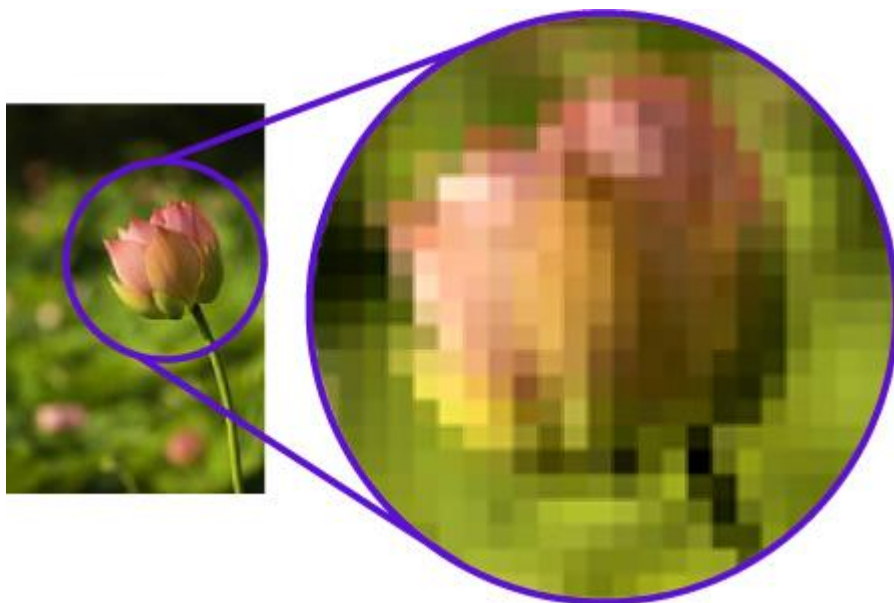


Figure 1 - Raster graphics [9]

1.2 Vector Graphics

Unlike raster graphics, the image is a single pixel of the grid. This means that the product is composed of basic shapes that have a predetermined value. It is thanks to this that it is possible to work with an object better than a raster object. Among the undeniable advantages is that when the image is reduced or enlarged, its quality remains the same, precisely because of predefined values and stored mathematical formulas that are re-counted in these operations. Also, thanks to easier storage, files are smaller if the object is simple. That is why this option is used mainly for creating different logos, 2D animations, and so on. The drawbacks are more difficult to capture an image.

Most used programs to create Vector Graphics: Adobe Illustrator, Inkscape, Vectr. In 3D graphics, all 3D rendering is done using 2D vector graphics techniques. [2, 19]

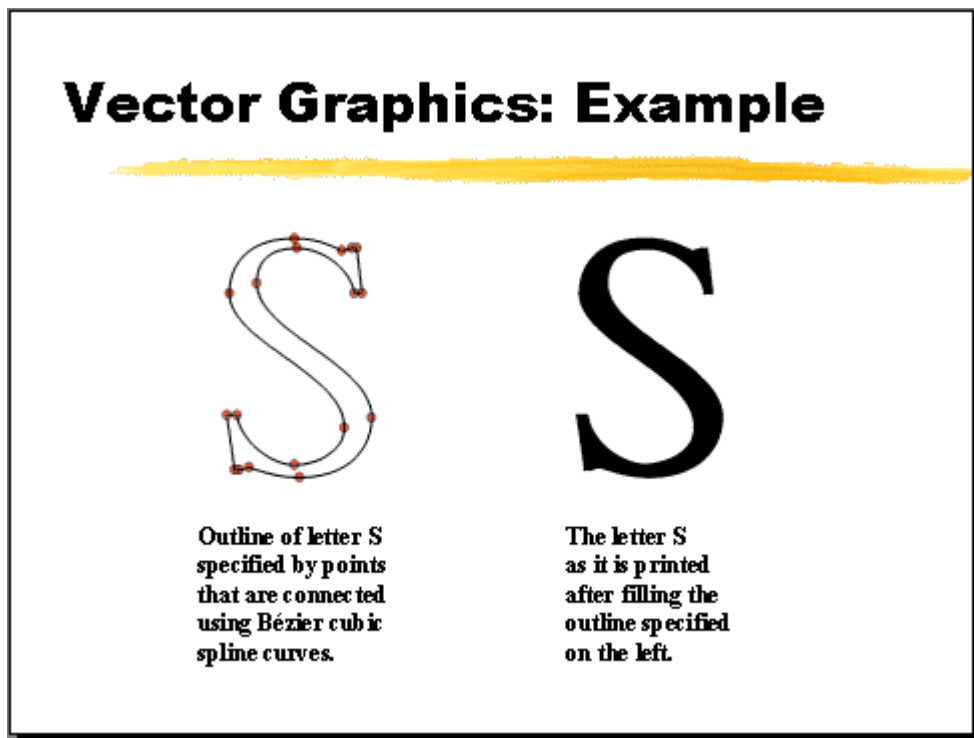


Figure 2 - Vector graphics: Example [10]

1.3 3D graphics

Unlike 2D graphics, three dimensions are used here. Therefore, thanks to this created object, it makes more realistic propositions than a 2D object, so it comes as much more realistic and believable. This style of graphics is mostly used in advertisements, CGI,

computer games architecture, design, but nowadays, thanks to the boom of 3D printers, it is also possible to model different products that can be subsequently created. [2, 19]

One of the biggest and greatest development of 3D graphics, it has been around since the 1960s. Leaders and creators starts with the University of Utah, where a project by David Evans and Ivan Sutherlands was established in 1968 and funded mainly by those two men. Using the help of students and students of this university, as well as students who have already studied this faculty, they have laid the foundations for computer graphics. It is worth mentioning that Jim Clark, who founded Silicon Graphics, Ed Catmull, co-founder of Pixar, John Warnock of Adobe, and Scott P. Hunter of Oracle, were among them. [20] Another important step for computer graphics was Henri Gouraud, who in 1971 invented the first form of polygon extermination called Gouraud shading. Henri Gouraud also collaborated with Dave Evans and Ivan Sutherland dissertation entitled Computer Display of Curved Surfaces. This technology calculates individual light values to the top of an object using a polygon. This is especially useful if the object on which the light is directed reflects light diffusively. It is a quicker and more efficient option for rendering. [20]



Figure 3 - Wife of Henri Gouraud – during face research [11]



Figure 4 - Gouraud shading - Sylvie Gouraud [11]

One year after the creation of Gouraud shading, Ed Catmull came up with Z-buffering, also known as depth buffering. It is the concept where all 3D pixels gained depth that is compared with stored buffer data that keeps the last known position of the pixel. This speeded up computing and rendering by a great amount.

In 1975, the new radical work of Bui Tuong Phong was introduced at Utah University. It was called Phong Interpolation, which is the way it should object to reflect the light. This is the effect when it compares the diversity of material and inequality. Phong Interpolation is much more complex than Gouraud shading because it uses multiple calculations. [19, 20]

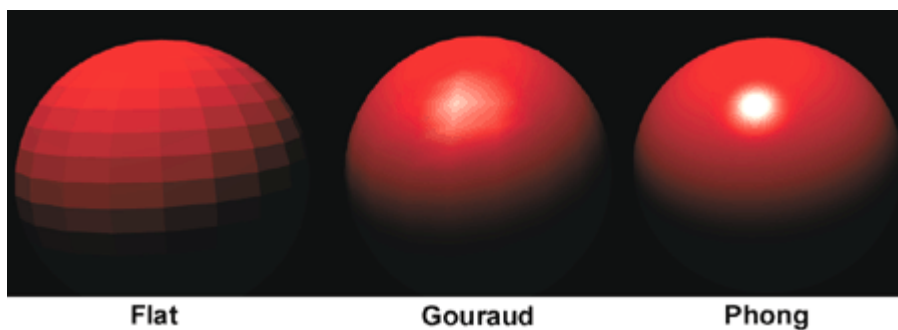
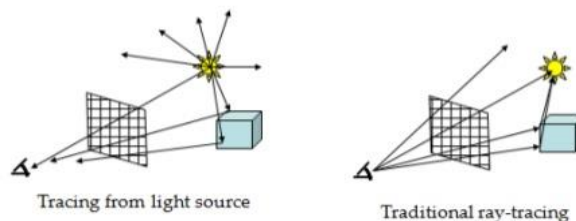


Figure 5 - Phong shading [12]

Another significant step in computer graphics was the so-called recursive ray tracing algorithm invented by Turner Whitted in 1979. This technology replaced the technology created by Arthur Appel in 1968. Technology named Ray Tracing was based on the principle of shooting a ray of the object until it encountered the object. Thanks to this, an algorithm has been created to calculate how the object should shine when the ray reflects, absorbs it, and so on.

The Turner Whitted algorithm extended three options, namely that when a single ray encountered a subject, they could generate three options: reflection, refraction, and shadow. The main drawback of this is the difficulty because each beam is calculated. After those, many more technologies and inventions were created, but those mentioned are one of the most important, creating the basis of 3D graphics as it is known today. And every invention after those till today are based on those, or on some other inventions which were based on those more basic ones. [21]

Ray Tracing from Eye



- Starting at the light position traces many rays that never reach the eye. Thus the traditional ray-tracing method is to start at the eye and trace rays back-wards to the source.

7

Figure 6 - Ray Tracing [13]

Future of 3D graphics really depends on numerous factors of current technology like HTC Vive, Oculus Rift and PlayStation VR. Biggest concern for most people is price, what is around 500\$ stand alone. With that, buyer needs rather powerful PC which can range even over additional 1000\$, or for PlayStation VR of extra price of 400\$, what is for some deal-breaker. At the very beginning of those devices, there was even problem with motion

sickness and even at current time some people are reporting that they are feeling sick using those devices. But it is clearly stated that it is not problem of device itself, but problem on side of the game-makers. Other than this, 3D graphics is still going to be used to create non VR-games, program and movies. [22]

1.4 3D project creation

There is a difference between the perception of a normal person and someone working with 3d graphics. A normal person takes everyday objects just as certain things how they are and sometimes how they were created. In history, it is mostly artists, who firstly started painting and then moved to the making of 3D works such as sculptures. That is why creators cannot take all the objects as they are, but they should realize a few relevant facts. One of them is how the object can look from all angles, not just from the current one. Sometimes, of course, one or two angles are sufficient in very rare cases, but it is mostly necessary to look at the subject from several positions to be able to understand how such an object is. The question then arises as to how this subject could be created more quickly and efficiently. There is an unlimited amount of progresses and how to deal with problems, but of course, the more effective it is to work, the better everyone is valued. Once it is evaluated, there are other factors, and these are materials. Each material affects how one or the other object looks, but also how it reflects the light. Glossy objects reflect and absorb light differently from others, so this must also be seen.

They are also followed by the question whether there is need to achieve photorealism or something else. For animated films, the objects will look completely different than when creator tries to model something from the real world.

Then there may also be the question of whether the object has relation to the space that is created. This will affect this material, and with advanced technology, it is not a problem for individual subjects to give not only a photorealistic look, but also weight and various other abilities linked to the material from which they are created.

But there is also the possibility that something is not lifeless, but it is a living person or something with an ability to move. Here, creator may experience a collision-making problem that the animator tries to prevent and the creator of the object tries to avoid. In the case of a collision, an object may be set to collide only with itself, with everything, only

with the surroundings or at all. Optional exceptions. Each of them has its advantages and disadvantages that can be practiced in different situations. In any case, they must not neglect, otherwise it could have fatal consequences in the project. [2, 19]

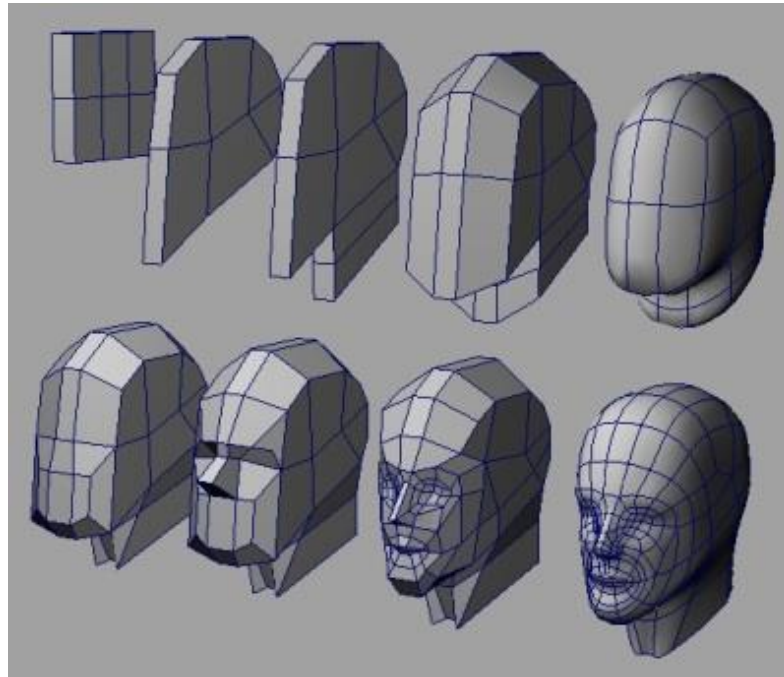


Figure 7 - 3D model creation [14]

Mostly, the final projects never form just in one program, because each has its own advantages and disadvantages. Some are intended more towards animation, some towards texture creation and others for the creation of non-living objects.

As an example, it is possible to design the creation of the main character for some animated film.

Everything usually begins with someone who has the idea and idea of what should look like. Here, it is drawn an art of that character, with various poses and features (Concept Art). To avoid the difference between the final product and the character's drawing, it is usually ideal to draw a character from multiple angles. It is then easier for the creator of the 3D object. [2, 19]

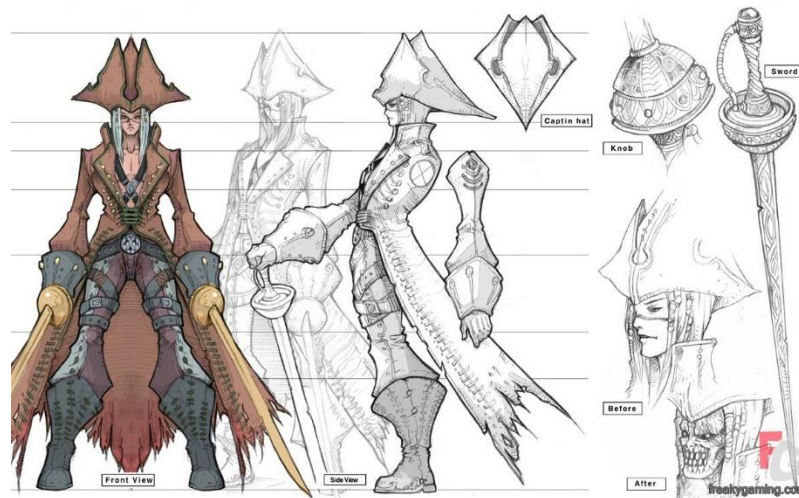


Figure 8 - Concept art for character creation [15]

In first program, create a model. Originally, these options were not, but now, there is an option to add bones, muscles, or organs and the like, either in the same program or in another. This is followed by using another program that will take this basic model to the end. Here it comes that there is no “ideal program” that is suitable for everyone and can do everything perfectly. Once the details and layout of the body are completed, textures are applied along with the animation that takes care of the various movements of the character already created. Of course, this can be created in one program, but mostly this work is spited among more programs than just one. Here, of course, there can be a problem with collisions, so this whole process can be repeated several times, but nowadays experienced creators are trying to prevent it during process of creation. With the built-in stand, animations are created to fit into the created world, and this finished product with many more factors, such as enlightenment, is then passed on, where the resulting product is made.

