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3D Modeling Optimization for Multimedia Production

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This thesis is a research project on the similarities and difference in 3D modeling and optimizations for different sectors of multimedia. The purpose of this project is to analyse three different areas, and carry out a project for practical comparison purposes with the creation of a 3D model using different methods of modeling and optimization. The methods used in this project is a workflow step by step process of production, for later comparison and analysis.

The result of this project was the creation of an optimized model for game production, the methods used at modeling pipeline and the comparison between different sectors of Multimedia illustrate the similarities and differences in modeling optimization between these sectors. This project is created to illustrate paths taken for modeling optimization in the biggest sectors of 3D production, with comparative results and analysis.

Keywords	3D, modeling, multimedia, production, film, animation, games, character, print, advertisement

Abbreviations and Terms

CGI: Computer Generated Imagery

CG: Computer Generated

3D: 3 Dimensional

2D: 2 Dimensional

R&D: Research and Development

Lag: The act of slowing down

Retopology: To change the topology of an object without changing the shape of an object

UV: U and V are the axes is 2D texture

Quad: A polygon with four sides

Tris: A polygon with three sides

Previz: Pre-Visualisation

Contents

1 Introduction

This is a research and practical project to compile the guidelines and processes needed for 3D modelling, and how to optimize workflow and methods of 3D modeling in relation to the diverse areas in the Multimedia industries. This project is structured as a guide for 3D modeling on specific areas such as print and still image illustration, animation character and environmental modeling, and the specific guideline to game character modeling.

The aim for this project is to demonstrate different methods and approaches to the workflow in 3D modelling production and how to optimize execution, overall quality, and speed in the development of your final product. This is a research aimed towards individuals that are aiming to get into the Multimedia industry, specifically advertisement/commercial production, game design and film production. It is necessary to have a certain passion towards this area, as you need to have patience and perseverance to complete tasks and solve problems.

The research will also cover the techniques used by the professional in several areas of the Multimedia industry, and by compiling the information a comparison will be created to distinguish the requirements between each.

The main project in this paper is an undergoing game production represented by the Game Portal team. The game in current production is called Hungry Jake and it is an Indy game that include both 2D and 3D elements. Game development is becoming very popular in the Multimedia industry, and 3D modeling is becoming a necessity to create a high quality game, therefore this project will illustrate the workflow of the process to develop a 3D game character using optimized next generation techniques.

2 Theory of 3D Modeling and Multimedia

2.1 Overview of Multimedia and 3D

2.1.1 Multimedia Background

Multimedia is a word that has several interpretations depending on the area of communication. [3, 2] In the most general form Multimedia as a word can be described as many means of communication. [1; 2] It is the method of delivering information in several forms and means. Multimedia in relation to 3D is a relatively recent engagement, nevertheless Multimedia has evolved from individual media such as still images, text, sound, video to a combination of all with the introduction of electronic technology. [4, 2]

The Multimedia industry is divided into several areas of productions, varying from still images produced for advertisement purposes, to motion films created for television and cinema. Throughout time the production has evolved, creating a hybrid pipeline of different talents to create specific work, not just in one area of the Multimedia industry, but in all areas depending on the necessity of the specific skill of a person needed in the production.

The Entertainment industry is one of the largest sectors of Multimedia, and growth in this industry has evolved collectively with technology in the production of film, commercials, games and many other areas of entertainment. It is clear that our contemporary society is demanding more and more from entertainment, and the competition of the entertainment industry is growing rapidly.

Despite the fact that this project is focused on the Entertainment sector, Multimedia can be observed in areas such as education, engineering, industrial, scientific, mathematical and medical. All these areas use Multimedia with similar approach, but for different means.

Multimedia is evolving and becoming part of a common aspect of our daily lives, where everywhere we look there are various implementations of Multimedia being used. This is commonly seen is media devices such as computer, mobile phones and televisions. The evolution of Multimedia soared with the development of devices with faster processing capabilities and display options, allowing a "Multimedia experience" to the user/viewer.

2.1.2   3D Background

CGI (Computer Generated Imagery) is the root of all digitally generated imagery, it is the source from where 3D was born, and now the word CGI is closely correlated together with 3D. It is common that when the word CGI is mentioned the first feedback is 3D and even more closely related to realistic 3D visualisations. Although 3D is closely related to CGI, it is a separate branch, consisting of specifically the representation of 3 dimensional objects. 2D on the other hand, is also a part of CGI but it only consists of 2 dimensional representation.

History of 3D can be traced back to the 1960's. It started when William Fetter, considered as the founding father of 3D, invented the word CG (Computer Generated) and the first algorithmic created 3D image called the "Boeing Man (1964)". [5] The building blocks of 3D were established during the 1970's when the computer technology was becoming available to the 3D developers. A great example of a technique that is still in use today is Gouraud Shading, invented by Henri Gouraud in 1971, where the polygonal faceted object can be smoothed out without additional polygon count. Figure 1 demonstrates the difference of the 3D model with and without the Gouraud Shader. [5]
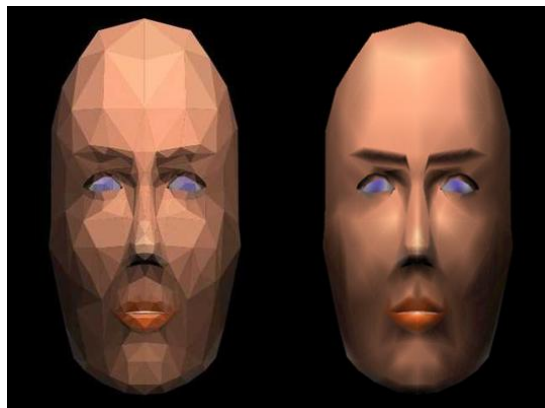
Figure 1. The Gouraud Shader [6]

The biggest milestones in 3D history took place in the 1980's, it can be stated as the birth era of 3D, where most studios of 3D production and animation was created in this epoch. Animation studios such as Pixar, Lucas Films, Industrial light & Magic and DreamWorks took an important role in the development of 3D content and allowed different companies to invest on the production of more advanced 3D production software. The widely known product of this era is the short animation "The Adventures of

Andre and Wally B", it can be considered as the first full animation short film and the start of 3D animation in the entertainment industry. [5]

The 1990's was the turning point of the 3D era, because consequently 3D became a commercialised success. Achieving awards in film and video games, hence the immense growth in the industry since then. The 1990's 3D creations contributed to award winning movies such as Terminator 2 and Jurassic Park, and video games such as Super Mario 64 and Tomb Raider. [5]

3D Contribution from the early days allowed several industries to grow in their respective areas, from the entertainment industry as the primary objective to medicine in the present time as a tool to improve methods and techniques. 3D has become the core for the evolutionary process of computer development, it has become one of the most important aspects of hardware and software R&D each industry will grow respectively to each other. [5] As Andy Beane (2012) says "3D animation pushes the computer industry to create". [5]

The growth and advancement of 3D content has allowed common users without technical background to produce professional content. This is commonly seen in studios, where most workers come from art background. This is due to the structure of current 3D production software that gives freedom to users to create and develop 3D content without advanced programming and mathematical knowledge.

A common and widely known 3D software development company is the Autodesk, Inc. Since 1982 with the introduction of AutoCAD, Autodesk has introduced several software packages aimed at specific target groups aiming to integrate 3D to their line of work. Allowing a faster and more accurate approach to production in several areas where 3D can be implemented. [7]

Every year 3D technology is developing exponentially, allowing progress in different markets and growth in the competitiveness between industries. It is important to note the growth in revenue in relation to 3D in the market, as it has become an essential tool to the growth in several branches of Multimedia specifically the entertainment branch.

Entertainment & Media Industry Overview

	Amount	Unit	Date	Source
Total U.S. Communications & Media Spending	1.189	Tril. US$	2012	VSS
Total U.S. Communications & Media Spending (projection)	1.455	Tril. US$	2016	VSS
U.S. Advertising Revenues (estimate)	153.0	Bil. US$	2012	Magna
Global Media Suppliers Advertising Revenue (estimate)	495.0	Bil. US$	2012	Magna
Global Media Suppliers Advertising Revenue (forecast)	510.3	Bil. US$	2013	Magna
Internet Users, Worldwide	2.41	Bil.	Jun-12	IWS
PRINT MEDIA				
U.S. Magazine Advertising Revenues, PIB Measured Magazines	20.1	Bil. US$	2011	PIB
Total Daily Newspapers, U.S.	1,382		2011	NAA
Total Daily Newspaper Circulation, U.S.	44.4	Mil.	2011	NAA
Annual Newspaper Advertising Expenditures, U.S. (Print & Online)	23.9	Bil. US$	2011	NAA
Net Sales Revenue of U.S. Book Publishers	27.2	Bil. US$	2011	AAP
E-books as a percent of Trade Book Sales, U.S.	15.0	%	2011	AAP
TELEVISION				
Licensed TV Stations U.S. (Including Digital & Class A)	2,034		Jan-13	FCC
Basic Cable TV Subscribers, U.S.	56.8	Mil.	Sep-12	SNL
Digital Cable Subscribers, U.S.	46.7	Mil.	Sep-12	SNL
RADIO & MUSIC				
Full Service FM Radio Stations, Including Educational, U.S.	10,509		Jan-13	FCC
Licensed AM Radio Stations, U.S. (Daytime/Unlimited)	4,793		Jan-13	FCC
Album Sales, U.S.	316	Mil. Units	2012	Nielsen
Digital Music as a Percent of All U.S. Music Sales	55.9	%	2012	Nielsen
Global Digital Music Revenues	5.2	Bil. US$	2011	IFPI
Digital Music as a Percent of Global Music Sales	32	%	2011	IFPI
Satellite Radio Subscribers, U.S.	23.37	Mil.	Sep-12	Sirius XM
FILM				
U.S./Canada Box Office Revenues	10.2	Bil. US$	2011	MPAA
Global Box Office Revenues	32.6	Bil. US$	2011	NATO
Number of Cinema Locations, U.S.	5,697		2011	NATO
Number of Movie Screens, U.S.	39,580		2011	NATO
Blu-ray, DVD & Digital Media Revenue, U.S.	18.0	Bil. US$	2012	DEG
ELECTRONIC GAMES				
New Computer & Video Game Software Sales, U.S.	245.6	Mil. Units	2011	NPD
Total Consumer Spending in Electronic Game Industry, U.S.*	24.75	Bil. US$	2011	NPD
OTHER				
Wireless Subscriptions, U.S.	321.7	Mil.	Jun-12	CTIA
Wireless Penetration, U.S.	101.0	%	Jun-12	CTIA
Number of iPhones Sold during the Fiscal Year ending Sep. 25	125.05	Mil.	2012	Apple
Number of iPads Sold during the Fiscal Year ending Sep. 25	58.31	Mil.	2012	Apple
Cell Phone Subscribers, Worldwide (estimate)	5.9	Bil.	2011	Portio
Cell Phone Subscribers, Worldwide (forecast)	6.9	Bil.	2013	Portio
Commercial Casino Revenues, U.S. (not incl. Indian Casinos)	35.64	Bil. US$	2011	AGA
High Speed Internet Subscribers, U.S., Fixed, Home & Business	91.0	Mil.	Dec-12	PRE
High Speed Internet Subscribers, U.S., Mobile, Home & Business	180.2	Mil.	Dec-12	PRE