When the project starts and the creator appears in 3D space, he has an unlimited space on which to create. It works with three numbers, x, y, z, commonly known as "world coordinates"

The basic objects with which it is possible to work are tops, edges, and surfaces. Thanks to them, it is possible to create so-called geometric/standard primitives, which are line of segments and triangles. This also allows to create a relatively complex scene that would not go without the coordinates.

Geometric model has been created, it can be used for much more complex models. For example, creating a bicycle from a car can be replicated to create the entire car and this car can be copied several times to create a more complex scene.

When creating a single project, you need to pay attention to the value in polygons. The more polygons the object has, the more detailed it is, but the worse it can be workable for animators and later to optimize the whole project. The more polygons the object has, the harder it is for the computer to work with the object. There are various technologies that allow objects built further from the camera to have smaller values in polygons than objects that are closest to each other. This enables you to save power and simplify the work of computer technology that does not have to work with objects of large polygonal value, and this also leads to so-called optimization.

The polygons are mostly triangular, which allows us to work more easily with the object than if it was shaded. The polygons are shown in the so-called wire frame model. [2, 19]

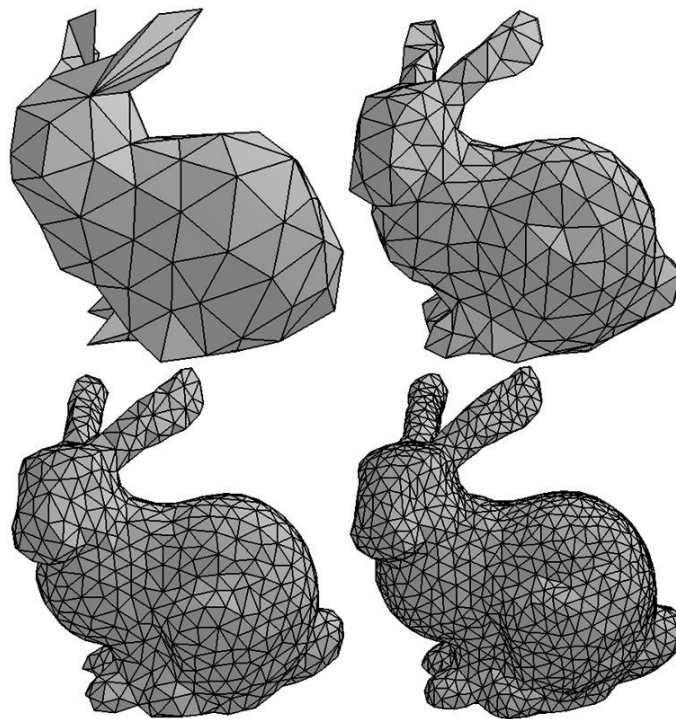


Figure 9 - Geometric Theory [16]

The project also includes a transformation that ensures that all projects are not on their own, or worse, in themselves. Thanks to this, it is possible to work with the object anywhere, not just the position where it will be the final picture. This means that, if

necessary, the object can work differently. Transformations include: magnification, shrinking, rotation, moving from point A to point B, shear. [2, 19]

1.5 Basic Objects/Standard primitives

Each program has its basic predefined 3D geometric shapes. They are called primitives in general, and the user can create the resulting object. All the programs among the basics include spheres, cubes, cylinders, pyramids, cones, but some of them also have a geosphere, a tube or a teapot. These objects have their own transformation capabilities, the main ones being the setting of the number of individual polygons that make up these objects. It is also possible to modify different polygons differently to such primitive primitives, which facilitates subsequent creation. [2, 4, 5, 6, 19]

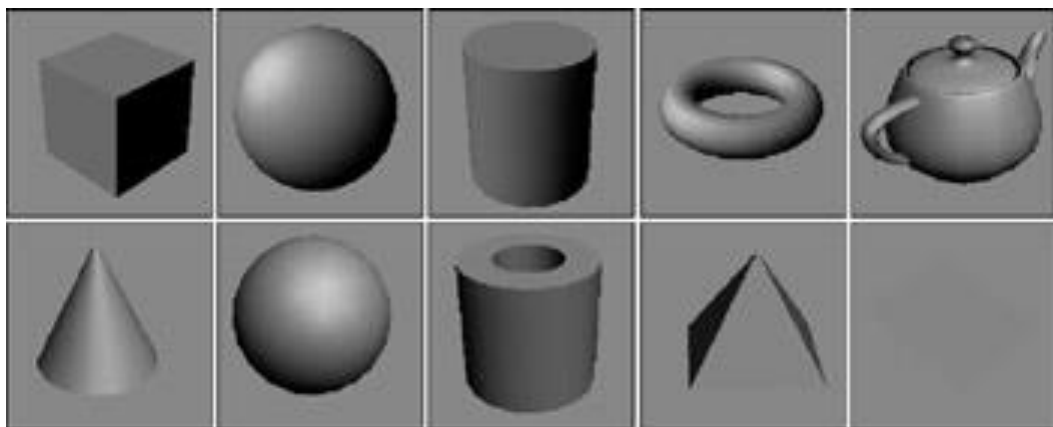


Figure 10 - Basic Objects [17]

Once the resulting project is created, using the various tools for editing objects in a project that differs from program to program, rendering is also known as image synthesis.

The biggest problem and computing load when 3D scene is to create a 2D scene / movie where the GPU is most loaded. It assists the processor in complex CPU calculations.

Because it is a most complex process for computer technology, rendering itself can take several hours, sometimes even dozens of hours, depending only on how complex the project is.

An acceptable outcome requires several important principles to be followed. The individual objects must be placed where they are supposed to be and at the same time the camera should be in a position where the scene can be appropriately captured. The

illumination of this scene must be sufficient, but it must not be too large, as it could result in a bad result. It all depends on individual materials. Everything is closed by a preview of the result that most programs will show before the product is exported. However, each program may have another result that depends on the rendering method.

The most common rendering result is either photorealistic rendering, where the effort is to get closer to reality. On the other hand, there is also a non-photorealistic rendering where rendering tries to render the scene as the creator wishes. This scene may not be close to reality and may only represent a certain unique style that could be created for such a project. [2, 4, 5, 6, 19]

Practical part

This part of the bachelor thesis focuses on comparing programs for creating 3D graphics. As the resulting model, a model of the generic character of a human being was used for which the reference model from the creator of the CG Cookie Concept (picture below) was used to help build a character. The goal of this project was not to create the exact shape of the chosen figure, but to compare the simplicity, usability, ease and realism of the final project.

When creating models in 3ds Max, Maya, and Mudbox, nothing has been used except what the programs offer. This means no downloaded textures, import assets created by someone other than the developer of this bachelor thesis.

This reference picture was chosen to help creator of project to create a human-looking object, which would closely resemble male human body. Goal was not to create completely similar looking human with all of the feature on chosen reference picture. 3ds Max, Maya, and Mudbox have been selected as one of the most used 3D programs for using 3D graphics and models. All of these programs are normally charged, but Autodesk has provided me free of charge with these programs in the Student Edition, which has all of the features as paid, except that the projects must not be monetized.

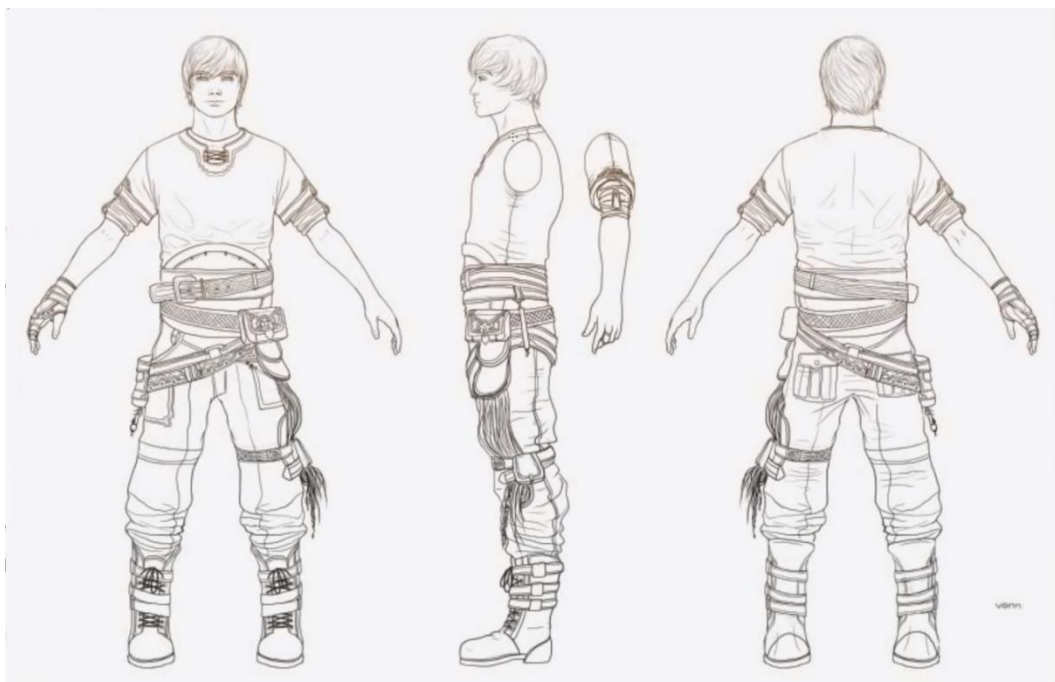


Figure 11 - Reference picture [18]

For each of the selected programs, a general description of the program, the environment, and the various features offered by the program. The following are pictures that describe the steps that have been created by the final project. These steps include the various functions that have been used and the evaluation of the individual steps, how easy it was to achieve the result. What made the problems, the stability of the program, but also what was missing in the creation of this step.

1.6 3ds Studio Max

1.6.1 Basic information about 3ds Max:

3ds Max or so called 3D Studio Max is a professional 3D graphics software from Autodesk. Large companies are using this program to create their products, products, or even to create or add a scene from some movies. For example, IKEA is known for having some of its products in its catalogues exclusively in this program. This program provides a wealth of customization for modelling, environment, rendering, and animation. It also offers the possibility to export individual models or other creations to other programs, not only to Autodesk software, but also to programs from other companies.

The Max 3D license is not paid in one instalment, but it is valid monthly, yearly, or three-yearly, at least on the official website of Autodesk:

The prices are:

1 month: 242,00 €

1 year: 1,936.00 €

3 years: 5.808,00 €

Autodesk provided the student version of the 3ds Max 2018, which has unlimited use, the ability to upgrade to a higher version that has additional features for creating this bachelor

thesis. However, when downloading, there is a warning that projects created in this program with this license are not intended for monetization, only for study purposes.

1.6.2 Workspace of 3ds Max

The main part of 3Ds Max is the window where project is being created, which is divided into four main views in the basic version, which can be changed anyway if needed. At the top left, you can see a view from above, next to it is a view from the front, then below the view is a view from the left and the last one is a perspective view that allows us to see the scene in 3D.

In addition to viewing the individual parts of the desktop, you can also set a view type that allows us to see the model in different perspectives, lighting, and the like. Also, there is a background setting if there is no gray-black background for that scene.

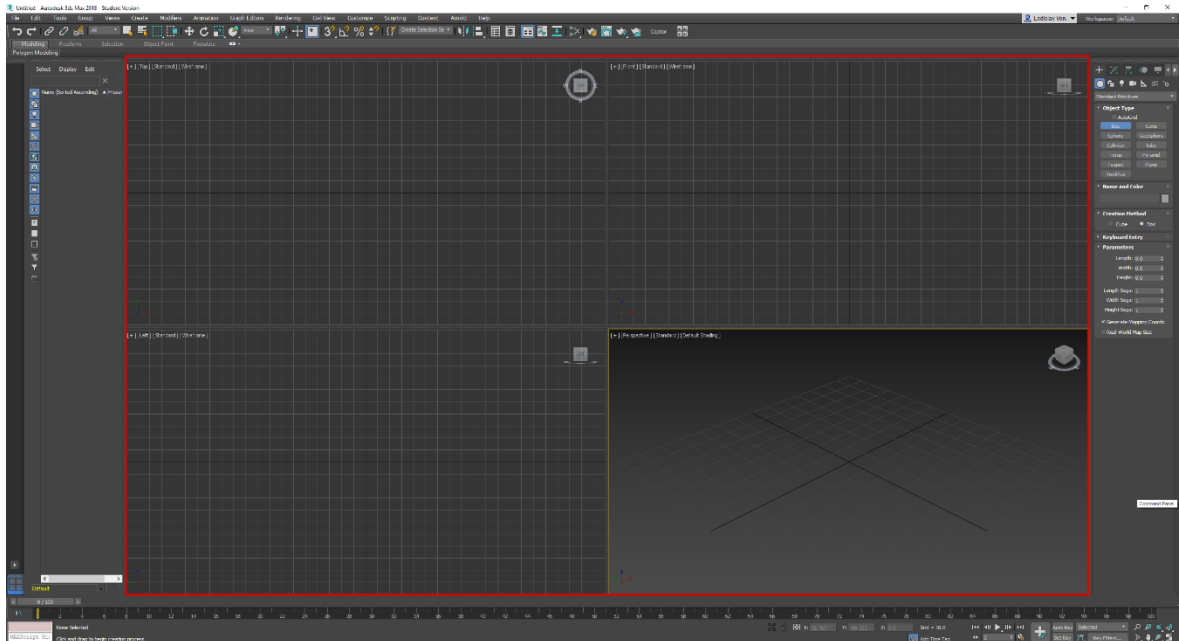


Figure 12 - Main window of 3ds Max

In addition to the work environment on the right, there is a window with standard primitives and other utilities, which are the basis for every project that is created here. This window also provides the ability to work with shapes, lighting, cameras, helpers, space warps as well as various systems. So to work with them and their work. When working with these, this window will also change to where you can work with different modifiers that vary according to the object you are working with. It is also possible to work with a hierarchy where the pivot settings (or the center of a given object) are used, motion, mainly used for animation, display, more display and work with what is visible in the workspace and last utilities, working with 3ds Max add-ons.

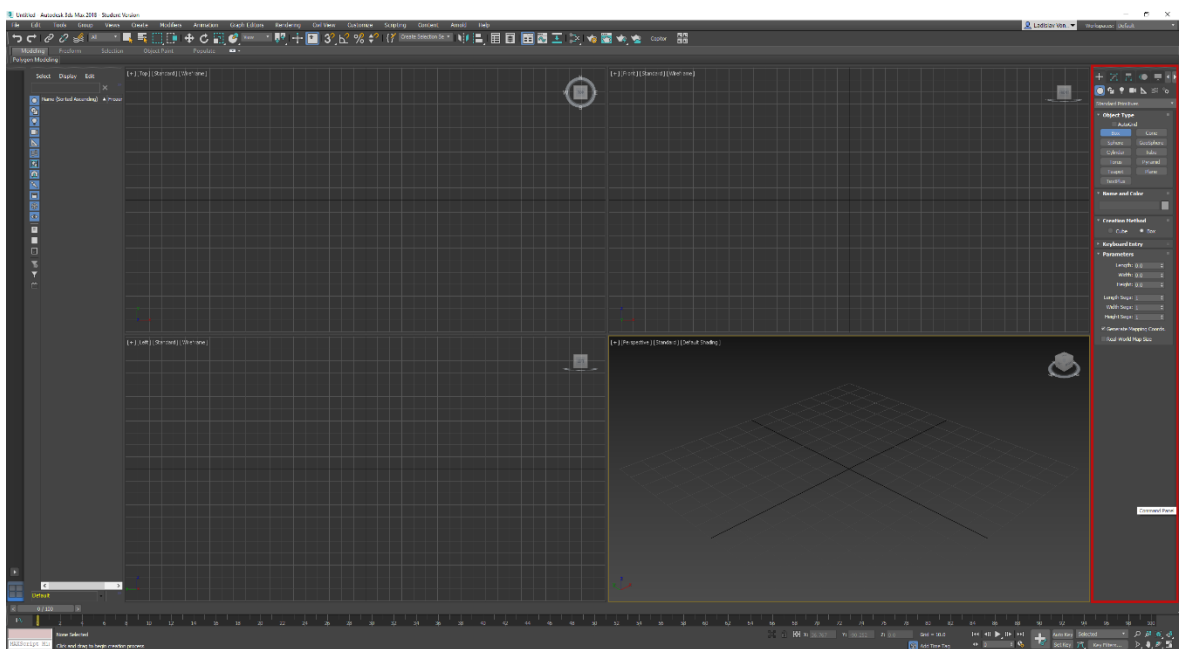


Figure 13 - Right window of 3ds Max

Another part of the 3ds Max program is the top panel, where most of the other features are not mentioned in the previous panel.

File provides working with files, from creating new projects, through opening, importing files to saving.

Edit provides work with a given project, step back, step forward, deletion, object movement, and various parts selection.

Tools gives you the ability to navigate individual scenes / layers, work with an object such as mirroring, but also measure distance from one object to another.

Group allows individual objects to add to groups, remove them from these groups, and then manage them.

View allows you to work with individual views, working with cameras, and setting individual views in the workspace.

Create is an extended version of the right window with multiple objects that are pre-created.

Modifiers contain generic modifiers that can be used at any time.

Animation lets you manage animation, track control and object movement, transformation, and rotation. There is also the management of individual layers in animation.

Graph Editor provides the ability to work with different tracks, create, store, and work with them

Rendering hides work with render settings, environments, working with render lighting, and of course the ability to render a selection or whole scene.

Civil View is designed for civil engineers and transport infrastructure planners to visualize projects that are related to their vocation.

Customize gives us the ability to customize 3ds Max as we wish, upload settings that we can download, and export this setting. Here's how to find units' settings.

Scripting provides the ability to create charts and scripts.

Content is here to redirect to a webpage: apps.autodesk.com

Arnold is a specific plug-in that was implemented in 3ds Max. It is a special render.

Help provides information about news, information, updates, changes, or provides help in the form of instructions.

Below these tabs is the work with objects, which is the most of the things we can find in the edit and tools tab, such as scrolling the project, rotating it, zooming in / out.

In the upper right corner, you can log in to an Autodesk account and also set up how your workspace looks.

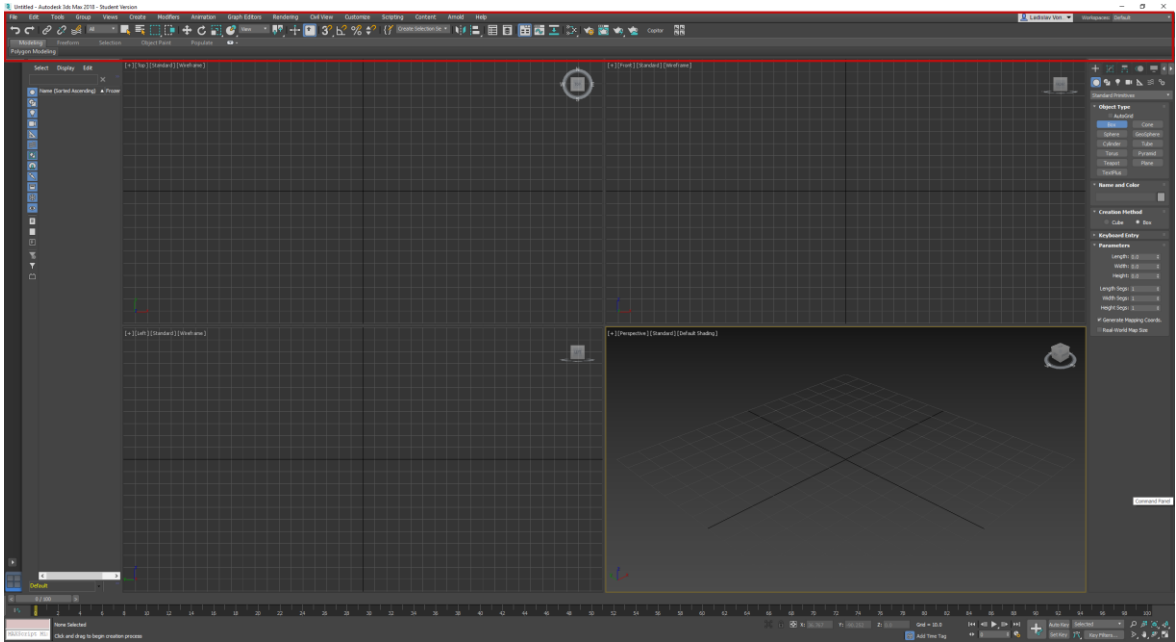


Figure 14 - Top window of 3ds Max

Another is the left window, which serves mainly for project orientation. If the project offers anything, we'll see it here. Subsequent work is possible, such as renaming, freezing an object, or even deleting it.

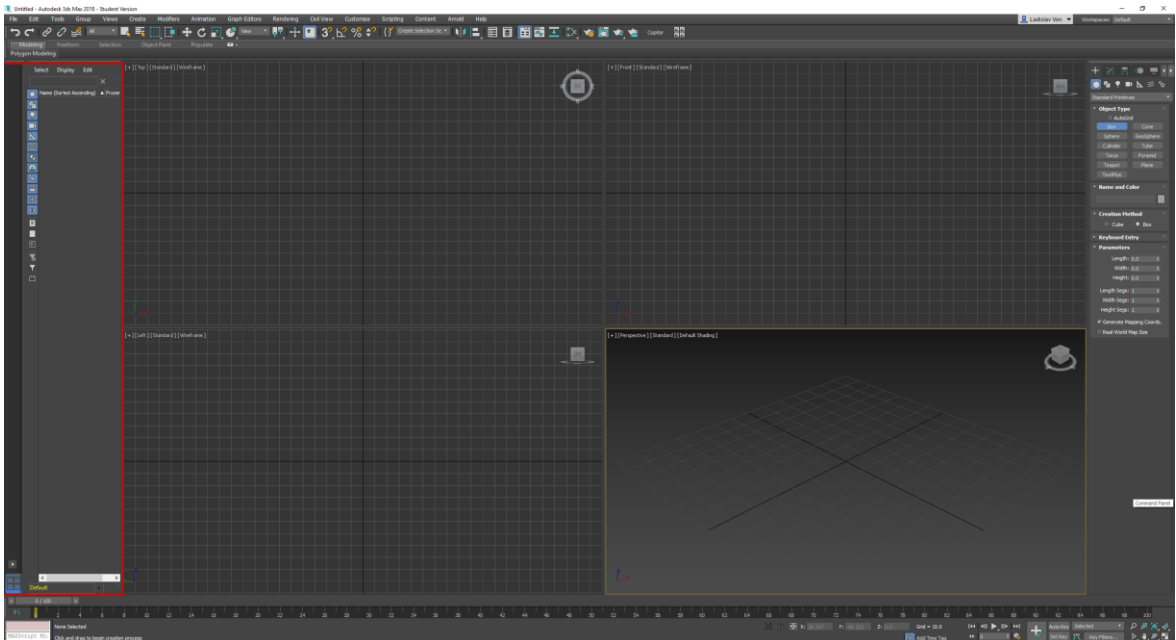


Figure 15- Left window of 3ds Max

The lower part of the 3ds Max program is primarily animated. The timeline can be adjusted with a simple slider. Below it is a window for working with the object and another window for working with the program using the Max Script scripting language. On the right side is the animation work, where you can run the animation, which will then be displayed in the window above. Of course, there is a stop, animation backward, forward, key frame settings and more work with an animation.

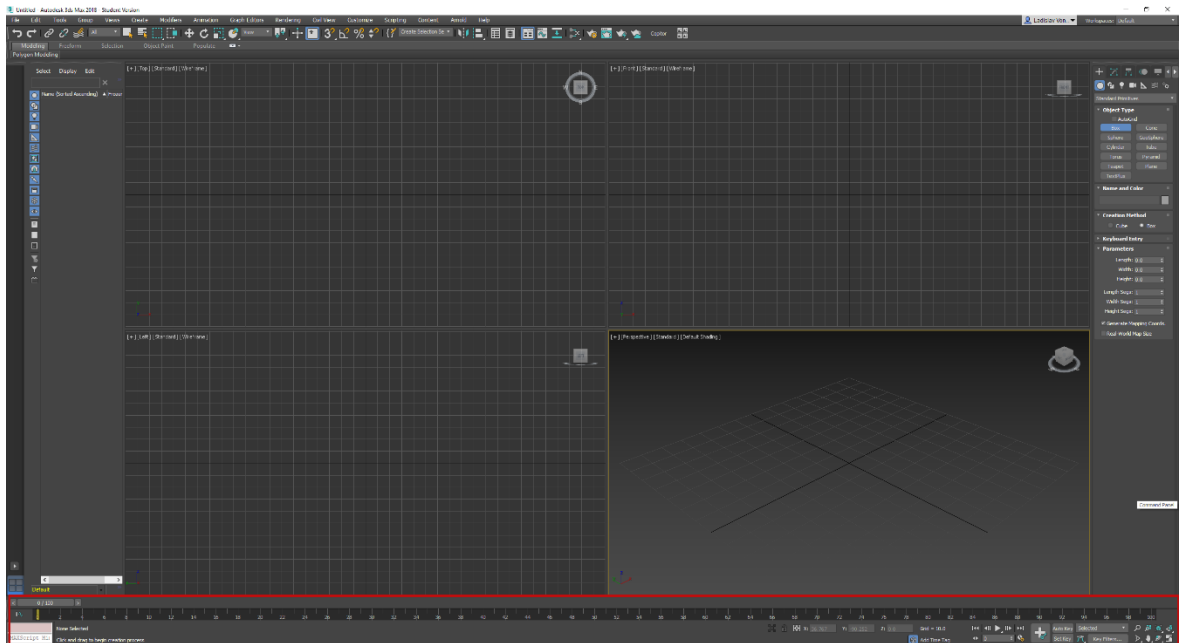


Figure 16 - Bottom window of 3ds Max

1.6.3 Project execution

The project was divided into four main parts, i.e. setting up reference, pants and shoes, body and hands, and finally head. In the 3ds Max, none of the objects could be used without importing already done models, so the whole model had to be created from scratch.

Setting up reference:

At the beginning, for a simpler creation, a plane was created on which the texture of the character selected for the project was applied. There was a minor problem with applying the texture correctly because the image did not exactly fit and had to be modified. X and Y

axes so that each individual surface has a sufficient distance from the object to be formed at the zero values of X and Y.

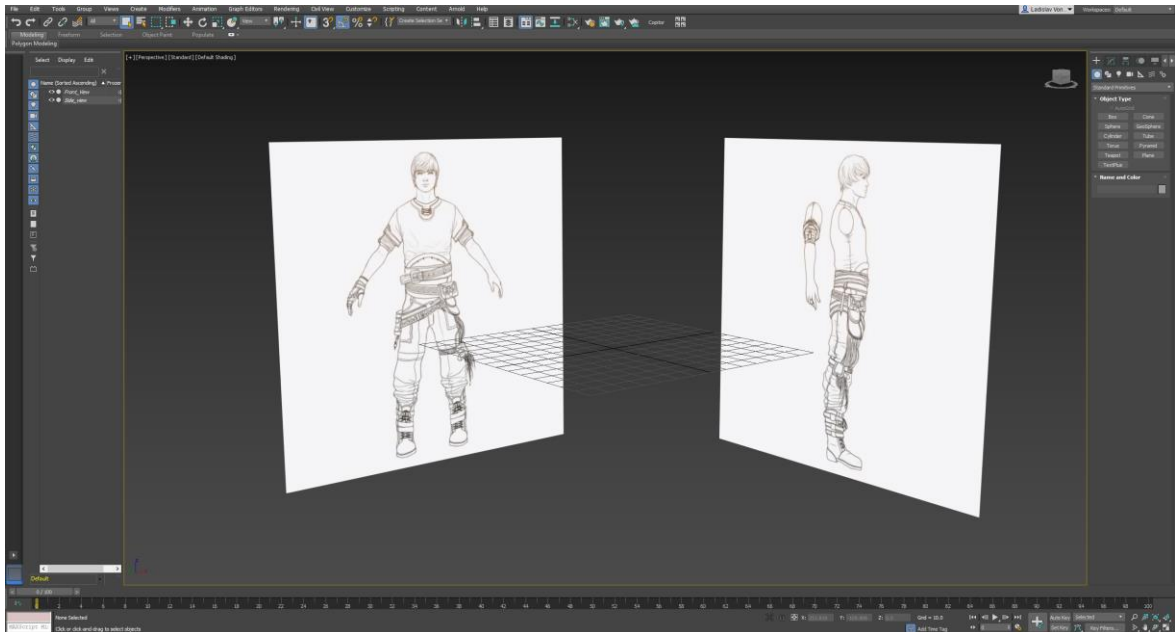


Figure 17 - 3ds Max - Setting up reference

Following was the creation of the hull, where the first bigger work with the features and possibilities of 3ds Max was used. The fuselage was created with the aid of a plane again, which was then pulled by the extruder to the edge of the character until the contour of the whole object was reached. Using the Swift Loop and Cut feature, polygons were gradually added to the required locations as throughout the project.

This whole object was created only halfway because 3ds Max offers the Symmetry option to mirror and update one object. This in this case was a better option than just copying the second part and then mirroring or mirroring itself.

The filling of these empty spaces followed by using the bridge and cap functions. Once the rib cage was created, work with individual edges and vertices followed to create the character hull that would fit that figure. When this was done, there was the creation of a hand, where we had to be weighed on the model's bumping points. This means that in the case of animation of this character, the object has a sufficient number of polygons. The same is true for texturing, which would be easier.

There followed the creation of hands, where work was much more complicated, thanks to the non-standard fingerprint of the character. On the hand, a standard cylinder primitive

was used, and so on every single finger, which had to be handed down together with the hand. The basic primitives were not far from the final result. When creating characters, the fingers are mostly stretched, which in this case complicates the object. The creation of fingers took longer than hull formation, because an abnormally large deformation during animation must be considered here. At the same time, it was necessary to think about the realities of individual joints and fingers. Once it was done separately, the arm and arms were interconnected.

The final step in this section was to create a simple T-shirt that was supposed to represent the model. Here was chosen the possibility of separating polygons, then creating a certain thickness of this garment and then deleting excess polygons that will not be seen any more. The last step was to link the individual parts of the fuselage to the t-shirt and complete the last few steps, such as fine-tune the deformation of the t-shirt covering the hull, or adjust the individual polygons.

Also, the TurboSmooth modifier was applied here, which will smooth the curves and give the model a much finer look.

The Relax Modifier has been used on the hands to adjust individual vertices that move away from each other, resulting in a much smoother result.