Figure 2. Film and Electronic Games Revenue 2011-2012 [8]

Figure 2 shows the revenue of 2011 -2012 of Film and Electronic games in the US and Canada alone, and it reaches an astonishing total of around 86 billion US Dollars. [8] This is not completely due to 3D alone, but CGI (Computer Generated Imagery) is commonly an essential part in most film production and the main source of games is 3D.

2.2   Foundation of 3D Modeling

What is 3D Modeling

3D modeling is an essential sector of 3D production, and the base of all 3D related compositions. 3D modeling or Digital modeling can be referred to "the process of creating a mathematical presentation of a three-dimensional shape of an object". [9, 4] It is basically the creation of an object in the x, y and z dimensions of digital space using 3D software.

3D Modeling is a process is either carried out automatically by machines and programs or for personalised production by 3D modelers. A modeler general job is to recreate 2D illustrations into 3D objects, these objects can range from industrial parts, architectural visualisations, character for animation and 3D environments.

To specify the role of a modeler it is important to understand that the 3D production pipeline is composed of a team, similar to a sports team, where each stage is as important as the one before. A modeler has to interact with next stages so that the final result is as planned, an example of this is correct topology for deformations in the rigging faze and correct topology for UV mapping. [9, 21]

Essentials Tools for a 3D Modeler

Hardware is the base structure for any production because without the hardware it is impossible to create content. Therefore for a 3D Modeler to achieve the best looking final product, and to create it with time efficiency, it is necessary to invest in good hardware. Software for any modeler is a tool for production, a modeler without the software is like a blacksmith without his hammer and anvil.

Hardware and software can be subjective, it will depend on the user and the budget he/she has to spend on hardware and software. But here is a list of essential aspects to consider on purchasing hardware for the specific use of 3D modeling and production.

Software choice is very subjective in the 3D community, since there are hundreds of software options to choose from. The 3D software market is very concentrated in a few large companies that produce several software for specific purposes, nevertheless smaller companies are finding their space in the market. This allows 3D modelers to have a wide range of options to find what suits them best, and is in their budget. Price in relation to 3D software can range from free to thousands of euros, and the high price for some of these software is because of the commercial use license.

Pipeline in 3D production

It is essential to have a clear understanding on the pipeline of any 3D production, this is because each member of a production team will be communicating between departments. Therefore as the 3D production is carried out, each department is aware of progress, problems and achievements.

In multimedia production, whether an animation, commercial, illustration or a game, the 3D production pipelines are very similar. The only difference would be in game production with the introduction of programmers, which are divided into another sector of production.

A common 3D production pipeline is composed of:

- Story
- Visual design
- Storyboard
- Edit
- Audio
- Modeling
- Scene setup
- Texturing
- Rigging
- Animation
- Effects
- Lighting
- Rendering
- Compositing

This general production pipeline above has elements that are not present in some 3D production, for instance many do not require rigging and audio, and 3D games usually do not require rendering and compositing. [9, 23]

Modeling is one of the few sectors of production which is interconnected with other branches of production, such as rigging, texturing, visual design and scene setup. And in many cases in a smaller production team, a modeler becomes a generalist having to work on several areas in the production phase. [9, 24]

It is common for a 3D modeler to constantly work with the concept art department, because in 2D art proportions of characters can be impossible to translate to a 3D model. This normally occurs with cartoon characters and therefore strong communicative skills as a 3D modeler is important; everything must be expressed in pre-production phase before the production occurs.

 A modeler should always aim to keep a 3D model as clean as possible, this is important because of other stages of production. To achieve a clean 3D model you must have a clean topology, a model must have a good flow of topology, and this is especially important in organic character production. A clean topology is normally is distinguished by a good flow of polygons and generally a quad and tris based topology mesh. [9, 44]

A modeler has to think ahead into the rigging phase, as the topology of a model will determine how the deformation will occur in the rigging phase. A 3D modeler should be aware which models require higher detail, especially if there are shots that require close ups, and if the 3D models has facial animation or any special transformation. A good example of this is game modeling. It is common to have sectors of modeling with one sector focusing on high res modelling for cinematic and another sector for the in game models. The in game modeler will have a limit polygon count. As a consequence problem solving will be the main trait in these situations as the modeler needs to figure how to organise the topology puzzle for the best results.

Figure 6 illustrates the topology of a human character for an online game. The topology flow is focused on the static appearance of the model, but with topology flow that can enable some animation. This is a perfect example of a great topology in a model, as each polygon is perfectly placed without additional segments to increment on the polygon count.

Figure 3. Professional game character topology [10]

Images such as this one is a good reference to 3D modelers in the game industry, as it has such good polygon distribution and flow. Nevertheless, it is important to practice different approaches to modeling such characters, and with experience and practice a personal method of approach will be the main tool used for similar projects.

Reference is a modeler's map and it will guide a modeler to not astray from the original plans. This is a common aspect in 3D modeling that beginners do not take into consideration. As a 3D modeler is also an artist, and it is common to see a 3D modeler adding some of his or her personal touch to the model. Regardless of a 3D artist being also an artist in a 3D production pipeline, a modeler has to follow the guidelines provided by the Art department, unless the 3D modeler is a character concept modeler or environmental and stage 3D modeler.

The most common reference materials a 3D modeler will work with are, physical reference, digital reference, printed reference, sketch reference and video reference. If the modeler is also the creation artist, it is important to gather as much reference information as possible before starting to model, the more information the more ideas to composite in the character design. However, if you are just the modeler with an art department planning the character, the reference material will commonly be sketches with characters and objects from various angles. [9, 84-90]

2.3 Principles of 3D Modeling

2.3.1 Modeling sectors

Modeling is divided in several sectors, and the two main sectors are organic and hard surface modeling. Organic modeling is normally used in the production of objects that require deformation movement for animation, such as a human. Being hard surface modeling depicts objects that do not deform when animated, such as a car. Nonetheless, this is not a rule, because any naturally "non-organic" shape can be treated as organic for animation purposes. A good example of this is the movie "Cars" by Pixar, where all the cars moved and deformed in a non-realistic way giving a clear example of organic modeling with a naturally hard surface object. [9, 113]

Categorising modeling nowadays is very difficult, because modelers are combining different sectors of modeling in the production. Therefore the word "Hybrid" can be implemented to describe the current situation of modeling, where both organic and hard surface modeling elements are combined to create one object.

2.3.2 Modeling Methods

There are hundreds of modeling methods for production, and although it is the modeler's choice, there are patterns that need to be followed. In each production a modeler will come across challenges that will require problem solving skills. By knowing different methods of modeling a modeler can help to solve these problems and reduce the modeling time. There are many variables in modeling methods, and the main variable is the software of production. Nevertheless, the basic methods of current 3D modeling patterns are very similar in most 3D modeling software.

Edge Extend is one of the traditional methods used in 3D modeling. It consists of extruding the edges of a polygon and moving it in X, Y and Z space to create an object. This method of modeling focuses on creating the full object from start, adding and welding polygons together to create the object. [9, 123]

Primitive Modeling is the construction of an object using different primitive shapes, such as cube, sphere, cone and cylinder. This is commonly used in most hard surface modeling production, because of the rawness of each primitive shape. [9, 124]

Box Modeling is one of the favourite methods of modeling in a production, box modeling is the manipulation of a box primitive to create different objects. It can also be described as the creation of an object using the same primitive without addition of any other primitive. In other words it is a seamless object. Box modeling commonly uses different techniques such as adding segments, bevels, loops and extrusions to create the impression of having several parts put together to represent the object. [9, 126]

Sculpting has become one of the most common methods in organic modeling, and it is a similar method to the traditional sculpting. The difference between sculpting and other methods of modeling is the ability to use the creative part without worrying about topology. It is also the best method of concept design before production. Sculpting has become a common method in most industries that require 3D characters and objects that require high detail and fast concept designs. 3D sculpting can be approached in many ways, and new methods of digital sculpting are being created with additional tools provided by software such as ZBrush and Mudbox. Digital sculpting normally results in high resolution meshes, reaching millions of polygons, which are then taken to other software for Retopology. [9, 128-129]

Real world objects are becoming common reference material to 3D digitalisation with the use of 3D scanning. It has become a common method for quick reference in production and most 3D scanners will analyse a real world object to give a good mesh from the scan. Nonetheless it is important to clean the scanned mesh of unwanted polygons. 3D scanners are divided into contact and non-contact, contact scanners require physical touch to input points in digital space, and non-contact scanners use light, x-ray or ultrasound to capture the surface of the object and convert it into a 3D mesh. [9, 131-132]

Dynamics is not exactly a modeling method, but it has become a useful tool to speed up modeling process and production. There are several complex shapes that if done by hand would take a long time, therefore dynamics helps to reduce the time of modeling by using physics simulations to form shapes. The common simulations used to deform objects are rigid and soft bodies. Soft bodies are deformable objects that act like cloth

and hair, and rigid bodies act like breakable objects such as glass. It is easier to create an object and shatter it using dynamics than having to model each shattered glass one by one, and this is the reason why dynamics is so important in modeling. [9, 136]

Although there are several methods of modeling, it is uncommon to see a modeler use one method throughout the whole modeling production. Different methods and approaches will depend on the modeler and the current problem that needs to be solved for each specific product. A modeler should have an open mind to different options, and learn new techniques and tools to improve.