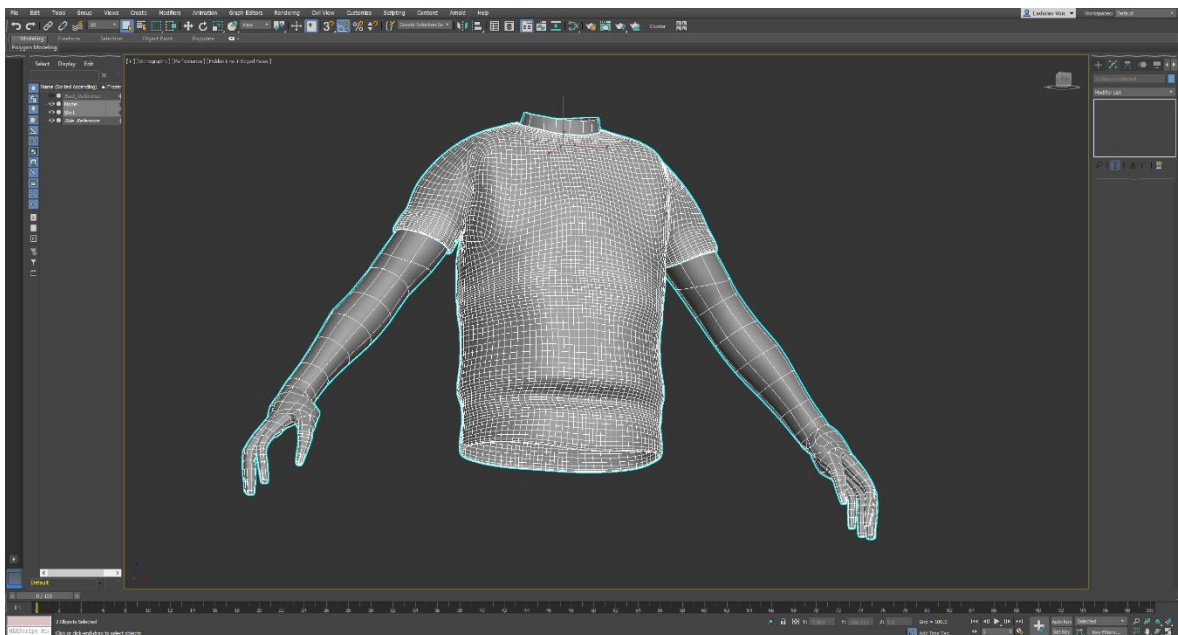


Figure 18 - 3ds Max - Body and shirt

After the creation of the body, the hands and the t-shirts followed the formation of trousers and boots. Since the character did not have the specified or indicated leg curves, only pants and shoes were selected.

As with the hands here, a basic primitive of the cylinder was created, which was pulled up to the level of the ankles and subsequently modelled to the desired result. Individual work with polygon edges and the TurboSmooth function has created the appearance of trousers folds. Symmetry has not been used when creating pants because of the variety of trousers on both sides. That is why it was necessary to attach individual edges to each other so that they did not overlap and at the same time did not create gaps between them.

After the creation of the trouser trousers, one of two boots was created, where another basic primitive, i.e. sphere, was again used. With the help of the above-mentioned functions and the individual movement of the edges, a boot was created. The bevel function has also been used to create a polygon in the middle of the polygon and link the edges to others and also to move the polygon as an extrude function. Also, the insert function has been used that works similar to bevel, but only creates a polygon.

Once the shoe was created, the TurboSmooth modifier was used again to achieve a smoother result. The boots and trousers have not been interconnected due to possible subsequent manipulation or possible addition of legs.

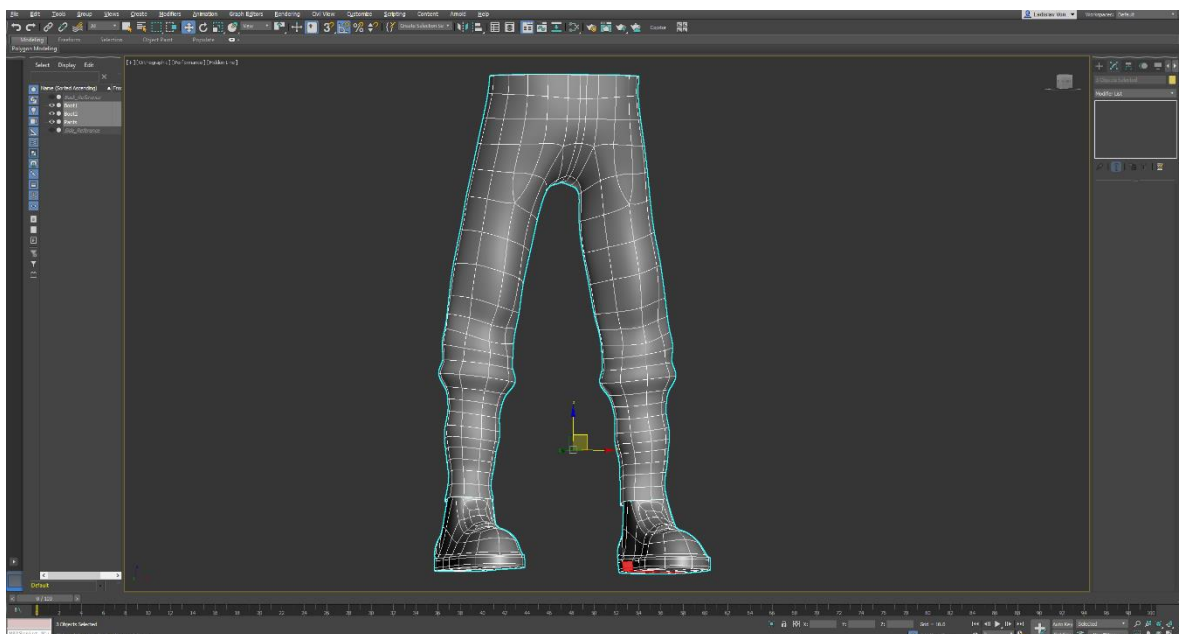


Figure 19 - 3ds Max - Pants and boots

The most complicated part followed the head. Here was the same procedure as the fuselage, but the individual headline connections had to be scheduled in advance. Due to the possible use of this model during animation, the individual polygons had to be arranged to provide sufficient opportunity for subsequent animation manipulation.

Moreover, because the refereed model did not provide enough insight into the construction and facial expressions, it was necessary to use the creator's experience with his face. Once the face was finished, individual adjustments were made, such as eye stitches, which must again have a large number of polygons due to blinking and the like. Once this was created, an eye was created using a simple primitive sphere, which was fine-tuned using the features already used to indicate the pupil.

One of the last steps was the creation of ears when the holes were cut from the finished head, and then they began to model the very simple ears that this head provided.

After that, the Symmetry Modifier and Turbo Smooth were applied to alter this model.

The last step was to connect the head to the body and create a neck.

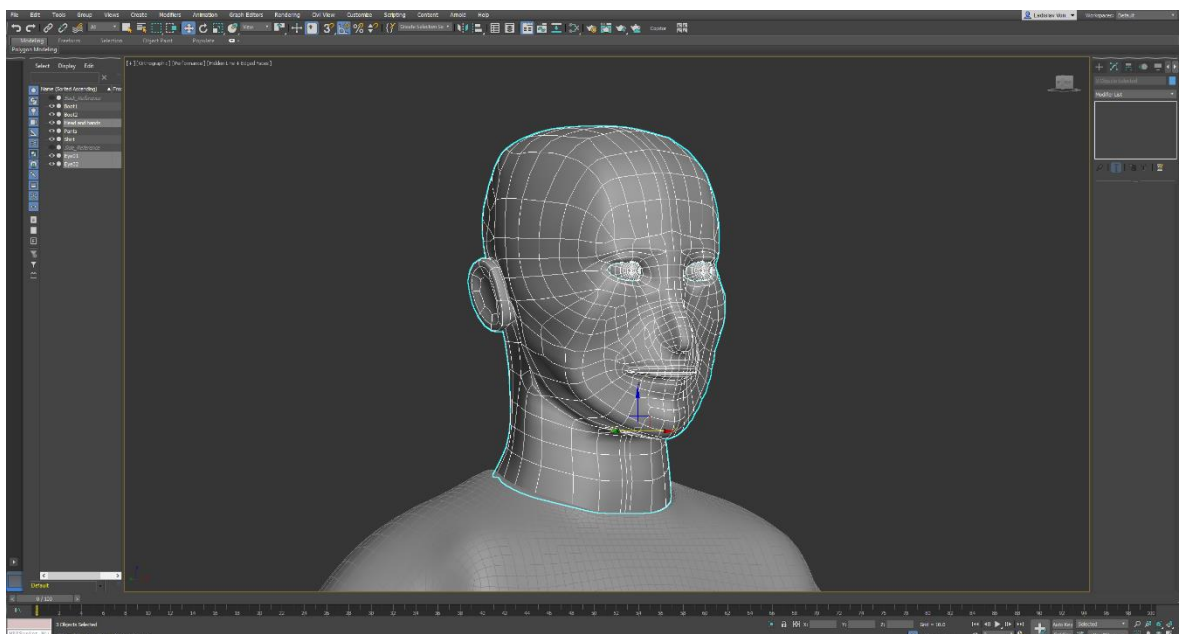


Figure 20 - 3ds Max - Head

The goal of this project was not to create a precise representation of the reference image, but to create a model that resemble of a male human and the reference picture was used only to assist in process of creating this project. It was also a test of Maya, where its strengths and weaknesses lie, how the performance was during work on this project, and what each program has to offer.

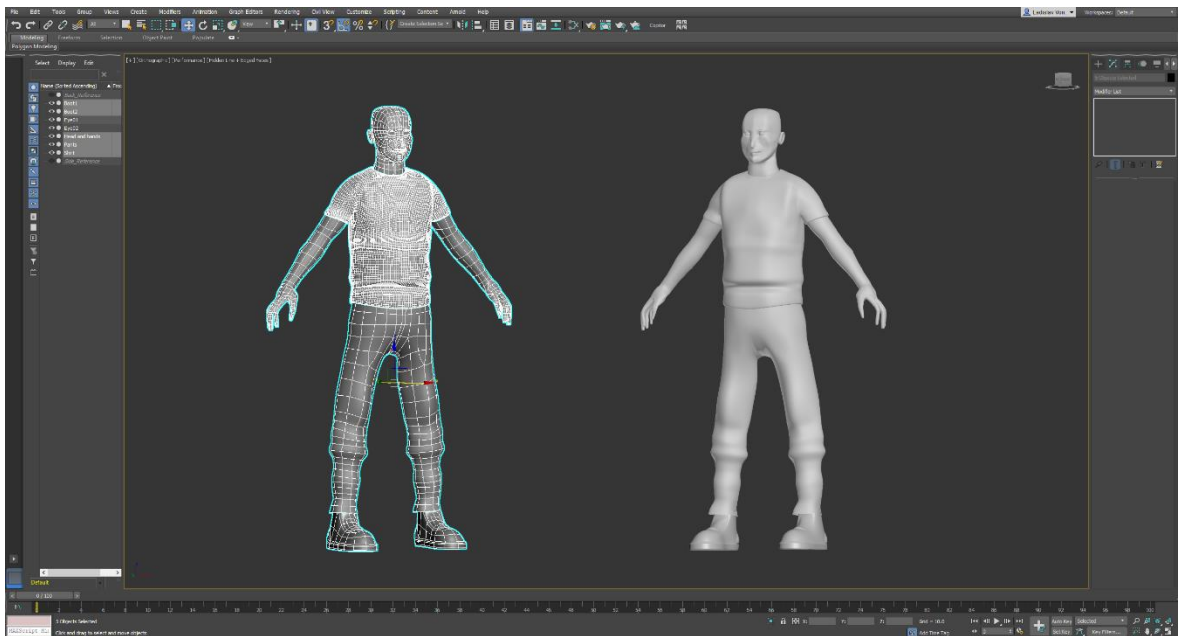


Figure 21- 3ds Max - Finished project

1.7 Maya:

1.7.1 Basic information about Maya

Maya is a professional 3D graphics software from Autodesk for creating 3D objects, animations, textures and rendering. In comparison with 3ds Max and Mudbox, this program is mostly used to create animations for characters, so that's why it is favoured mostly in film making. Autodesk is selling this program at the same price and variants like 3ds Max.

The prices are:

1 month: € 242.00

1 year: 1,936.00 €

3 years: 5.808,00 €

Autodesk provided the student version of the Maya 2018, which has an unlimited use, the ability to upgrade to a higher version that has additional features for creating this bachelor thesis. However, when downloading, there is a warning that projects created in this program are not intended for monetization, only for a study purposes.

1.7.2 Workspace of Maya

Similar to 3ds Max, the main part of this program is a centre screen where only a perspective view of the objects in the project is the default. Using the space button, this window is divided into four windows very similar to the previous program, where you can see the top view from the top, from the right perspective view, the bottom left view from the front and the bottom right from the side. Each of these windows, either selected or unselected, has settings for cameras, views, shadows, lighting and much more.

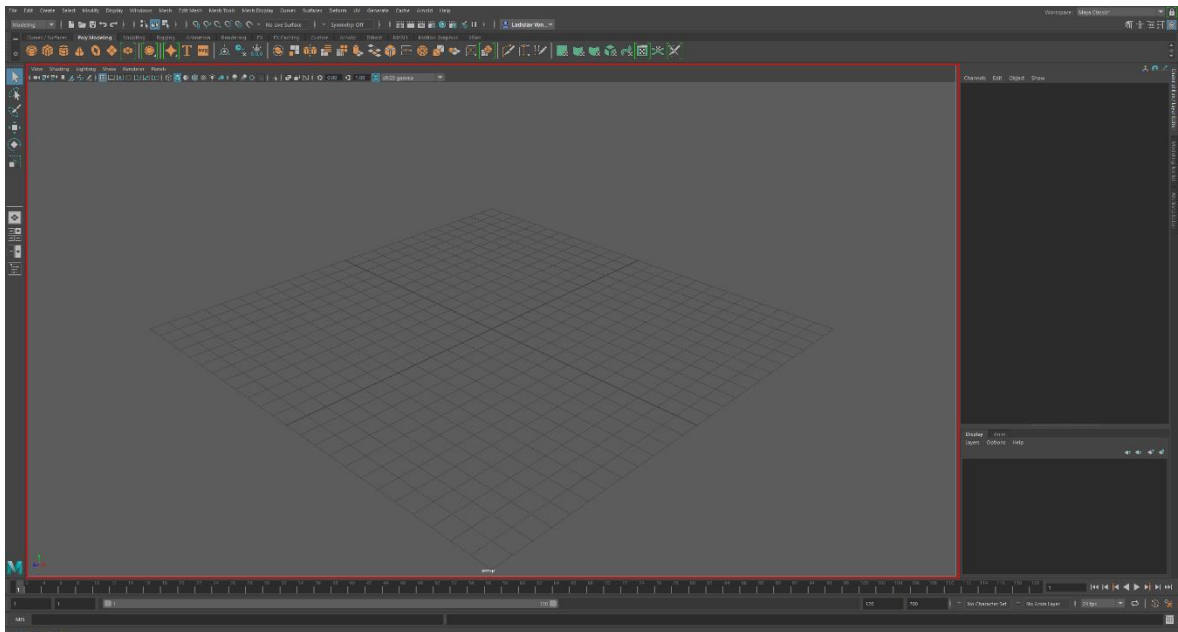


Figure 22 - Maya - Main window

To the right of the previous main output is a panel with individual channels, settings, objects, and individual attributes. When working with any object, different attributes, settings, are displayed in this window

Below this tab is the layer setting that works on the base of the groups. You can put countless objects in each layer, which then behave according to the settings of their assigned layer.

To the right of these tabs there are two sub-tabs. These features were on the Channel Box / Layer Editor tab.

Here is a sub-tab of the modelling toolkit, where some of the features are listed in the upper window (below) and in the Edit Mesh, Mesh Tools and Mesh Display tabs that can be found again in the top window. This is a quick way to work with the object without using tabs from the top windows.

The last subtitle is the Attributes Editor where you can set more detailed attributes for the selected object in the project. If no project is selected, the window is completely empty.

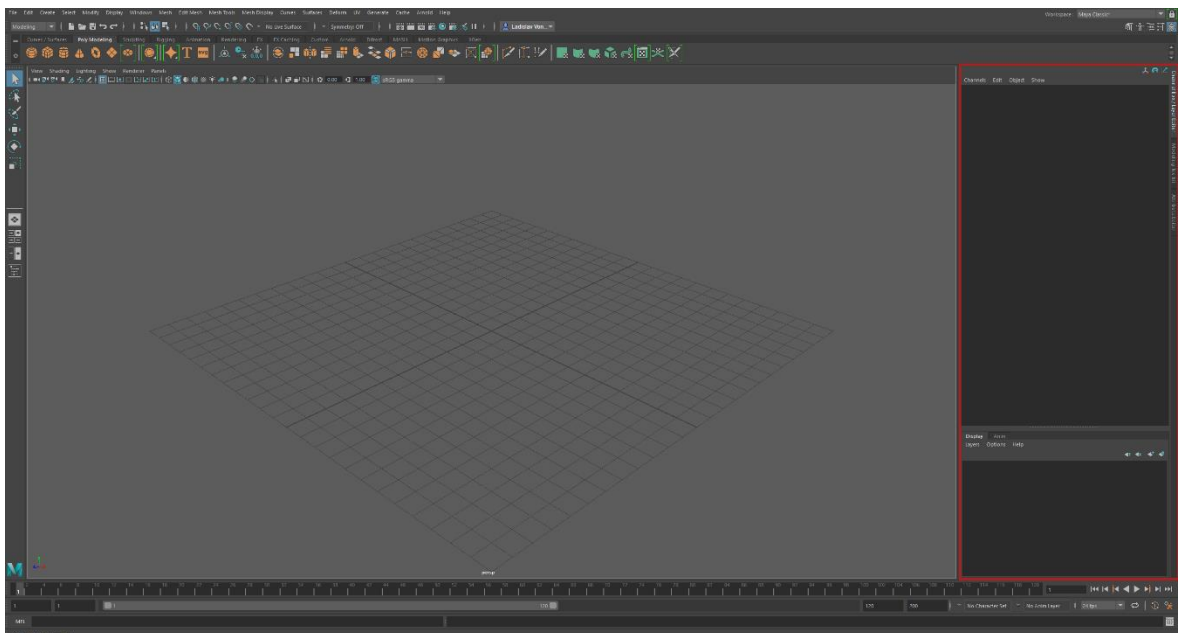


Figure 23 - Maya - Right window

On the left side of the main part of the work area of the Maya program there is easy operation and work with the project. Project selection, movement, rotation, magnification and shrinking. Below these options is the panel setting and the bottom of this window is the logo of this program, which opens the browser with the autodesk.com/products/maya/overview website.

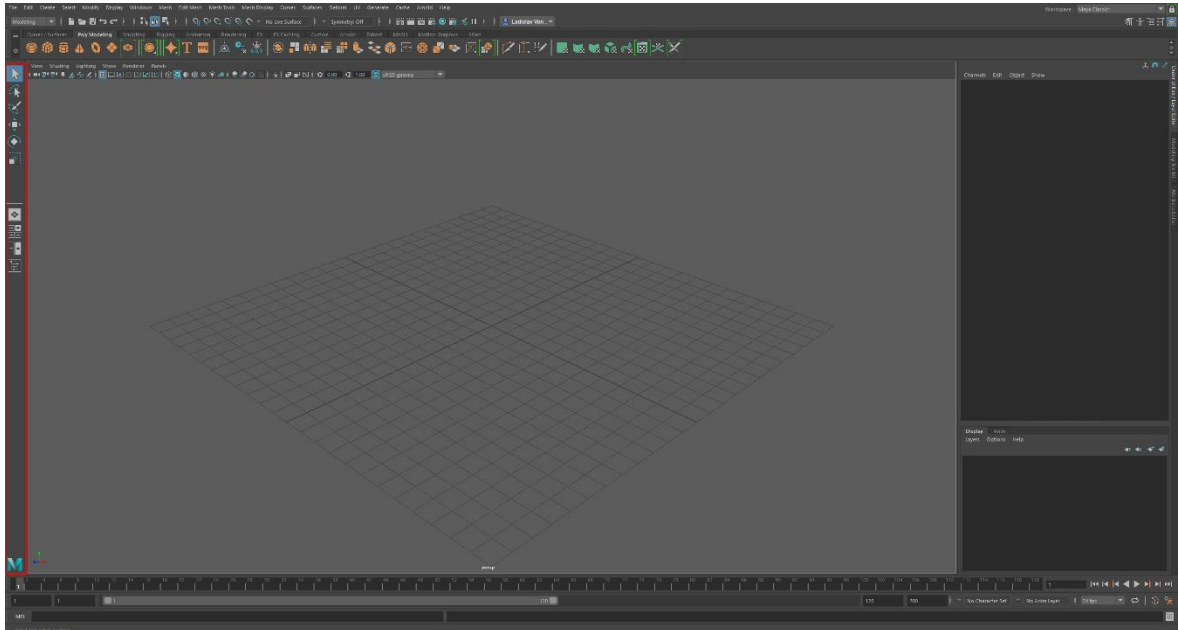


Figure 24 - Maya - Left window

The top panel provides most of the options with objects and with the project itself and the program itself.

File provides working with files, from creating new projects, opening, importing files to saving.

Edit provides work with a given project, step back, step forward, deletion, object movement, and various parts selection.

Create allows you to create individual primitives, such as polygon primitives, standard primitives, and more. We also find the scene lighting, the camera, but also the work with Curve tools.

Select lets you work with individual objects in a project, from selecting all, selecting all by type, and sorting them in the hierarchy. Also work with individual components.

Modify provides the ability to work with transformation tools, such as restoring, locking, or copying. There is also work with the Pivot of a given object, work with attributes, objects, assets and more.

The display allows you to work with objects, how they will look like animation, rendering, but also find the grid settings.

Windows allows you to customize the Maya program environment, individual editors and other elements.

Mesh / Edit Mesh / Mesh Tools, these three items offer the same and it is working with the object. First we find the functions for combining, remesh, mirror, transfer and finally optimization. In the second, there is more work with individual object components, vertices of the same object, edges, or entire polygons. In addition, it is possible to work with the curves created. The last of these three provides additional tools and work with individual polygons.

Mesh display is focused on working with object display, such as edge smoothing, vertebrate work, colour of individual vertices, normal, and display attributes.

Curves is an extended work with curves that was not included in the Mesh Tools. We can find the curves and edits here.

Surfaces provides work with project areas, creating and editing individual NURBS surfaces.

Deform allows creation of deformation of individual objects, editing and colouring of individual scales that can be assigned to an animation.

The UV editor allows you to interactively modify UV texture coordinates for individual polygons, whole objects, or just parts thereof in a 2D view.

Cache allows you to work with individual caches, such as Alembic Cache, BIF Cache, Geometry Cache, and GPU Cache.

Arnold is a specific plug-in that was implemented in Maya. It is a special render.

Help provides information about news, information, updates, changes, or help in the form of instructions.

Under these spells there is the possibility of further setting and editing of the environment.

Most of these other sub-tabs are contained in bookmarks above them.

Not covered in the upper tabs are:

Sculpting, a feature that is extensively featured in the next Mudbox program, which lets you work with an object like mud.

Rigging is the setting for animation when working with a project to represent a moving living object.

An animation provides additional elements that are linked to elements in the lower window (see below)

Rendering allows you to quickly access individual present renders.

FX and FX Caching is to set the effects in the project.

Bifrost is a procedural framework, a Maya plug-in that allows you to simulate fluid and aerodynamic effects.

MASH is mainly used in animation to create versatile motion design.

Motion Graphics is a superstructure of implemented elements in this program, allowing for greater flexibility in working with motion graphics during modelling, animation, effects and lightning.

XGen is a geometry instancer allowing you to add and populate the surface of polygon meshes by using an arbitrary number of other objects that are randomly generated and located on the object's surface.

At the top right, we will find the possibility to edit the workspace of Maya.

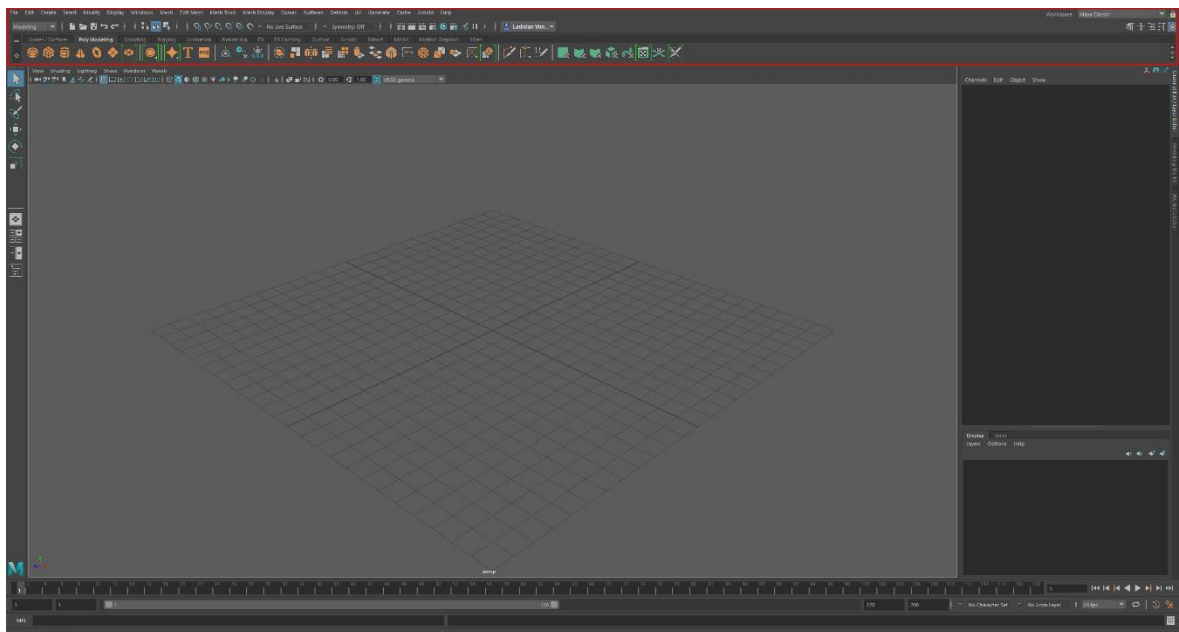


Figure 25 - Maya - Top window

The bottom part of the Maya program is mainly for animation. Here we find a timeline that can be adjusted using a simple slider. Right next to this is the ability to control just this animation, such as animating, animation stopping, forward, backward, and so on. Also,

there are settings in how many frames per second we want to see the animation, which is appropriate if we want to see how this animation looks at higher or lower shots.

Below the timeline is the MEL button, which allows us to switch between MEL and Python. Next to this button is a window for working with the program using individual commands.

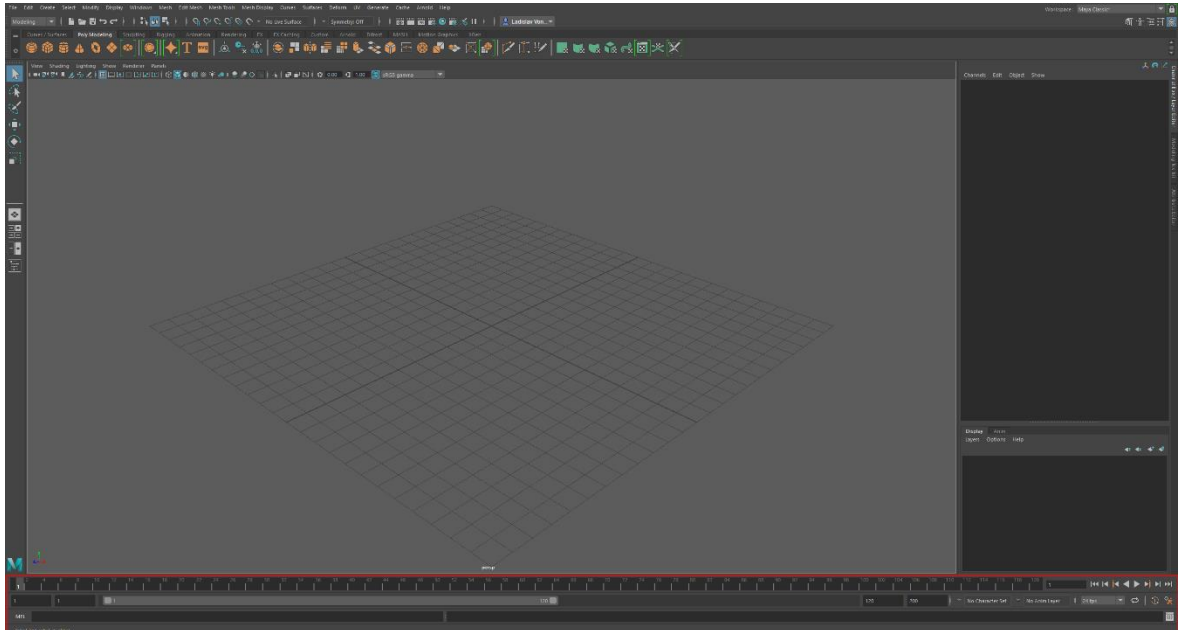


Figure 26 - Maya - Bottom window

1.7.3 Project execution

The project was divided into four main parts, i.e. setting up reference, pants and shoes, body and hands, and finally head. In the Maya, none of the objects could be used without importing already done models, so the whole model had to be created from scratch.

Setting up reference:

At the beginning, for simple creation, Maya allows for the straightforward implementation of references as selected for this project. That's why it was very easy to upload an image and then adjust the distance from the centre as needed.