3   3D Modeling Optimizations in Multimedia

3.1   Illustration and Print

3D modeling optimization will vary in production, nevertheless it is important to establish a general workflow that limits errors and contributes to swiftness in the production. In illustration and print modeling stages of optimization is relatively different to other areas of 3D, this is due to the static result of the final product. Illustrations and print media that require 3D production are normally associated with the advertisement industry, and this can clearly be seen in most static advertisements.

Illustration and print production that require 3D are heavily dependent on 2D software editing, this is due to accurate results and faster product delivery. Throughout production 2D software, such as Photoshop, there will be the intermediate compiler that merges both 2D and 3D elements together.

3D Modeling optimization in this branch of multimedia requires less steps than other modeling branches. The general concept of modeling for illustration and print is to focus on the final result from the start of production. Unlike in other branches the sole purpose of modeling is to deliver the final model for compositing, without worrying about polygon structure and flow. A common rule is that the final model should look as close to the concept as possible, and because there are not frames to render, the polygon count can vary.

Polygon count in illustration and print is not so important, this is due to the one frame rendered for production. Nevertheless, any professional modeler should aim to create a good polygon structure and flow, thinking about render time and for future use. A common approach to modeling for 3D is following the guidelines established by the art department, this approach is commonly used in well establish studios and companies. A smaller studio's guideline may vary between concept design and rough planning, and therefore modelers can also be a part of the planning stage as well as the execution of the product.

Illustration and print that focus on using 3D elements as a part of their production pipeline is growing as the advertising agencies compete to create unique results. One of the most well-known advertising agencies that focus in print and illustrations is "Arsthanea" [11]. It has become a worldwide known agency because of the work and clients that they have, ranging from TV channels, companies and games. Figures 4 – 8 illustrate a common approach of a professional company in the production of an illustration for a game.


Figure 4. Concept Layout [12]

Figure 4 illustrates the concept layout phase introduced by the 3D artist, this step will be revealed to the whole production team to see what can be done or changed. 3D modeler will use this reference as a starting point for the project.
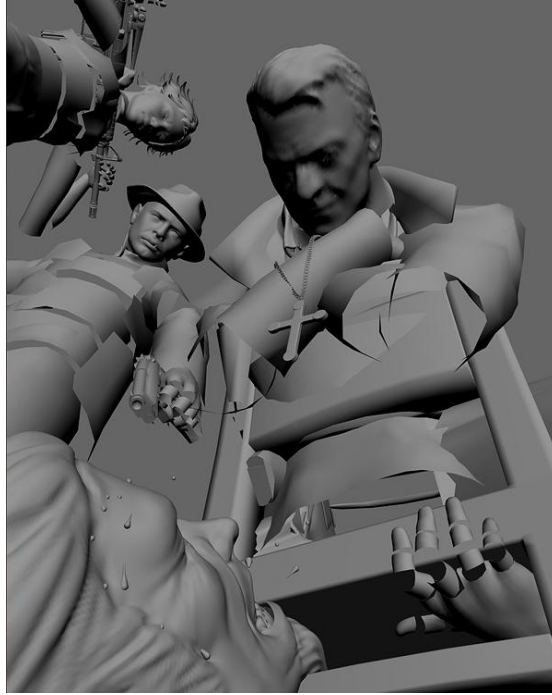
Figure 5. 3D Model Layout [12]

Figure 5 illustrates bases mesh models to recreate the layout of the scene introduced by the art department. This is an important phase because a 3D perspective camera view normally creates a different mood and environment than a 2D sketch. Therefore planning out the positions of the models will help reduce tweaking further in the production stages.
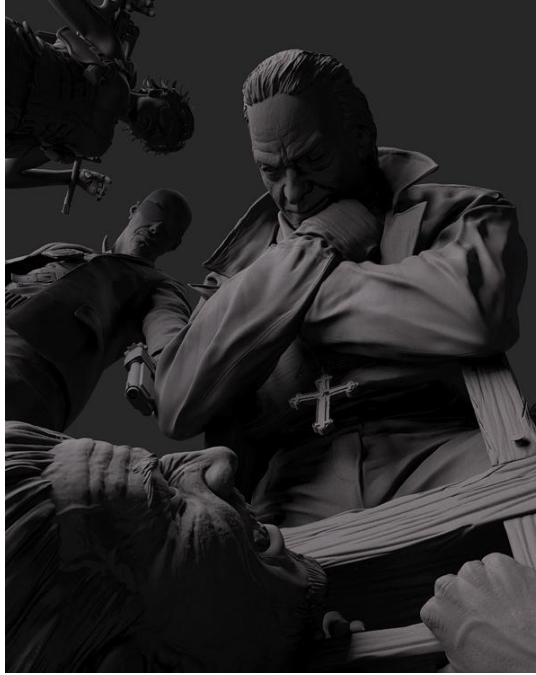
Figure 6. Detailed Models [12]

Figure 6 shows how a higher resolution mesh, which will be implemented to replace the dummy objects in the scene These objects are now at a higher subdivision level and the detail fine detailed modeled onto the mesh is implemented using a sculpting software such as ZBrush or Mudbox. This stage can be the most time consuming one in production, as it requires a lot of time to reproduce accurate details.

Figure 7. Framing [12]

Figure 7 shows a common method of 3D used in illustration and print. The use of framing a view will allow the modeler to work only on the areas that will be shown in the final result. This is a common method also used in animation but in different ways. As you can see the character model under the chair does not have a body, and this is the reason why the planning stage is so important.

Figure 8. Comparison [12]

Figure 8 illustrates the final 3D render on the left and the final composition on the right. It is clear that both images are different, this is due to the matte painting addition to the right composition. After the modeling stage has been concluded, as well as texturing, lighting and rendering, the final touches are implemented by a matte painter.

When using 3D, this is where the difference lies in illustration and print production. These final touches are implemented by a digital artist to "fake" elements in a scene. Common elements that are included in the final touches are, extra textures, hair and background environment.

3.2   Animation and Film

3D modelling optimization for Film and Animation are categorised by the artistic style of the set and characters, this is an important control attribute in production to make sure that all objects, characters and props are stylised in the same way. Thus, modeling objects with similar polygon structure, example would be the contrasting styles of photo realistic and stylised. [9, 118]

Film and Animation are commonly implemented with highly detailed and structured polygonal characters. In comparison to games and stills, and this is due to the flexible polygon count in most film and animation production. 3D model in film and animation will be partially concluded with the final renders from a render farm, unlike a game which has to create characters, and objects that are able to render in real time for gamers using limited hardware. Nonetheless film and animation is not produced only by large studios, there are a lot of Indy films and animations that have been produced with a very professional output. Time is the biggest issue in these productions, and a small studio will normally take much longer to produce something than a large studio. This is due to previously mentioned hardware as well as man power. Therefore, there is no specific style to be implemented and a limit in polygon count for animation and film. An animation can use very low resolution meshes or very high ones depending on the story and mood the person or group wants to convey.

In film animation the most important aspect of modeling is the polygon flow and structure, because most characters and objects that will be rigged and animated must have a seamless flow for perfect deformation. Throughout the years different polygon structures for characters in specific humanoid characters have been created, and there is no correct structure to follow. Nevertheless, there are good methods that have been proven to work quite well for specific types of models.

The four point perfection is the perfect rule for any 3D modeler in animation and film industry, this is the rule of making sure that all or at least most polygons form a Quad. A Quad limits models from deforming in the wrong manner. However, there is one exception called a tri. Although a triangle is not the best option for correct deformation it is still used in modeling to reduce the amount of polygons in some areas or to fix other polygons. [9, 156]

Meet Meline, a 6 minute short film, is a perfect example to illustrate modeling optimizations in film and animation. This project was created over the span of 2 years by Sebastian Laban and Virginie Goyons. A lot of optimizations were required in the modeling phase to ensure a good workflow in production, and to limit problems because of hardware limitations.

Meet Meline modeling phase was structured in 3 general phases, the Previz, Animation model, and Final model. The steps taken in these modeling phases ensure a good and error free workflow on the next stages. Figures 9 – 19 illustrate the process in the modeling optimization for production in Animation and Film in the Project Meline.
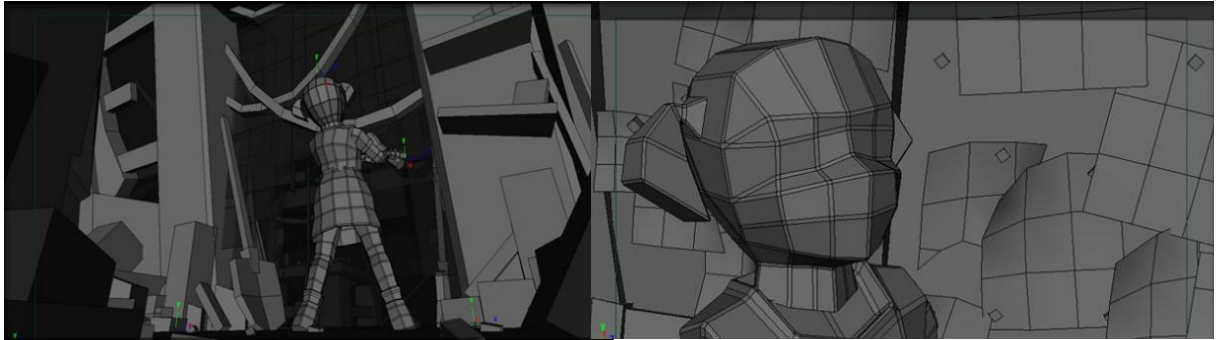

Figure 9 and 10. Previz [13]

Figures 9 and 10 depict the process of Previz, which is the Pre Visualisation phase. This stage in production is to test different possibilities scenes, camera angles and actions. Previz can be set into the category of a 3D Animatic, which is used to create a rough animated 3D storyboard.

Previz is quite useful gathering reference when animating and removing any issues before the actual animation. A common problem animating straight away without a Previz or Animatic is to remove sections of animated scenes because of poor planning.

Figures 9 and 10 illustrate the simple structure of the 3D models giving only a rough image of what the scene will look like. Previz allow to set up a scene with simple polygonal objects which can later on be replaced with the fully modeled objects. It is common for characters that will be animated to have separate body parts. Therefore when using the Previz the animator can position poses that will determine the next animation phase.
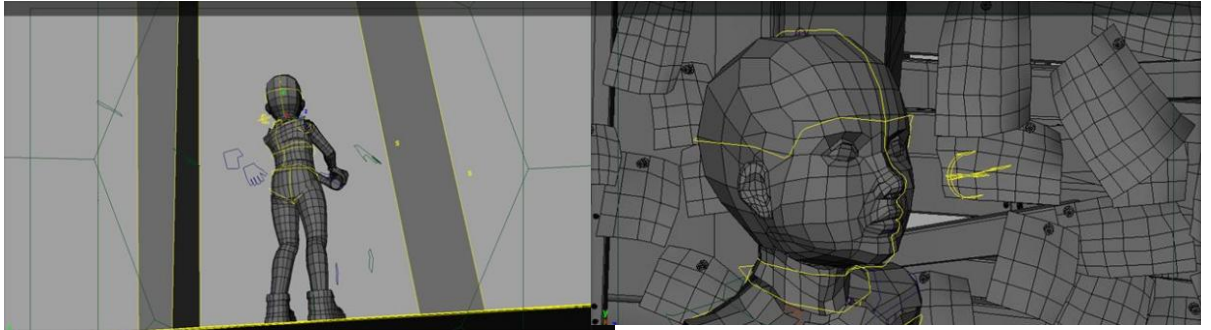
Figure 11 and 12. Animation [13]

The animation sector of production requires a base model with similar polygon structure to the final higher resolution mesh, and all characters which will be animated will have the exact same property. This step is important for the animation phase because of the workflow during animation. In this section only the essential items that will have interaction are present, while all the other objects are hidden for a lighter work environment. This step is essential if the hardware is not powerful enough to create a seamless working environment,

The base mesh will be rigged and animated, therefore it is important to keep the polygon structure very similar, as the animation will be transferred later to the high resolution character mesh. Figure 11 and 12 demonstrate the character model with few details and no objects in the scene, and only essential objects of the character are present. At this stage the main objective is to illustrate general movements.

Essentially the model polygon structured is aimed towards future animation purposes. Therefore, creating loop segments around the eyes and mouth is essential for correct deformation during the rigging and animation stages of production.
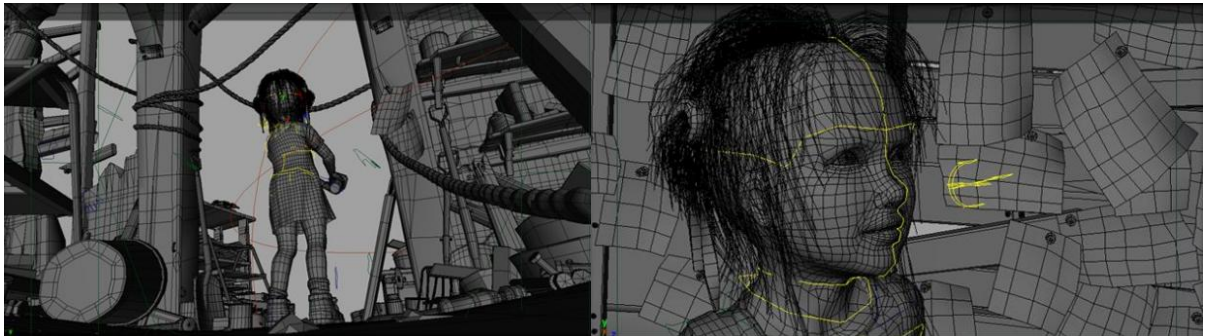
Figure 13 and 14. Viewport [13]

Figure 13 and 14 illustrate the final scene setup, where all the items separately modeled are added back to the scene for final tweaking in animation and scene setup. The higher resolution character mesh has now replaced the low resolution character mesh, and props such as clothing and hair has been implemented.

By analysing the higher resolution character mesh, it is clear that the mesh has been subdivided to enable a smoother output and allow better deformations throughout the animation.

Figure 13 shows a clear hierarchy on polygon priority, where objects that are predominant in the scene have higher resolution meshes in comparison to objects that are on the side. This is an important method to simplify and optimize modeling production. By limiting details in sections which are not in focus, the rendering step will also take less time.

Close up shots illustrate the importance of making sure that the model's polygonal structure is clean, because these are the shots where small mistakes can be spotted. Therefore keeping the model structure using the four point perfection standard is the best way to avoid any mistake.
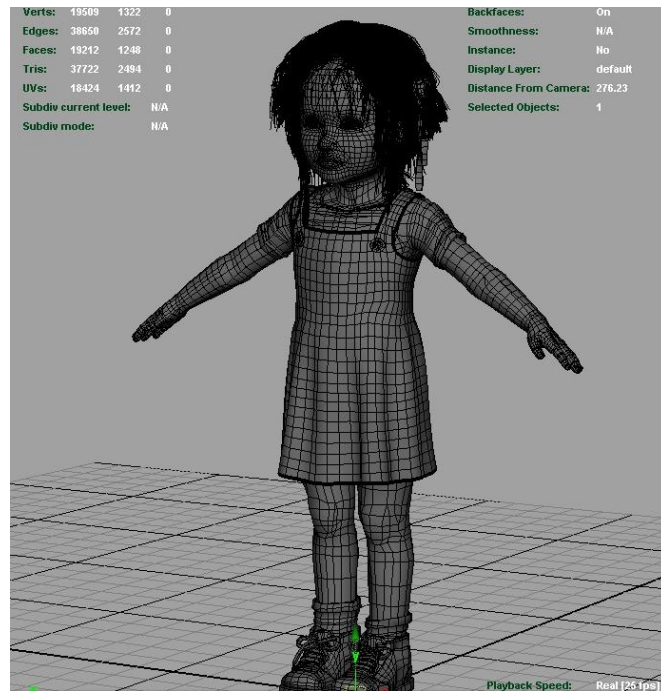
Figure 15 and 16. Final Render [13]

Figure 15 and 16 illustrate the final rendered look of the main character mesh, demonstrating perfect polygon structure with no visible mistakes. Important aspect in 3D animation and film is to create a style and stick to it in a composition. Meet Meline clearly shows the importance of following this "rule".

Figure 17 and 18. Environment polygon count [14]

Figure 17 and 18 illustrate the polygon count in the 2 main sets of the short film. The Cave and The Bedroom are compact with several objects, nevertheless 420,000 polygons is a good number for such a high and packed environment. Because most objects are not animated, they do not hold high resolution texture maps making the scene light.

Verts: 19509 1322 0
Edges: 38650 2572 0
Faces: 19212 1248 0
Tris: 37722 2494 0
UVs: 18424 1412 0
Subdiv current level: N/A
Subdiv mode: N/A

Backfaces: On
Smoothness: N/A
Instance: No
Display Layer: default
Distance From Camera: 276.23
Selected Objects: 1

Playback Speed: Real [25 fps]

Figure 19. Meline High Res model [14]

Figure 19 illustrates the high resolution version of the Meline mesh. This model has a total of 19212 polygons averaging at next generation game character which means this model is quite low resolution in comparison to most 3D animation and films, which can reach millions of polygons.

3.3   Video Games

3D modeling in game production is currently the largest branch in which, throughout the years, optimization has changed constantly. This is due to the evolutionary process of technology, nevertheless traditional methods of 3D modeling and optimization are still in use.

3D modeling in game production is solely focused on optimization for different platforms and hardware. There are several factors that come in place in the production of video games. In most cases this is made possible by the extent of processing and rendering power provided by the hardware running the games. The variety of games produced nowadays aimed at different devices, such as mobile phones, computers, and gaming platforms, is what drives the gaming industry to improve the content delivered.

Production aimed at different platforms will determine the modeling optimisations required, therefore, it is important to work aiming at specific gaming platforms. This aim will reduce the limits required throughout production, especially during the modeling phase. The modeling phase for game production consists of limits, thus being the reason why game modeling is not as flexible as other 3D modeling sectors of multimedia. Nonetheless, 3D modeling for game is the most interactive method of experiencing the 3D objects, viewed in a game engine.

The main reason why optimisation techniques for game production is so important is the poly count limit. From a mobile device to a high end computer there are poly count limits, meaning there is a limit of polygons in a scene that can be rendered without any problems. Unfortunately there are no rules that state an exact number, this is due to the other such as textures, rigs, lights, engine, shader and hardware capability.

Game production requires a lot of testing for the perfect experience, this is where modeling optimization in game development is important. It is equally important to know the specific targeted engine, hardware or platform that will be the main step to start production. Every platform and engine has specific guideline manual to make sure the game is produced according to the correct standards. A mobile game guideline for an iOS device will be completely different to the guideline for a gaming platform such as the Xbox360.