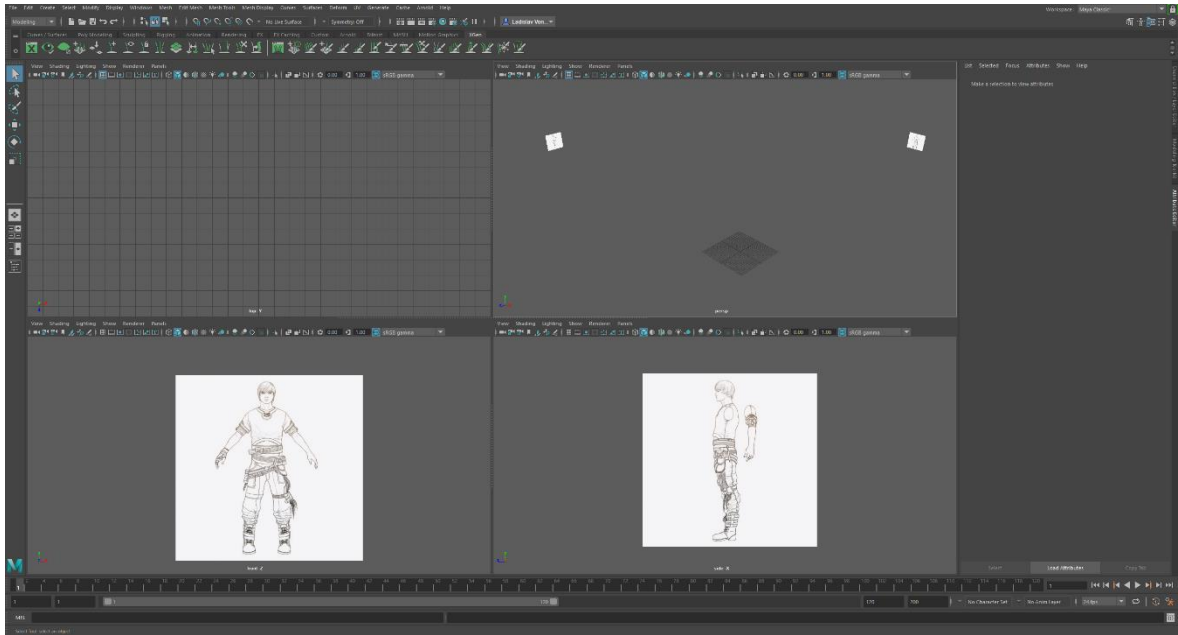


Figure 27 - Maya - Setting up reference

The project began with the creation of trousers that were created by creating only one half of the subsequent mirroring of one part on the other. This was accomplished by creating a standard primitive, a cylinder, which was then modelled by shifting individual edges and fitting according to the reference picture. Multi-Cut has been used extensively, as in the entire project in this project, to create individual folds on the pants. Also, the Insert Edge Loop and Offset Edge Loop functions were used when polygons were needed across the edge of the trousers. Slide-Edge subsequently served to fit individual edges. It followed the editing of individual edges and polygons using standard functions and creation of boots, where the basic primitive Cube was used, which was completed with the function of extrusion and the subsequent modification of polygons by the aforementioned functions. Followed by the mirroring on the opposite side, and the use of Smooth Preview, which completely erased the entire object.

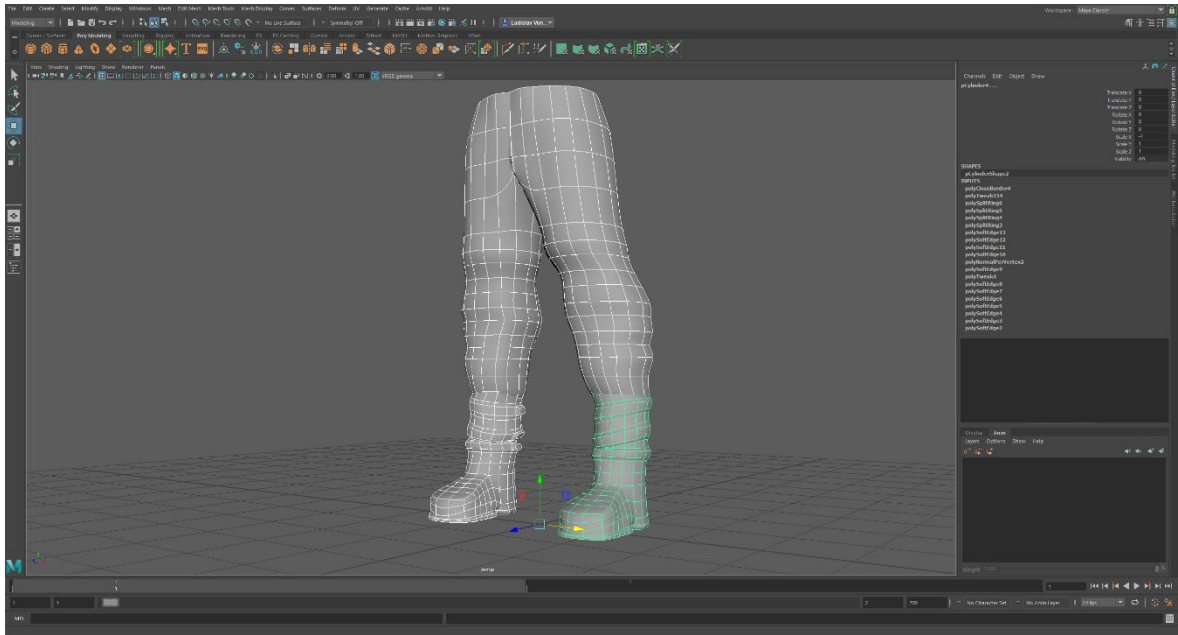


Figure 28 - Maya - Pants and boots

There followed the creation of the body. Here was used the method of creating a primitive plane and the subsequent pulling of the entire fuselage and joining the individual polygons using the bridge function and also connect. Because only half of the hull that was re-shaped on the object's t-shirt was created, it was possible to use the duplicate special function, which works similarly to the symmetry in the previous program. This allows the symmetrical behaviour of one half of the object as the other.

Together with the T-shirt, a hint was created on the neck and followed by the creation of hands. Again, there was a cylinder used to resemble an arm and enough polygons for any animation, for which reason the arm should have a possible deformity.

Due to the impracticality of the reference, due to the uninjured fingers but slightly creased, it was relatively difficult to capture the shape, length, and individual curves on the fingers. At the same time, it has to be taken care of enough polygons to be needed and suitable location to avoid collision of polygons during animation. The hand itself took much more time than a t-shirt, trousers and shoes, thanks to the complexity of the object.

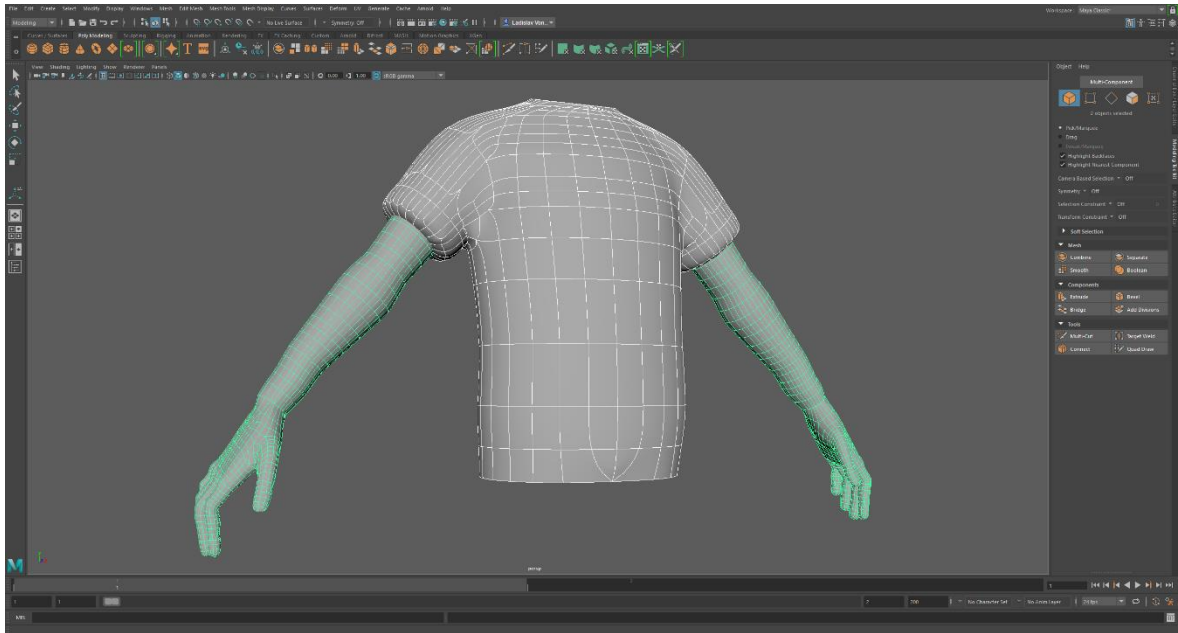


Figure 29 - Maya - Body and shirt

The last part before fine-tuning the whole project was the most complicated part, namely the head. A procedure like that of a T-shirt in this project was applied, thus pulling the whole head with the primitive planes and creating a mask to which the eye, mouth and ears were cut. During production, a sufficient number of polygons had to be taken care of and the correct polygon connections to allow the creation of a character figurine that could later be animated.

Creating an eye was done using a simple object, a sphere that was slightly modified and then copied to the appropriate location to have both eyes.

The ear was made from the hole with the same features as the whole project and was modelled to resemble the ear. The last step in this step was to connect the head to the neck and place it on the body of the object.

For this, the head had to be linked to the hull of the character, because the Maya project does not allow the interconnection of two objects that are not really one. The eyes remained unconnected with the head due to possible rotation.

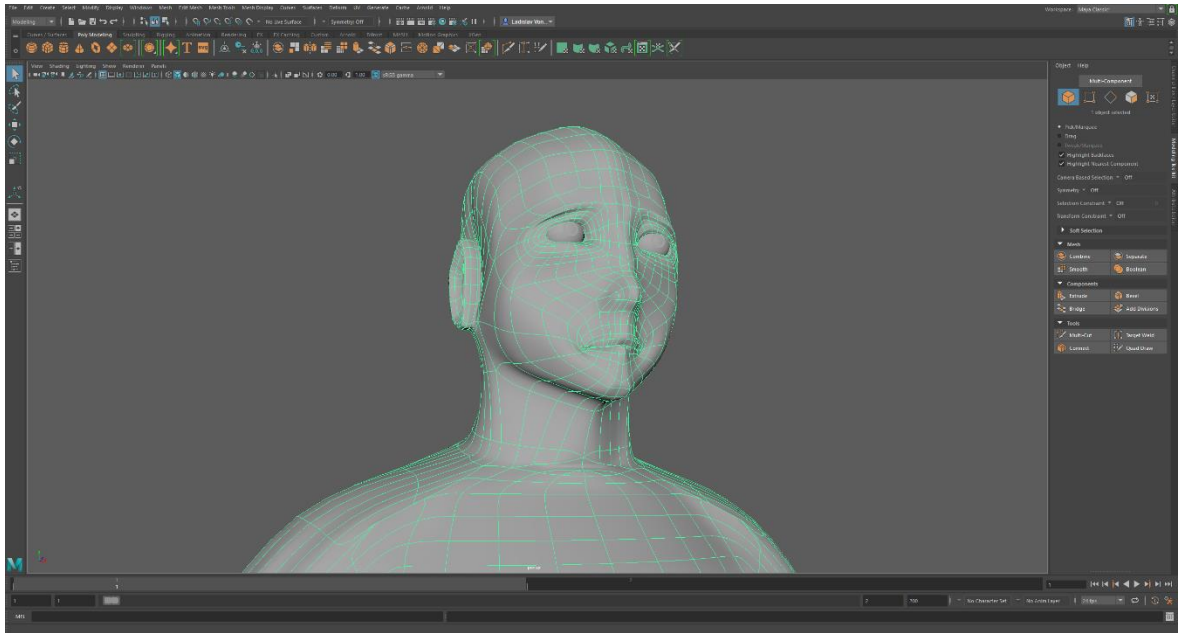


Figure 30 - Maya - Head

The goal of this project was not to create a precise representation of the reference image, but to create a model that resemble of a male human and the reference picture was used only to assist in process of creating this project. It was also a test of Maya, where its strengths and weaknesses lie, how the performance was during work on this project, and what each program has to offer.

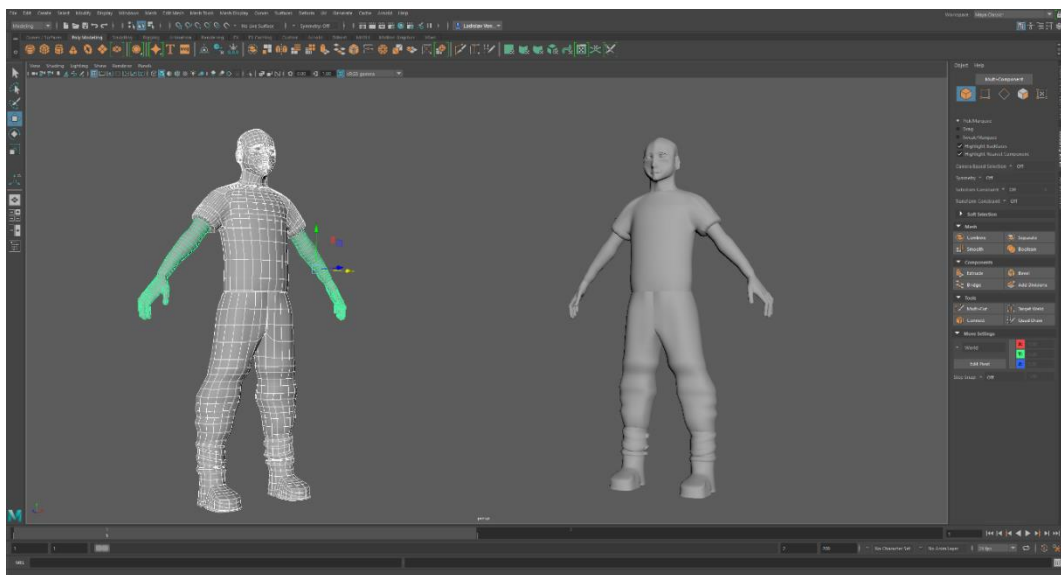


Figure 31 - Maya - Finished project

1.8 **Mudbox**

1.8.1 **Basic information about Mudbox**

Mudbox is a professional 3D graphics software from Autodesk for mostly creating living characters and their texturing. Also, most of the characters are created here to be exported to various different programs for animation. Creating some of the inanimate objects can be relatively problematic here, so others usually use this program, thanks to the simpler creation of non-living objects in other programs. Nevertheless, Mudbox excels in creating details of individual characters and their details, especially on the site of high deformation and animation, such as the face in particular. Autodesk is selling this program at various costs, charged monthly, yearly or three-yearly.

1 month: 10 \$

1 year: \$ 100

3 years: \$ 240

Autodesk provided the student version of the Mudbox 2018, which has an unlimited use of the ability to upgrade to a higher version that has additional features for creating this bachelor thesis. However, when downloading, there is a warning that projects created in this program are not intended for monetization, only for a study purposes.

1.8.2 **Workspace of Mudbox**

The main window in which Mudbox works is in the middle of the program. The Mudbox launches a perspective view. If necessary, display additional views, the fastest option is to press the right button and then choose Switch View, where we have Top View, Side View, Front View and currently in use.

In addition to the 3D view, you can see all views in a 2D view called UV view and next to this tab is Image Browser where you can find the possibility to import different images that can be used as reference or texture.