3D modeling in game production requires optimization to be implemented in game. Before modeling it is wise to see if the object will be seen from close or far distance, this will determine the polygon priority hierarchy. The main characters on a third person game, for example, will require higher detail and a denser polygonal model, because this character is the point of focus in the game. A smaller main character in a mobile device requires less detail; therefore, less polygons to show those details are needed. Figure 20 illustrates the possibility of recreating the same character with different polygon count and structure.

Figure 20. Mobile Topology [15]

Figure 20 illustrates the importance of polygon optimization without changing the general look and style of the model. The models from left to right illustrate a polygon count ranging from around 3,000 polys to 300 polys. It is important to notice the loops around the elbow and knees which are present in all models. This is because all of these models will be animated and deformations for bending, thus requiring more polygons in the area. The modeling structure of the characters in figure 20 is aimed at mobile gaming devices, keeping poly count of the character under 3,000 polys. In comparison figure 21 illustrates the difference of polygon structure running a on a much more powerful hardware platform.

Figure 21. Medium Res [16]

Figure 21 illustrates a common topology structure for characters in an online PC game, and in comparison to the previous figure 20, the poly count is five times higher demanding more power for real time rendering, this genre of game, commonly called MMO (Massively Multiplayer Online), has similar characteristics in their modeling optimization and can be clearly seen on their triangulation method of structuring their topology. Triangulation topology is the splitting of a quad polygon in a mesh to create a higher resolution mesh. This is used to support deformation in certain areas, and it also allows engines to calculate these models faster and more efficiently.

Although triangulation is commonly seen in games in the implementation phase, triangulation of all models is happening real time during modeling phase. However, this is not shown on the viewport unless a triangulate modifier is applied. Therefore, the four point perfection is a visual guideline to modeling as mentioned in the film and animation section of this chapter. Underneath the quad system the software has tessellated the polygons into triangles as shown in figure 22.
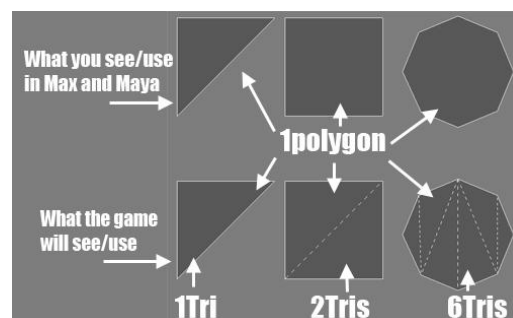

Figure 22. Tris [17]

Figure 22 shows copies of the same polygons but looked at in a different way. An octagon, when divided into triangles, becomes 6 individual tris, showing the way game engines see that octagon. Nevertheless, this does not mean that 3D objects implemented into a 3D game engine will be required to be have a triangle polygon structure, because under the visual polygon reference every polygon is triangulated.

Games aimed at high end computers have always been ahead of the competition in terms of graphics capacity. Nevertheless, gaming platforms such as Xbox 360 and PlayStation 3 have inhibited the gaming studios to create a higher quality games since around 2006, because of hardware limitations. Next generation games with the introduction to new consoles will be soon introduced. They will bring a larger flexibility on the current methods of modeling optimizations changing the future of 3D modeling and pipeline in 3D game production.

Next generation game modeling optimization will start to take on the approach of cinema and movie production. Character models and environment objects will in future gain higher poly count to produce higher detailed models giving a cinematic feel and experience to gaming. Although 3d modeling optimizations will change, this change has been occurring progressively throughout the years. High polygon models such as in Uncharted 2 in 2010 already demonstrates where next generation modeling optimizations is heading.
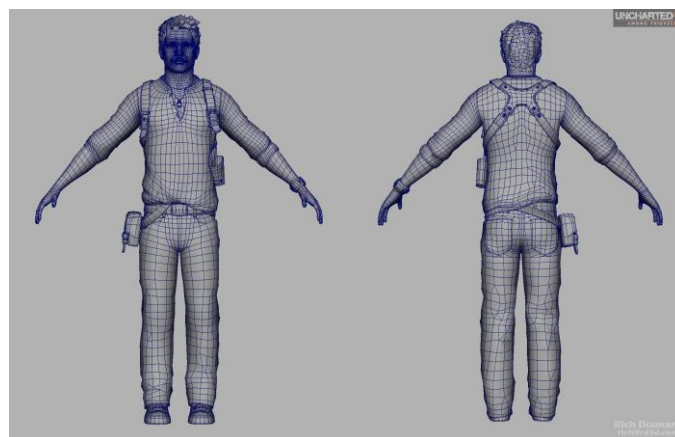
Figure 23. Next gen [18]

Figure 23 illustrates how a high polygon density model is used for the main character in the game Uncharted 2, reaching a poly count of around 30,000 polygons. This game is a good example of the characteristics the game development community is aiming towards, the high level of detail pushing the graphics boundaries.

When analysing the polygon structure of high detail game characters, it is clear that the game industry is aiming to reach a visual level of experience similar to CG films, with the difference of actually experiencing the story and being part of it.

4   Practical Project

4.1   Project Overview and Plan

This project is aimed at the development, creation and optimization of a 3D game character for a game project by the Game Portal team. As the 3D artist I was assigned the concept design and modeling Retopology optimization sector of the design team.

This project was primarily aimed at a game that will be implemented to a mobile device, iOS and Android. Also a PC version of the game will be tested before further optimizations are done to be implemented to other devices.

The illustration and description of this project is to demonstrate the workflow in the optimization of 3D modeling for a mobile game using next gen techniques. I chose this method to demonstrate the change in modeling techniques occurring in current game studios.

The procedure in the development of the main character called Jake will be a simulation on a professional method of approach to modeling a game character. The project will be divided in 4 main stages, concept design, model structure, optimization and refinement. These stages will be the guideline to the workflow in the development of Jake. Below is the general guideline followed by the character development project.

Workflow:

- Brain Storm
- Illustration Concept Design
- Polygon Structure Plan
- 3D High Poly Mesh
- Retopology Optimization
- Detail Optimization
- Refinement

4.2 Project Workflow

At the beginning of the project the team got together to discuss the physical attributes to implement on the Jake model. A brain storming session, where the whole team gave ideas and discussed the general aspects of the character model was held. A brainstorming process requires a background story. This is important because when creating a character it is good to know who he is, where he is from and what he does. After understanding the character's background, a written description of the character was handed to the illustration artist for a quick sketch. Figure 24 illustrates the first paper drawn sketch of Jake.

Figure 24. Jake Sketch [19]

Figure 24 illustrates the concept art sketched by a member of Game Portal. This sketch was introduced to the design team, and fortunately it was a perfect match to what we were imagining. This Sketch was then given to me for reference purposes to start the process of 3D concept design for this character. Eye caching parts of the drawing such as the leg, character's bulkiness and clothing helps to create and focus on the dominant features to bring life to the character.
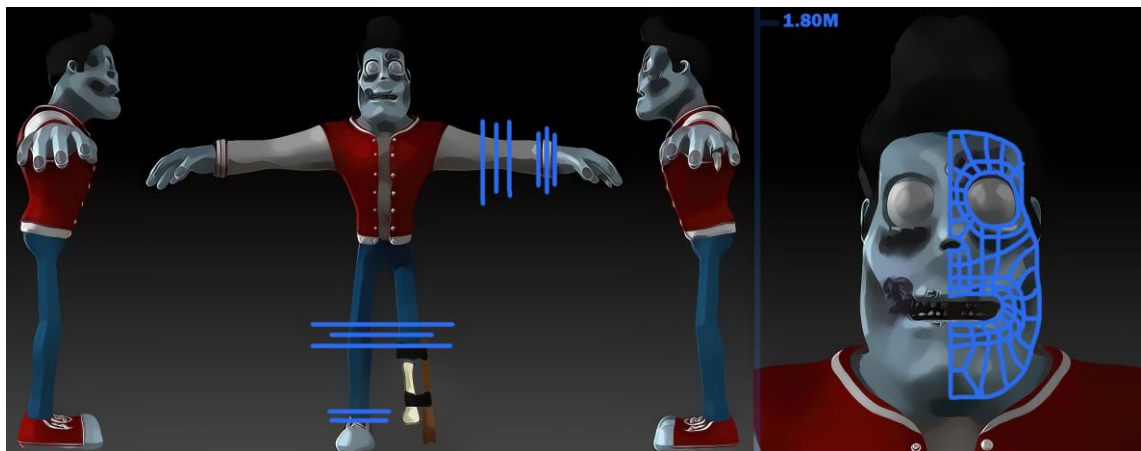
Figure 25. Jake Reference

A Photoshop T-Pose and polygon structure plan was created as illustrated in Figure 25. The purpose for this reference is to make sure the 3D model came out as planned, and to have a reference point when modeling. The facial polygonal structure was used to see a general layout of how the polygons would appear during the Retopology phase of production. Blue line segments were added in the joints to make sure that these locations should have a higher polygon count for animation purposes. In the same way the facial topology structure in figure 25 shows the necessary loops around the mouth and eyes also for animation purposes.

External reference was also an important aspect to start production. Clothing and accessories were searched to make sure this reference image was created to the standards that we believed matched Jake's personality. For instance the baseball bat leg was a well thought out process during the brainstorming phase, which gave Jake a unique feature as the main character of the game "Story".

The following section of production is the sculpting phase, which determines the perspective outlook of the character. In 3D space a model can look very different to the reference drawings; therefore, a constant reference check was important throughout the whole production.

ZBrush was the primary tool used in this phase, and the whole base and a large part of the modeling optimization were done using this software. The first stage of modeling this character was to create a base mesh that could be manipulated in later stages. Although there are several methods to start, I personally prefer this method as it is the fastest and most optimized method of modeling from personal experience. Figure 26 illustrates the base mesh create using ZSpheres.
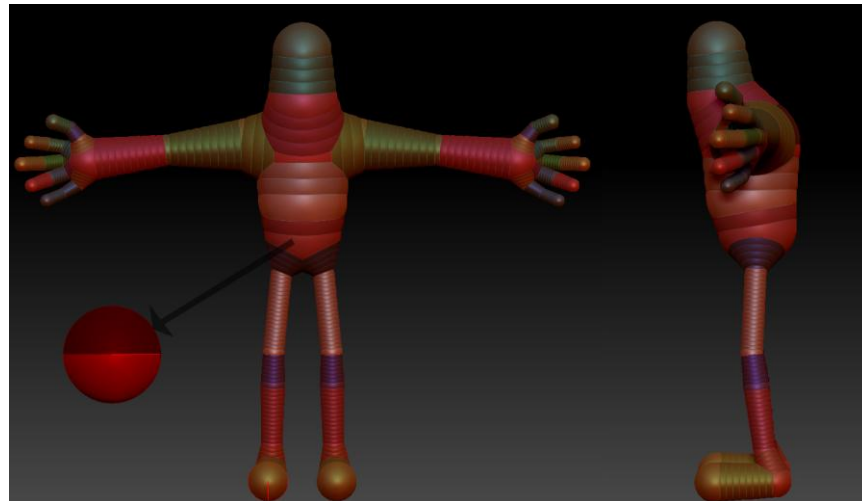
Figure 26. Jake ZSphere

Figure 26 demonstrates the first base structure of Jake, this base was made from a single ZSphere which is now located as Jake's hip. The process of creating this base mesh is relatively straight forward, as ZBrush has the option of working in symmetry, with the shortcut key "x" on the keyboard, or by locating the symmetry option under the transform menu.


Figure 27. Controls

Just like other methods of modeling, drawing a ZSphere and moving, scaling and rotating to the correct position was the start of creating this base mesh. Figure 27 illustrates the drawing, moving, scale and rotating section of the tool bar and their respective keyboard shortcut.

Figure 28. Mesh 3D

Figure 28 illustrates the PolyMesh version of the ZSphere base as shown in figure 26 This a preview version of the PolyMesh that can be accessed by pressing "a" on the keyboard. After the base mesh is apparently similar to the general look and ratio of the reference it is time to convert the mesh into a PolyMesh object. This can be accessed through the Tool section on the right, and pressing the "Make PolyMesh3D" to finalize the conversion.
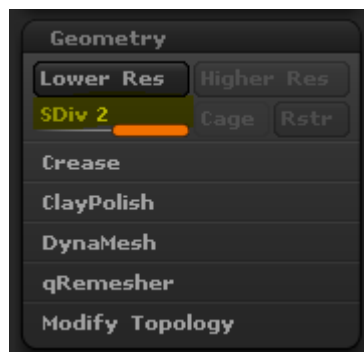
*Figure 29. Geometry Subdivision*

The PolyMesh version will be composed of subdivision level, which can be accessed in the Geometry Tool section illustrated in figure 29. This tool will be important to optimize the detail levels, a high subdivision level will modify the object to tessellate and create a higher poly count mesh. Nevertheless, lower subdivision levels can be accessed to modify larger sections of the model.

The model is now ready for the start of the sculpting procedure. There are important tools inside ZBrush, which will speed up the workflow for seamless modeling optimization. First it is important to be acquainted with the 3 main brush types the sculpting brushes, transpose brush and mask brush as illustrated on the table below.

| Main Brushes:	Description
Sculpting Brushes = **Q**	The main brush, used similarly to traditional Sculpting methods.
Transpose Brush = **E**	Move large parts of the object around, normally used together with Mask Brush to translate, rotate and scale sections of the object.
Mask Brush = hold **Ctrl**	Masking Brush used to isolate areas where you want to work, and to be used with several masking techniques.
Extra Brush:	
Smooth Brush= hold **Shift**	Part of the Sculpting Brushes, it is automatically assigned as Shift because it is a constant brush being used to smooth out the polygons.
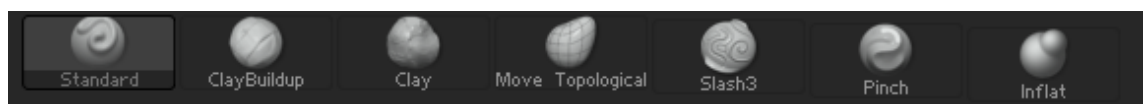
Figure 30. Sculpting Brushes

The brushes illustrated in Figure 30 are among the few brushes that can be accessed from the left toolbar brush palette. The brushes in figure 30 are commonly used brushes for sculpting, mainly the Move Topological, Clay Build up and Standard brush. Each brush serve for a specific purpose and when used correctly, can optimize the workflow of sculpting.

The following step of converting the PolyMesh model into a DynaMesh is to prevent a spread polygon density around the model. DynaMesh creates a unified polygon mesh that allows sculpting without worrying about the underlining mesh.

Figure 31. DynaMesh

DynaMesh can be found under the geometry Tool section. By selecting DynaMesh the object will be converted into a DynaMesh with the selected resolution. DynaMesh is a much denser polygonal mesh, perfect for sculpting and detailing as shown in figure 31.
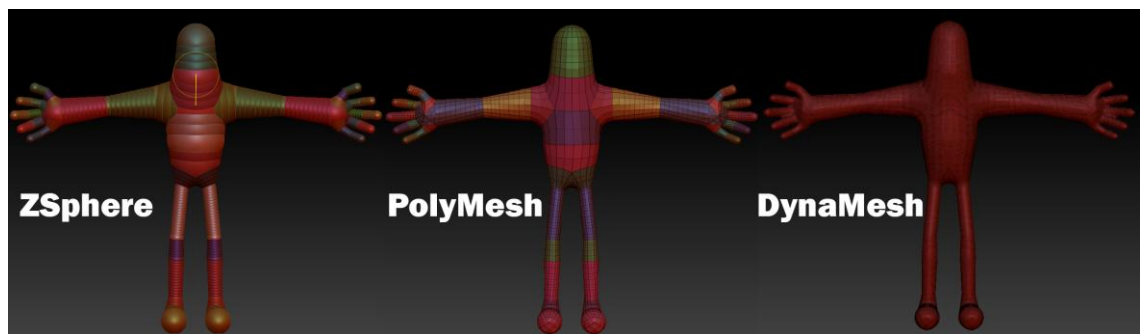

Figure 32. Polygonal Comparison

Figure 32 illustrates the difference between the types of Polygonal object that have been converted in this modeling production. ZSphere was the base and skeletal structure of the model, giving the general look for the conversion of ZSphere to PolyMesh. PolyMesh is a polygon structure mesh that can be sculpted with manual subdivision polygon arrangement, and DynaMesh is conversion from PolyMesh to reduce issues with scattered underlining geometry.

By observing figure 32, it can be seen that DynaMesh is compact with polygons, allowing higher detail on the Sculpting phase. Nonetheless, it is important to move the PolyMesh into the form and position before converting into a DynaMesh, because after conversion the model will retain the polygon count and structure.

When the DynaMesh modifier has been implemented as the new polygonal structure, the mesh is ready for the sculpting phase. The sculpting section consists of building block phases, meaning working from lower resolution base to a higher more detailed resolution mesh. The base and start of the sculpting phase is illustrated below in figure 33.
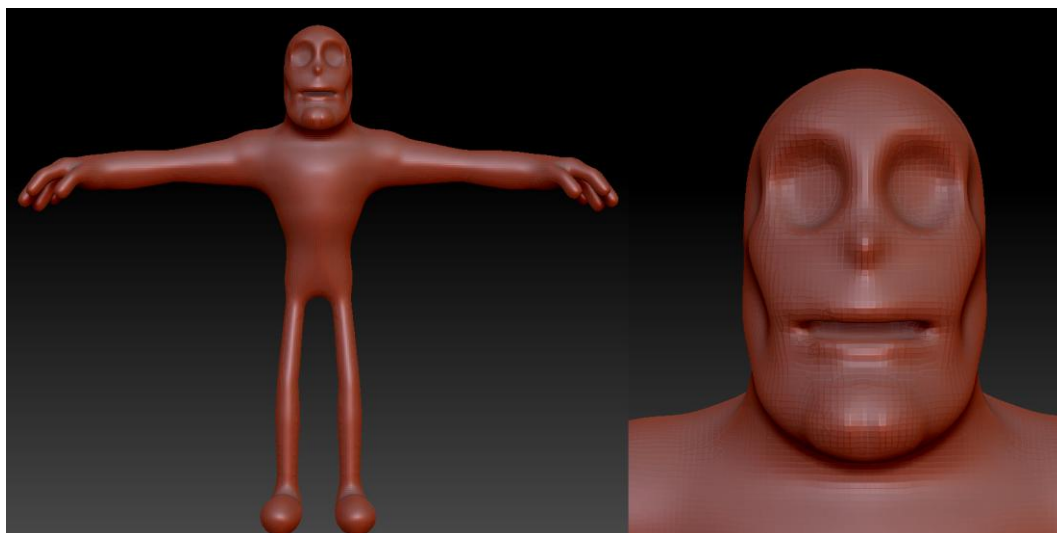

Figure 33. First Base Detail

Figure 33 depicts the first level of additional detail. The purpose of this first phase is to give the general overall look of the object. Cavities such as the mouth and eyes are created, as well as the muscle volume. In this section size referencing was the most important aspect, making sure that the proportions of this model correlated with the illustration reference images.

The process of constantly smoothing and averaging the polygon structure of the model is continuous throughout this phase. It is important to not skip this averaging technique as the model is moulded to the general shape of the character reference. The reference character model has clothes; therefore, the point of interest for the model is the head. The head, hand and left leg will be the most detailed sections of the model, nonetheless it is important to keep a clean mesh structure before creating the character's clothes.