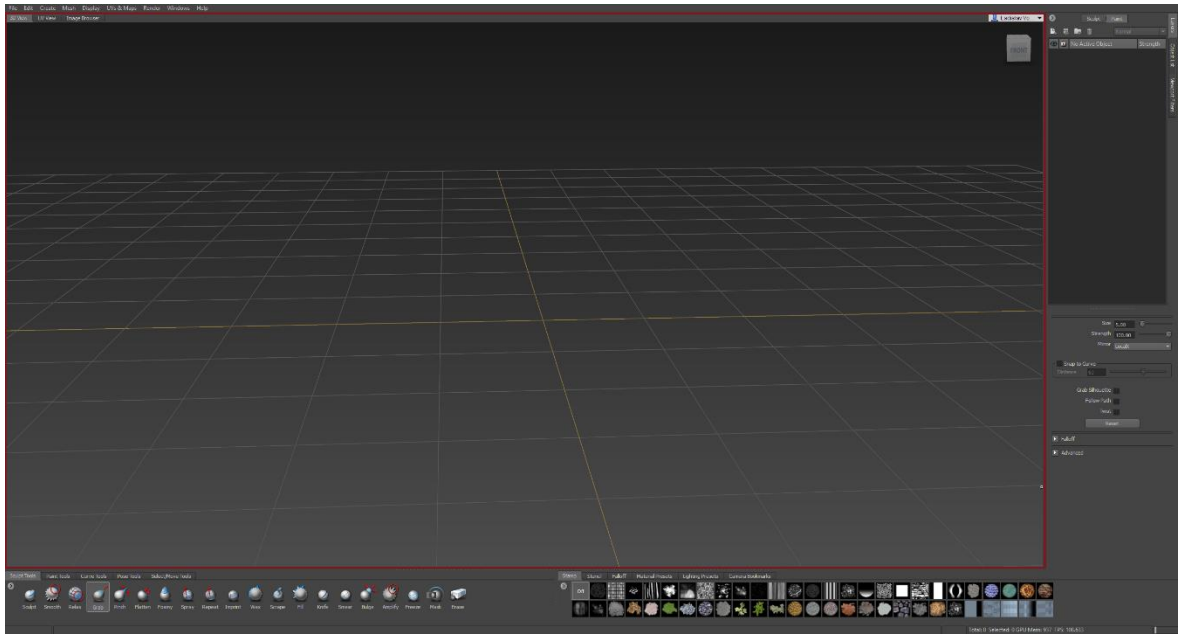


Figure 32 - Mudbox - Main window

To the right of the main window is the ability to work with layers and individual objects in layers. There is also the possibility of moving the selected object, its rotation, size, movement and so on.

Below the layers is a list of all objects in the project, named Object list. Here we can see all the individual objects, including the cameras, the skeleton of the character, and so on.

The last one is a viewport filter that lets you choose filters as it will look like.

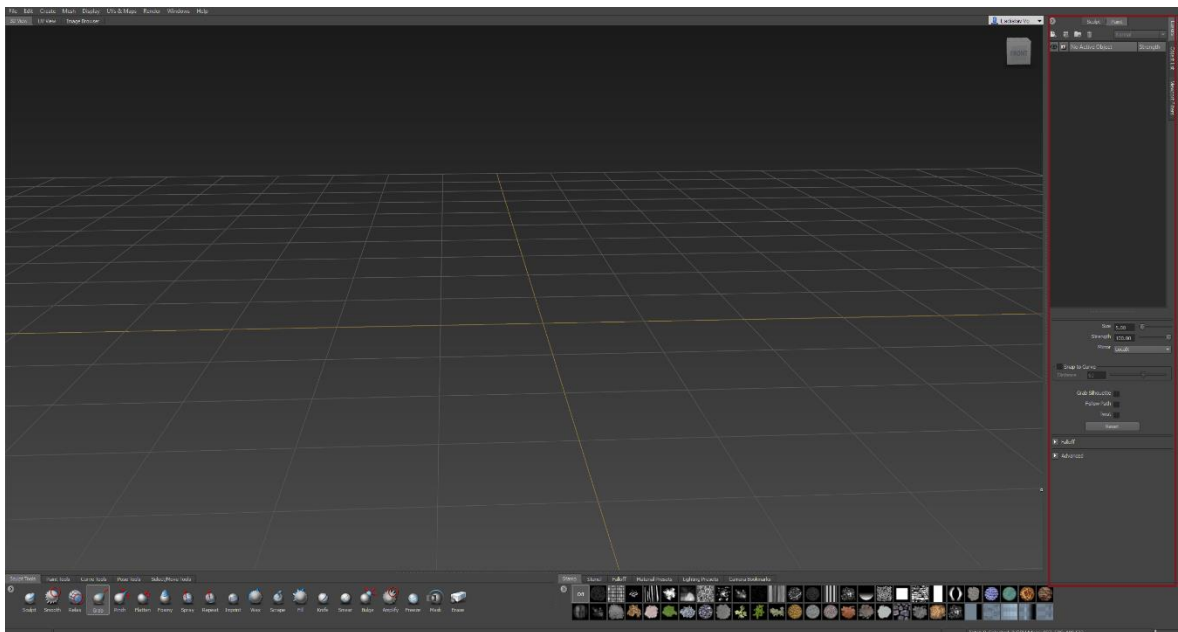


Figure 33 - Mudbox - Right window

Above the main work area there are a few bookmarks that offer additional features when working with the project and the individual objects in the project.

File offers options such as creating a new project, saving, exporting, importing, and so on.

Edit gives you options to go back one step, to duplicate object parts and delete them, to select objects in a project, to freeze individual objects, and to locate individual parts of the project.

Create offers simple creation of basic primitives, curves, cameras, but also lights and materials.

The display allows hiding of individual objects, their isolation, but especially here we find how our work surface looks.

UV & Maps lets you change the project to UV, which is useful when exporting individual objects to other programs.

Render provides simple render settings that are included in this program

Windows is the setting of each window in the program, including setting hotkeys, importing settings, or exporting them.

Help provides help if the creator is unsure. There are also tutorials to control this program, purchase a license, update the latest updates, or redirect to the Mudbox home page.

Also, on the right, we will find an opportunity to sign up.

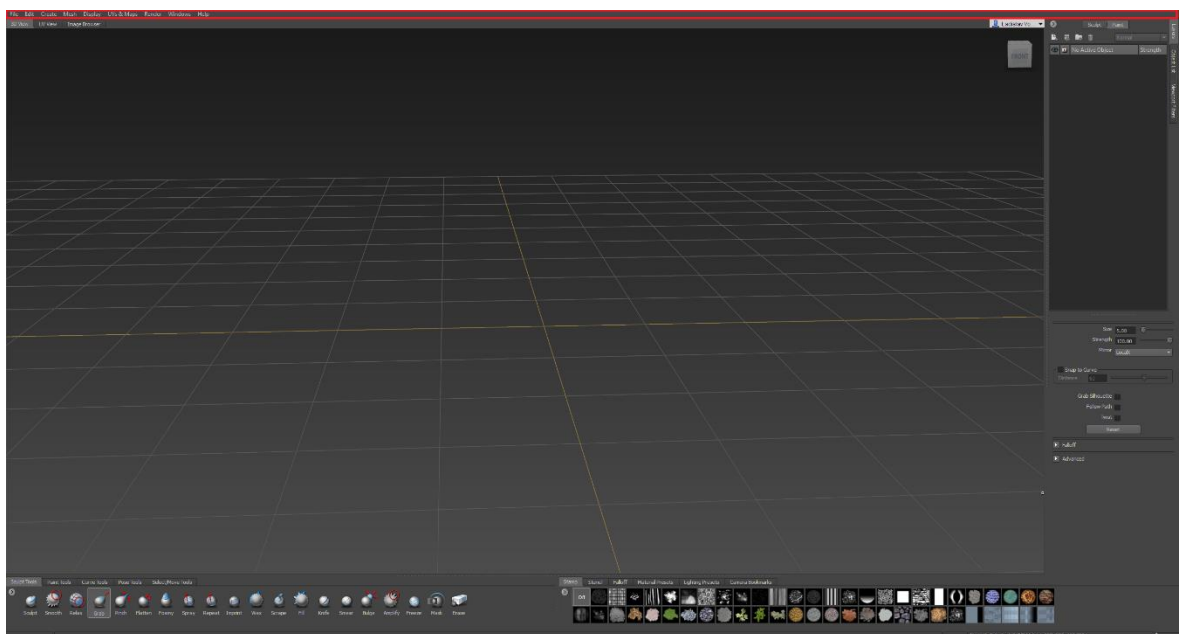


Figure 34 - Mudbox - Top window

The last window of this program is the bottom bar where the main control over the project is located.

On the Sculpt tools tab, we find all the options that can be handled and handled by the project. From simpler options such as Grab, where the polygon catches and then stretches, it is more complex than Wax, which can lay layers up to more complex than Knife, which can sculpt shapes in the object.

Paint tools are mainly for colouring the entire project in the absence of textures. Eventually staining the project in the presence of textures.

Curve tools are here for drawing curves and editing them.

Pose Tools is mainly used to create a skeleton for a character, moving from a pivot, and adjusting these joints to move with a character.

The last one is Select / Move tools, which allow you to move, rotate and rock the project. It is also possible to select individual polygons, but not individual edges or vertices.

To the right of this we have 5 other bookmarks, including Stamps, Stencil, Falloff, Material Presets, and Lightning. These are mainly used to edit the exterior of the object or objects.

The last is Camera Bookmarks, where it is possible to work with individual tabs for cameras that have been stored.

At the bottom right, additional information is available, such as the number of polygons that are currently selected, how many programs the graphical memory takes and how many frames per second it can show.

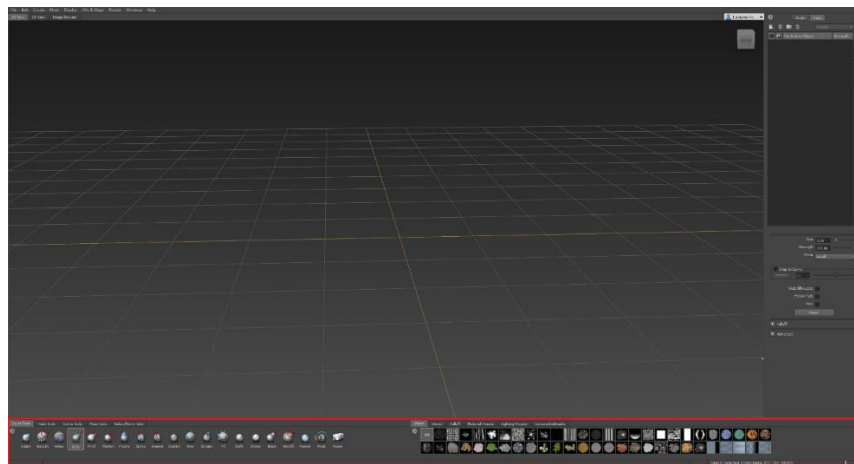


Figure 35 - Mudbox - Bottom window

1.8.3 Project Execution

The project was divided into four main parts, i.e. pants, shoes, shirt and whole body of the character. In the Mudbox, there is an option to use whole model of the body, so cause of this, basic model of the body was used, but adjusted to resemble body more.

Setting up reference was not usable in Mudbox, but workaround was used. Uploading reference picture via “Stencil” feature allowed display of the reference picture to help modelling the model. Main problem was that there was no way of locking it, so it had to be constantly scaled up and moved around to help model the character.

Before the trousers were created, it was a matter of creating a body, and then the joints were delivered, which then allowed the rotation of the limbs, their movement and even the tilts. This was extremely useful because of the ability to adjust the position of the character exactly to the position that is on the reference picture.

Once this was created, the work on the trousers could start, where the basic primitive, the cube, in which the fill was removed, was selected. There was the possibility to work with the fact that the whole trousers were created with a filling, but because it is clothes, the option to work only with the area of this empty primitive was chosen.

The addition of the New Subdivision level has already been used, allowing for the creation of more polygons between existing and lighter modelling.

Some features of the sculpt tools have been used to create pants, and due to the impossibility of duplicating or using symmetry, each pair of trousers has been designed and modelled separately. Achieving a similar appearance and uniform distribution of

polygons was probably the biggest problem. The mirror feature has been used to make it easier to work on the pants because it could work on the two legs at the same time, but despite the asymmetry, the work has been quite harsh.

The Grab and Smooth/Relax options were used most in this step, allowing the individual parts of the trousers to be pulled into place and the second function to smooth out the unevenness between the polygons.

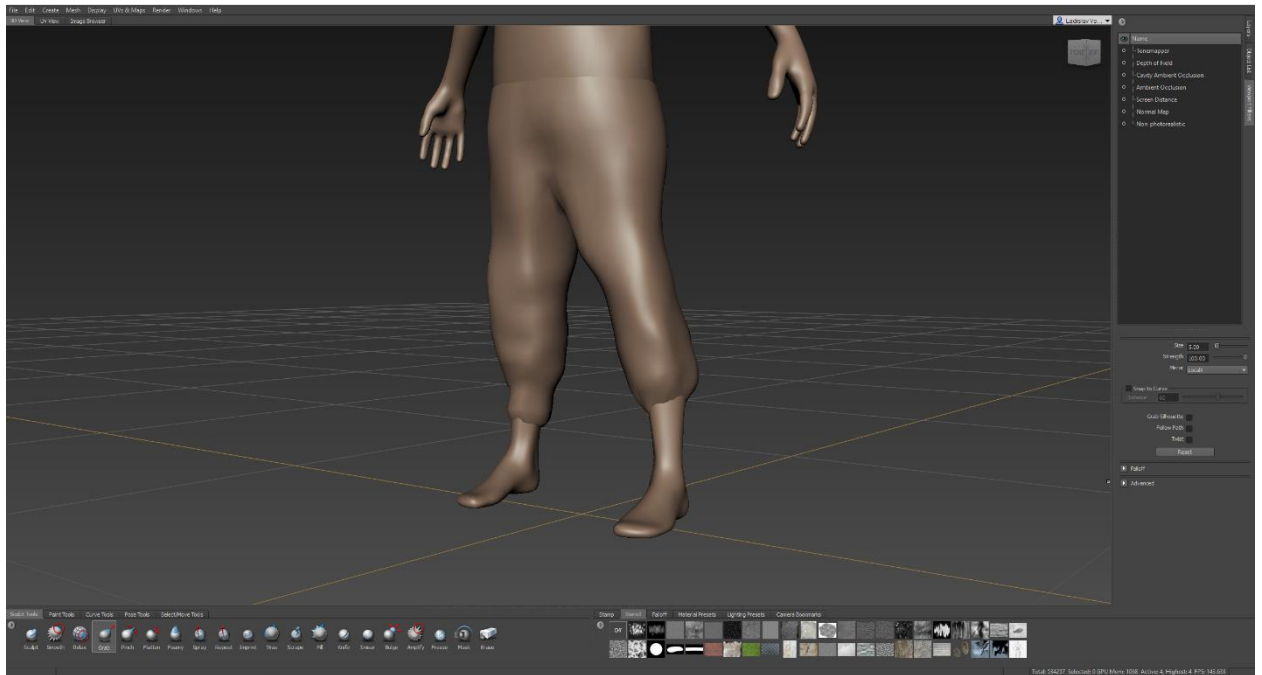


Figure 36 - Mudbox - Pants

After the legs were created, one of the two boots was formed, using a similar procedure to the legs. Creation of a dice without filling and subsequent modification into the shape and form of one shoe. In this step, the flatten function, which aligned the individual polygons, was mainly used on the sole. The foamy function has been used to create more rounded shapes and so achieve the appearance of the shoes.

Once a shoe was created, it was enough to duplicate it and turn it in a mirror, and then adjust it so that the individual trousers fit into each of the shoes. So the trousers have gone through a slight adjustment to make the model look natural and logical.