The shaping process will be a continuous symmetry modeling technique used in ZBrush. It allows a seamless workflow, where at the end non symmetric details such as scar tissues, anomalies and props can be implemented to the object.
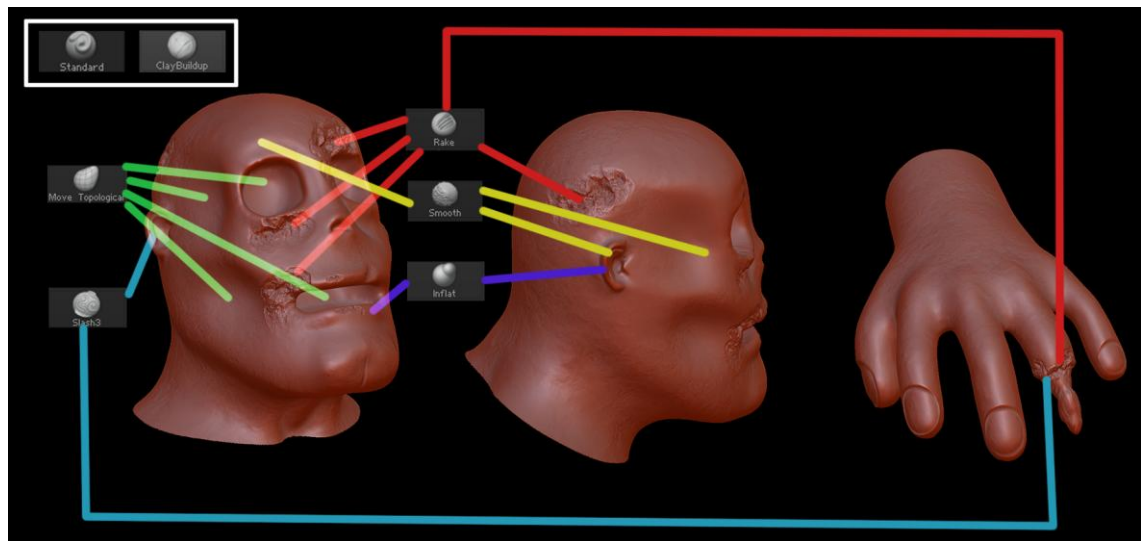
Figure 34. Extra Details

Figure 34 illustrates the additional details implemented to the character model. The base brushes, Standard and ClayBuildup are highlighted in figure 34 with a white outline. These main brushes with a combination of masking and the move tool were the overall shape manipulators throughout the base creation process. After this other brushes such as rake, inflate and slash are introduced to work on subtle details of the model.

The most visible change in the addition of detail to the character are the rotten flesh wounds, which are created using a combination of the rake, slash and move brushes. Small yet noticeable details such as nails are implanted to create the high resolution version of the character. These details on the game version model will not be present on the physical object, instead the detail will be conveyed through texture maps and normal maps.

Smaller geometry changes will be implemented in this stage, such as the bone exposure on the left hand ring finger. Small details such as these are worked without symmetry to provide variety and personality to the characters. Even though the bone finger is not a big change, it is still important in later stages to create a topology structure for the bone, instead of using texture maps to fake the topology changes.

Masking in ZBrush has several uses and methods to approach modeling, one of which is to extract highlighted mask to create new geometry. During this next stage in modeling production, it is common to extract all necessary parts, such as clothing and hair, for later detailed work. Using figure 25 reference image, the clothing style of the character becomes clear. Therefore, to recreate the style and position of the character´s clothing, it is important to keep comparing the masking selection to the reference.
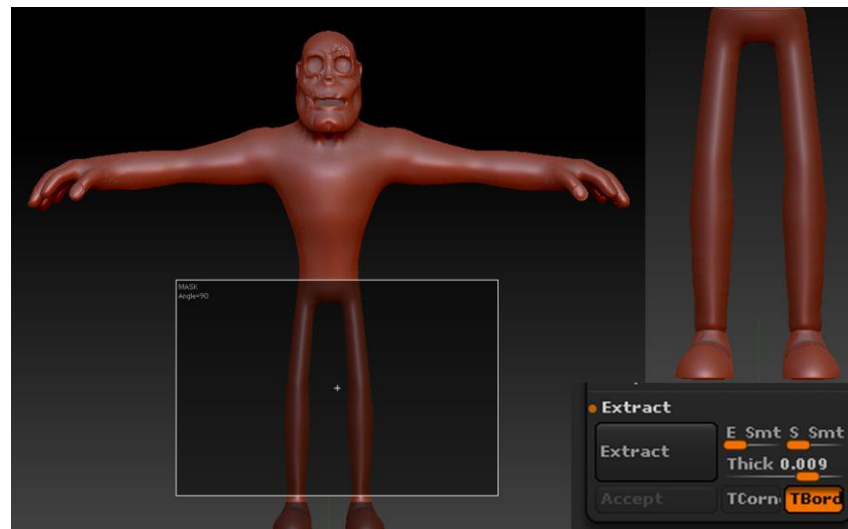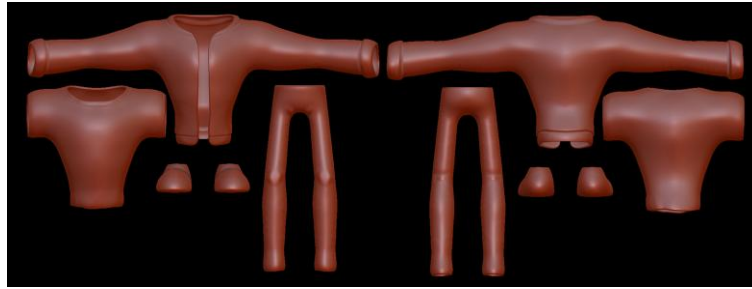

Figure 35. Masking Extract

Figure 35 demonstrates the masking selection with the procedure of holding control and dragging the selection on the viewport, for the trouser masking selection. On the bottom right of figure 35 is the extract submenu under the SubTool section. The Extract option contains several options for the extraction of the highlighted mesh. However, the most important option is the Thickness: the higher the value, the thicker, or more extruded, the extract will be. Keeping the thickness value of under 0.009 is good for clothing, as shown with the extraction result on the top right image in figure 35. It gives enough flexibility and thickness for sculpting.

It is important to note that the extraction process will duplicate the highlighted mask into another SubTool. This ensures that nothing will change with the original highlighted model. The polygonal structure of the extracted mesh will be a perfect copy of the original mesh. Therefore, if the object is at a lower subdivision, the extraction will be at that particular subdivision.

Figure 36. Accessories

Using the masking technique illustrated in figure 35, different clothing accessories were created as shown in figure 36. The highlighted masks around the character's body were extracted, and then sculpted for finer detail. The style of this character mesh has a cartoon standard which is too detailed for this project, for example cloth wrinkles and patterns, are not present in this section of production.

Figure 37. Additional Elements

In Figure 37 additional elements have been added to the scene through the SubTool section. Primitive elements such as a sphere and cube were manipulated to create the additional elements such as eyes, hair and teeth. The manipulation process for these objects is similar to sculpting phase of the character's body. In addition a constant duplicate and mirroring techniques using the Deformation tool section were used during this process. The resolution of the additional elements are lower in polygon density. This is done on purpose, because this high resolution mesh will undergo a Polygon restructuring phase in the Retopology section of modeling production, thus the topology of these external elements will only be a base for the next phase. Unlike the body mesh

that holds additional mesh details on the surface, this object will be used as a mould in later stages of production.

Although different elements are separated from the main body object, they will be unified in the Retopology phase for the in game model. Retopology phase is the next step to achieving a well-structured topology model for game and cinematic use. The Retopologizing phase consists of using the high density polygon mesh of the sculpting phase and using it as an external mould to recreate the model with conscious polygon placing.

Topogun will be the primary software used in this phase. I chose this software because of its optimized workflow, allowing me to work as fast as possible without any obstacles. The Retopologizing methodology is very straight forward and similar to most models that require Retopologizing. The polygon structure is the biggest issue in this phase, where it depends on the user, poly count limit and time limit for production.

The user can take on many approaches of Retopologizing. An example of this is working from a bigger polygon and gradually adding necessary details, or detail polygon structure from the start. Poly count limit is the second issue especially for game production, and in this project a poly count limit for this model was estimated at less than 2,500. This number is a good start to model a mesh with good resolution for a computer game and high end mobile devices. It is also a good starting point for later modeling optimization, to implement for other less powerful mobile devices. Creating this base model for different devices will save time in future production stages, in case this model will be reused for different purposes such as a cinematic animation.

This phase of modeling optimization is the final general structure modeling section before final touches and additional parts can be finalised. The process of Retopologizing can be seen as a puzzle, this is due to the previously mentioned correct topology structure, or the four point perfection "rule". Keeping this model well-structured will prevent future problems in other sections of production. Therefore, this is one of the most time consuming sections of this modeling production. An important reference for structuring the polygons is to question which parts of this model will require bending and stretching for animation, as these parts will require more polygons and loops for deformation.

Figure 38. Topogun Tools

Now the project has been moved to Topogun for the Retopologizing phase, and a base mesh with .obj file extension has been exported from ZBrush. The exported file size output is 722 MB, this is again due to the high poly count mesh from ZBrush. Nonetheless this mesh will not be used for any modeling, it is a reference mould for polygon to be structured on top of the reference. This process is very similar to the Make live function in Maya, where the object can interact with vertices, edges and faces that are added on top of it.

Figure 38 illustrates the process of adding a segment to the reference model, creating a polygonal structure on top of the reference. A tool section is illustrated in figure 38 with numbers for explanatory purpose. The simple edit tool referenced as number 1, is the common select, move, rotate and scale tool. The simple create tool is referenced as number 2 and it is used to create geometry on the surface of the reference. These two tools are the most common ones used in any Retopologizing software. Additional tools such as draw tool (3) allow the modeler to draw the polygonal segments with the software algorithm to connect the intertwined segments into polygons, bridge tool (4) used to connect edges between unconnected vertices. Tubes (5) is a good tool to create loop segments around tube shaped objects, such as the arms and legs, brush tool (6) allows modify function of vertices using a paint like method, and an extrude tool (7) to extrude edges along the reference. All these tools in combination are used during the process of creating the new optimized topology.
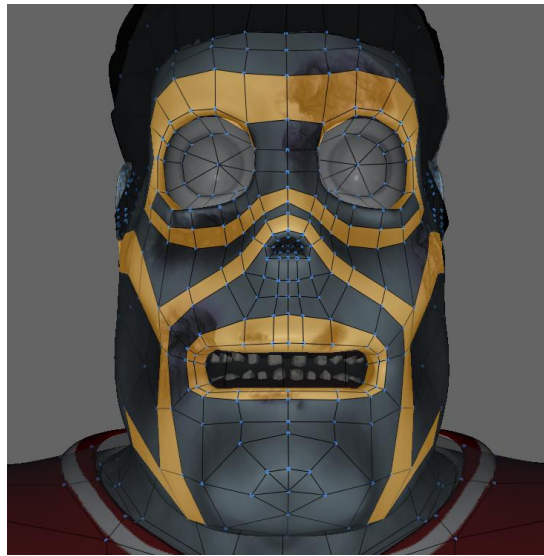
Figure 39. Topology Flow

Figure 39 illustrates topology flow with the highlighted faces. When rebuilding the topology of this model, it was important to understand the facial components of the model. Analysing and understanding that the character is a version of the traditional "Zombie", it is important to keep the appearance similar, meaning the character will have loss of muscle tissue and fat. For example this model does not have eye lids because of soft tissue, thus having little movement in that section. The topology flow should guide the locations where the character has more movement, such as the eyes and mouth. This topology optimization technique allows the modeler to optimize the amount of polygons added to certain parts of the model, sparing unnecessary polygons, and if needed adding the unused poly count to other parts of the model.

Figure 39 illustrates a model that is still quite dense in polygon count, in relation to a mobile device game character. This is due to optimization that can be later on implemented for different mobile devices, this being the base for all models. This base is created for the process of texturing rigging and animation, which can be later on transferred to different versions of the same model.

Figure 40. Poly count Comparison

Figure 40 shows the comparison between the sculpted ZBrush model and the Retopol-ogized model in Topogun. By looking at the poly count it is clear that the model has been optimized, from 12 million polygons to just over 2 thousand polygons. Reaching the base model mesh aim of under 2500 polygons. Having a close comparison be-tween the two images, it is clear that the image on the right lack the same details as the image on the left. Nonetheless, these details will be transferred using normal maps, but overall the objects look identical.

Looking at the image on the right it becomes clear that the density of polygons are concentrated on the areas which will require detailed deformations in the animation phase, for example the head and hands. This density of polygons in the mentioned areas will be reduced in case this model has to be optimized for other mobile devices. Having this model base will allow easy polygon reduction or addition.

It is hard to compare these two models, because the purpose for the ZBrush model is to be an exact reference for Retopology. However, the opposite process of first model-ing the high density mesh and then creating the lower resolution mesh contradicts the rational method of modeling, but in this case I believe that it allows specific polygon structure plan to be thought through. Also it allows greater creativity in the sculpting phase.

Now that the model has been optimized, it is time to implement the additional parts of the model which was not possible until now, where symmetry is not an issue. Because of the use of symmetry, a detail such as the left leg baseball bat design which was planned at the start of the project, was not implemented into these previous stages. This is due to a faster approach working in complete symmetry than adding the non-symmetric parts at the end. This can be seen in figure 41 below.
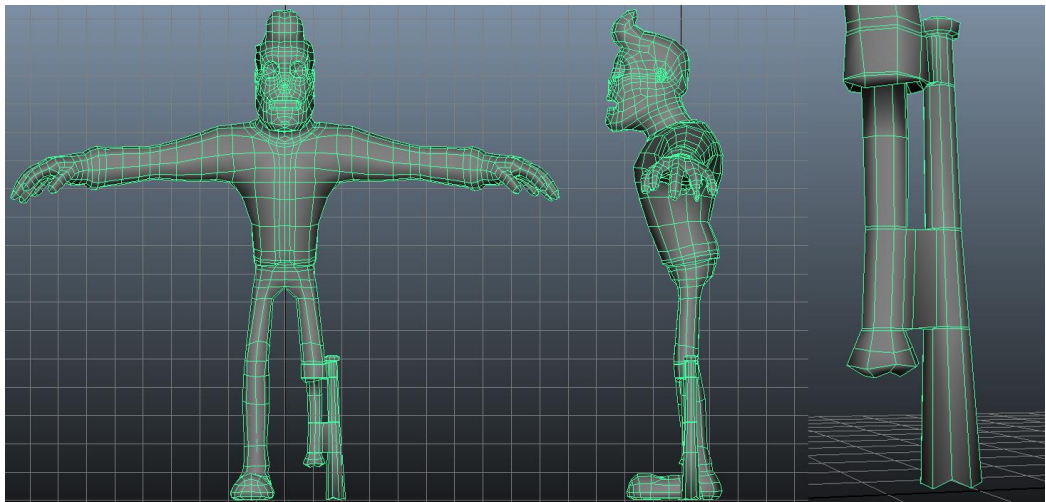
Figure 41. Additional Parts

Figure 41 demonstrates the additional non-symmetric part of the object, the baseball bat leg. The process of creating this element was using a simple box modeling technique of extruding as section were I amputated the left leg to recreate the previously planned design. Because the poly count was under the 2500 aim, I was able to do it in more detail than previously planned. Another small section which was changed in this final phase was the left ring finger, which was planned to have bone sticking out of a flesh wound.

Figure 41 shows the final stage of the modeling phase. Now additional objects such as the eyes and teeth will added to the object, and UV mapping and texture baking will take place. It is important to take time in this final stage to tweak and fix small errors made during the Retopology phase.

Figure 42. Object Size

The model created in this project is aimed at mobile devices. Therefore, figure 42 illustrates the size comparison between the objects, and how irrelevant some details are as the object decreases in size. Polygon optimization takes into consideration the actual scale of the model, allowing the modeler to check the model in relation to the scale in the screen. Decreasing the scale will also decrease the poly count.

Because the model polygon count averages at around 2000 polygons, with smoothing and additional details this model can also be used for the in game cinematics. Using these methods and workflow allowed me to create a "Universal/General" model that can be used for several sectors in multimedia.

4.3   Analysis and Comparison

It is clear that there is not one defined method or approach to modeling, nonetheless there are good methods that can implemented to speed up the production and flexibility of the final product. My method and approach is aimed at a pipeline that can change the visual elements of the model. Therefore, having a conceptual approach to modeling using sculpting techniques allows a wide flexible range to add or remove elements from the model before the polygonal optimization.

This method can be clearly seen as an alternative approach to modeling, or an opposite modeling approach, because the modeling phase was basically started from a high-resolution mesh and developed into a lower resolution mesh. This modeling approach is also extremely dynamic; it allows the modeler to increase and reduce polygon density and structure working in subdivision levels.

In comparison to traditional methods of modeling, where the model is created using different techniques such as box modeling and edge modeling, there is little flexibility in these techniques: the model needs to be complete because the final output needs to be complete with a good polygonal structure straight away. Therefore if changes need to be made it will take a lot longer to preview the changes. This is different from the sculpting phase where all the modifications can be made before making the final polygonal structured model.

The approach to modeling that I took in this project is very similar to the new approach in the creation of next generation models. This approach requires a sculpting base before the model is optimized in any way. This method allows a detailed analysis of the model to be discussed before taken into the next stage of production. This process is also common in high detail film and animation, where sculpting is used as a base for later polygon structuring.

Although there are many benefits to this approach, there are also a few draw backs. The main problem with this approach is the software budget. Having one software such as Maya to create the model, but using traditional methods, will be cheaper than using a variation of software, in this case ZBrush, Topogun and Maya. Having these software will help optimize both model and modeling process, and therefore, it optimizes the time spent during this phase in the production pipeline. To conclude the comparison, it is important to take note that modeling methods and techniques are constantly changing, I believe that this approach is being used increasingly in the industry.

With a critic mind-set I believe that a few stages of the modeling process used in this project could have been optimized to increase production speed, I believe that the early stages of base sculpting could have been used to generate the final look of the character earlier during the planning phase, which would have allowed the design team to create different looks for the main character. Nevertheless, the overall output was satisfactory in relation to the planned reference material.

5   Conclusion

3D Modeling in Multimedia is becoming a common branch in the pipeline of different industries, such as illustration and print, animation and film, and video games. The growth of these industries has allowed the thriving 3D industry to evolve side by side, creating different methods and approaches to tasks and problems in production. Modeling optimization has become a section of 3D production in most pipelines, creating, fixing and recreating 3D models to the specific needs of production.

3D modeling in Multimedia, although very similar, has specific details that need to be approached in different manners, creating a variety of branches inside 3D modeling. From hard surface modeling to organic modeling, branches are formed to produce work for specific areas. Knowing the difference in modeling approaches between these branches will allow a modeler to tackle problems in different Multimedia scenarios with specific methods, which will allow a faster and more efficient modeling workflow in the production pipeline.

The project workflow in this Thesis illustrated a workflow version in the approach of modeling optimization for video game. In specific 3D character modeling for a mobile device, the methods and techniques in the project were a mirrored approach to next generation model creation. Using different techniques such as sculpting and Retopologizing will speed up production and approach modeling in a creative manner. The seamless workflow of Retopology phase expanded the options to model for different purposes and devices, having a base mesh created for different Multimedia sectors.

The final result in comparison to ideas which came during the planning phase and references was satisfactory. Nonetheless, the optimization of the 3D model can continue if needed in future stages of production. The project output will be used for all three specified sectors of Multimedia mentioned in this thesis, illustration and print, animation and the actual video game. They will demonstrate the optimized value of the 3D model output in relation to these different sectors of production.

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