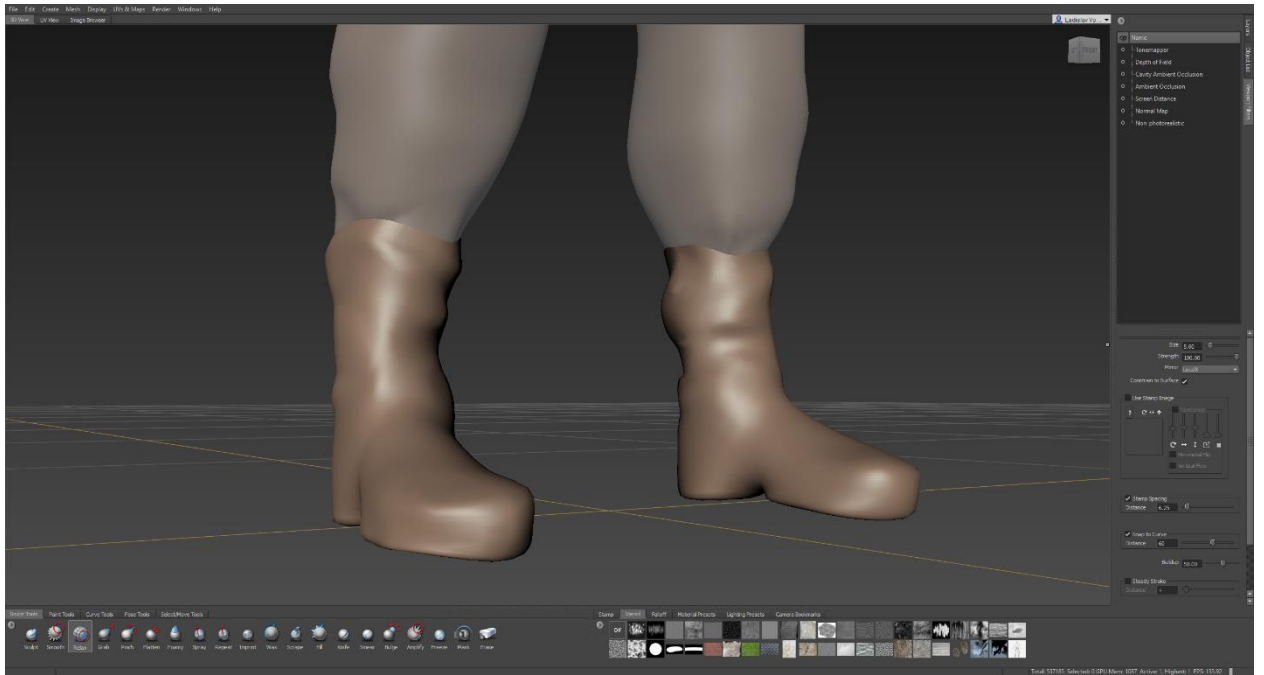


Figure 37 - Mudbox - Boots

After the boots were created and duplicated, a character t-shirt was created. The same style of work was applied here as in the previous steps. The grab function is used to pull individual polygons and then smooth out smooth and relax. Gradually add polygons to the entire object to create a smoother look that will resemble the character's t-shirt. There was a tuxedo at the same time with the trousers so the t-shirt would fit into the figure pattern while being close enough to the trousers. Care was taken to ensure that the character does not have a t-shirt in the body and at the same time that the shirt does not pass through the already created pants. Also, that the pants did not have too much distance from the T-shirt and simply did not get around the figure.



Figure 38 - Mudbox - Shirt

The most recent and probably the most complex part of this project was the creation of details on the face. The character itself provided in the Mudbox program had hints on her face, but in no way was done.

At this step, almost all of the features from Sculpt Tools in Mirror mode were used to work on both sides of the face, which was already symmetrical.

At the beginning, the number of polygons was increased twice to work on more detailed parts of the face, such as an ear or eyes.

There followed the adjustment of the neck and lower jaw with the help of the Grab functions, which led to some places being pulled out, then smoothed out with Smooth. The Foamy and Wax functions have been used mainly to create and add material to the characters, especially in the area of the ears and faces. The Wax function also has the opposite function, similar to the scrape function, where it picks up the material and so when you need to remove the material on the face, it has been worked with these functions. Of course, the Smooth feature was used at each step to help keep the model without sharp edges.

Fun and Bulge and Smear have been used on the nose, thanks to which we managed to create a nose while using the Wax function.

The knife function was used to create the earlobe and the ear itself, which originally merged with the model and thus achieved a certain offset from the head.

Sculpt has been used to create eyebrows, which apply the material in a defined shape and spacing.

There was a fine tuning of the details that were on the face, such as smoothing the individual surfaces and fine-tuning the details.

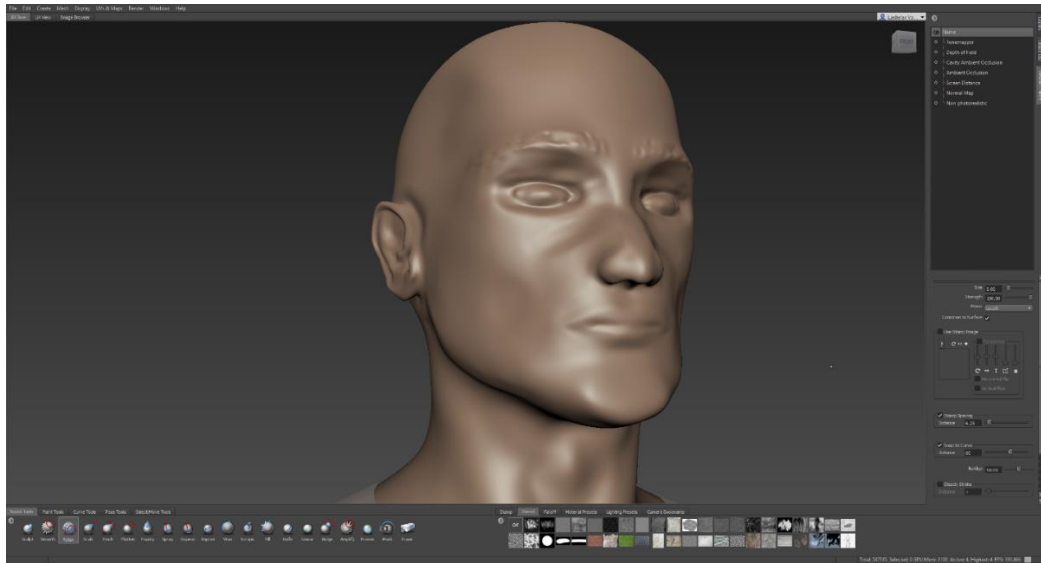


Figure 39 - Mudbox - Head

The goal of this project was not to create a precise representation of the reference image, but to create a model that resemble of a male human and the reference picture was used only to assist in process of creating this project. It was also a test of Mudbox, where its strengths and weaknesses lie, how the performance was during work on this project, and what each program has to offer.

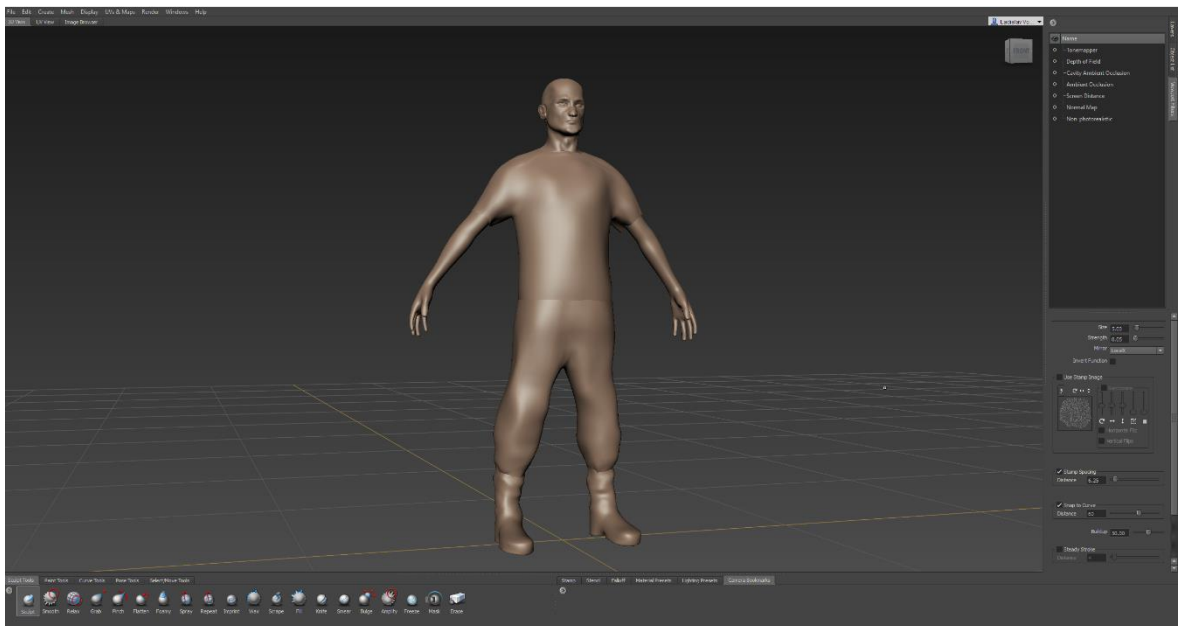


Figure 40 - Mudbox - Finished project

Results

All three programs, 3ds Max, Maya and Mudbox, are from the same Autodesk manufacturer, but there are quite a few differences in usability, cost, controls, load on the computer at work, interconnection among other programs, and so on.

Price:

Program:	Price per 1 month	Price per 1 year	Price per 3 years
3ds Max	242,00 €	1.936,00 €	5.808,00 €
Maya	242,00 €	1.936,00 €	5.808,00 €
Mudbox	8,12 €	81,25	195,00€

Table 1 - Price

(Price of the Mudbox was converted via rate 1\$ = 0,8125€)

First table number 1 we can clearly see the comparison of three programs, 3ds Max, Maya and Mudbox, where first two have same price in every category, but Mudbox has clearly lowest price among all of them.

All of those three programs have a similar controls, where Mudbox and Maya have identical controls with 3ds Max being slightly different. Mudbox and 3ds Max have a cube in the top right corner to allowing control of the scene even through that, something which Maya is lacking.

Overall, controls are really intuitive and everything in all of these three programs can be key-bound for more ease of control.

Usability and accessibility in the three programs differ greatly. Starting with a Mudbox, who lacks a lot of options of the other the programs. Creating a character or any project is possible in all of these three programs, but likely hardest to master in Mudbox. When starting a project with the other two programs, there is an option to approach the task with various ways and approaches, in Mudbox user is able to use only sculpt and work with any object as it would be created from mud. There is no variety and options to approach tasks other than to model an object with layering more working material, adjusting it and trying to match it.

Whereas in the other two programs, there are various ways how a final project or just part of the project, some object, can be rendered. Either by creating standard primitive and adjusting it, adding more and more polygons and edges, or creating a plane and tracing the whole project with those and then connecting them to fill the object.

In Maya, there is also a way to sculpt your project and work with it similar to Mudbox, but it lacks many of the options in Mudbox. For 3ds Max, there is no such thing implemented to work with the project as in Mudbox.

In 3ds Max and Maya, there are additional features compared to Mudbox, which this program lacks. Ability to animate, create effects, even simulate some entities like weather or even a traffic.

Each program is quite complex and looking for a specific tool is rather difficult. Mudbox is the easiest to work with, but that can be accounted to the fact that there are not as many ways to approach different programs which can occur during creation of the project.

Followed by 3ds Max, where there is less options how to animate and simulate stuff, but more options how to work with parts of the objects, whole objects or project overall.

Maya has most of the options in animating and creating a simulation, but on the other hand creating any object can be quite troublesome due to the lack of options when approaching tasks. But at the same time, there are far more options than in Mudbox.

Load times, crashes and usage of the hardware:

Program	Load-times	RAM usage	GPU usage*	CPU usage*	Crashes
3ds Max	18,2 seconds	711 MB	25,3%	18,9%	0
Maya	21,7 seconds	675 MB	20,2%	14,5%	1
Mudbox	4,1 seconds	180 MB	22,3%	17,2%	14

Table 2 - Load times, crashes and usage of the hardware

* GPU usage and CPU usage was tested on the same project, trying similar functions along all of the three programs to see how demanding they are on those two components.

Load-times, RAM usage are average amount among 10 test samples. RAM usage is when there is no project loaded in the program, because then it adds up. 3ds Max among all of

those three programs has the worst results, only area where 3ds Max was able to shine was how often it crashed during creation of the project. But, it is the most demanding program amongst the three and only slightly better than Maya in load-times. Maya was the program with longest load-times, mid-ranged RAM usage and best results when working on the same project among the three programs. There was only one crash during creation of project.

Mudbox was able to pull off the best results in Load-times and RAM usage. It was in the average during GPU and CPU usage but had far worse results in crashes. During creation of the project, it was quite normal for Mudbox simply to stop responding or instantly crash, without the option to recover any data.

Test of the backup. Cause of the work with Mudbox, there was a simulation of Blackout and if any of these three programs have built-in backup in case Blackout or anything similar would happen. As said in the last part, Mudbox even in this test was unable to create any backup or restore lost data. Maya and 3ds Max on the other hand was able to recover all the files and part of the project. Only difference was how much they can recover. 3ds Max was able to restore a project with last save of 1 minute and 32 seconds before the simulated Blackout. Maya was able to restore project with last save of 2 minutes and 58 seconds before the simulated Blackout.

Saving of the project was quick, usually taking under 5 seconds without any message prompt, but Maya, during loading a project or saving/quick-saving was constantly giving message that this project is a Student's work and it was created in Student version of Maya, reminding that this project cannot be used for commercial purposes.

All of those three programs are able to import and export not only from and to Autodesk programs related to create 3D projects, but even to other programs without any problem.

Conclusion

Main goal of this Bachelor thesis was to compare these three chosen programs. Comparison was made on programs: 3ds Max, Maya and Mudbox. Each of these programs has its pros and cons, where each program shines, where it has advantage and disadvantages.

Mudbox would be recommended to anyone lacking funds, due to this program being the most affordable among the three. As well, this program offers a unique way of modelling, sculpting and working with an object as it would be created with mud, but on the other hand, it can be for some specific group of people harder to work with. This program is quite easy to pick up and use, but as said, creating an object or whole project can be for some people more troublesome and for others easier than creating them in other programs. Additionally to that, there is no way of creating any kind of animations and effects or simulations.

So if the user would want to learn how to model objects in this program, with money being an issue and the user does not mind occasional crashes, Mudbox would be an ideal pick for them.

3ds Max has many more options than Mudbox but on the other hand, it is far more expensive. There is no option to create a project like in Mudbox or partially in Maya. It has a lot of functions and standard way of creating projects, which most people in 3D design area would be used to. Option to animate and effects are there as well, simulations too, but not as much variety as opposed to Maya. Creation of any object had various ways how to handle things and how to go forward compared to the other two programs.

For a standard way of creation of 3D objects and projects, where money is not an issue and the user would like to try animation as well as simulate made objects, 3ds Max would be ideal pick for them.

Maya falls somewhere in the middle point between those two programs. It offers a way to model objects in the normal fashion and also in a way similar to Mudbox, modelling objects in a unique way, sculpting them and working with them as they were created from

mud. Of course both ways are not as complex as in 3ds Max and Mudbox. Pricing is identical to 3ds Max and much higher than Mudbox.

Among the three, Maya has the best options for animation, effects and creating simulations. At the same time Maya is probably hardest to pick up due to the fact there are a lot of tools for mentioned processes.

Maya would be recommended for anyone, who is really not sure if they would like to start creating projects in a "sculpted" way as in Mudbox, or allowing them to rather go for 3ds Max way of creating those objects in each project. At the same time I recommended this program to anyone looking to do animation.

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