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Character Creation: Comparison of 3D and 2D Video Game Graphics Workflow

Juho Ollila

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Description

Ollila Juho

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Abstract

Indie video games are rising in popularity. Developing video games as a single person has been a thing since the start of the industry. However, it is not easy, especially with rise in competition. As a developer, one of the choices that needs to be made is whether to develop a game in 2D or 3D. There is a lack of guidance in terms of academic research to help this decision. The goal was to produce academic research to give helpful information, rather than attempting to answer if one is better than the other. This information is aimed to help game developers make their choice.

The workflow of creating 2D and 3D graphics for a video game was compared. The objective was to find what benefits do both 2D and 3D graphics have and finding steps to ease the process of creating animations for them later. The research method chosen to complete these objectives was action research. A framework was created through qualitative research via a literature review about creating graphics and video game character design. This was used in a practical implementation where a video game character was first designed and then created in both 2D and 3D.

The major conclusion from the results of the practical implementation is that 2D workflow is quicker and arguably easier than 3D workflow, but the latter is more flexible for adjustments later. Using armature models ease animating at a later stage with both graphical styles. A 2D character likely requires new assets to be drawn when adding different animations. With 3D on the other hand the model can be utilized and manipulated easily for creating new animations.

Keywords/tags (subjects)

Game development, computer graphics, 3D modelling, digital painting, video game characters, solo game development, indie game development

Miscellaneous (Confidential information)

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1 Introduction

At the beginning of the video game industry and all the way to the 1990's, 2D video games were the norm. Along with the advancements of technology 3D video games became not only possible but also rose right next to 2D as another norm. Both styles of games still have their place even today. Neither game can be considered objectively better to overrule the other. 2D video games have a solid place especially in the retro-inspired games space. 3D games on the other hand are favoured when things start to get more complicated. (Starloop Studios, n.d.)

Indie video games are on the rise in the US. 17 percent of PC and console players played indie games in 2022, while previously the percentage was 13 in March of 2021. With the rise in popularity of indie games, more smaller teams can make games. One thing to notice though is that the effects of Covid lock-down to these numbers is likely. During Covid many of the bigger titles' releases were delayed, which likely had a big effect to the dip in percentage of players those games had. (Fleck, 2019)

Developing video games alone as a solo developer is its own endeavour. Still, it is nothing new. Solo developers have existed since the beginning of the industry. Today the difference is that the competition has grown massively. (Addison, 2021)

2 Objectives and Methods

2.1 Objective

The objective of this research is to give more insight of using both 2D and 3D graphics when developing a video game. Especially the community of solo developers, in other words those who want to or might already be making video games alone as the sole developer, should get insight to help choose whether to work with 2D or 3D graphics. This research will go through the process of creating a character ready to be animated in both 2D and 3D. A practical implementation is produced. A character is created for a video game with a side view perspective and cartoony and exaggerated art style. These factors have been chosen to make the design and art style of the game something that makes it quick and easy to deliver similar looking products with both 2D and 3D. Essentially, this research aims to ease the choice of 2D and 3D graphics in a case where it is primarily an aesthetic decision.

In conclusion, the research questions aimed to be answered by this research are:

1. What are the benefits of using 2D graphics in game development?
2. What are the benefits of using 3D graphics in game development?
3. How can video game characters be created in a way that they are easier to animate later?

2.2 Research Method

Graphics creation and video game character design are researched first through a qualitative analysis via literature review. The next step is a practical implementation where a character in both 2D and 3D graphical styles is produced. This character will be ready to use in a video game. Afterwards the researcher goes through the results of the practical implementation and attempts to give answers to the research questions with the compared information gained from both the literature review and practical implementation. The research method is action research.

According to Kananen (2009), action research is research and improvement of the people's own work in practical work life. The goal is to solve practical problems in different communities, such as companies, public entities, hospitals, etc. Action research is seen as a practice and strength coming from the operators. Still, it is hard to give an unambiguous definition because this is not just a single research method but more of a group of research methods.

2.3 Information Retrieval

When searching information, the researcher mainly used Google, and Google Scholar. Using Google Scholar was preferred, but it did not always yield adequate results. In those cases, normal Google search was used. Search terms such as game development, indie games, 2D graphics, 3D graphics, and art styles were often used to find information. Most sources were on the internet, but a couple sources were books.

Sources were evaluated first on their objectivity and trustworthiness. The first step was to find the author and find information about their background. First, it was important to make sure the author actually existed. Then their background was checked if they have something else under their name in the field. The goal was to find authors who seem to have firsthand knowledge or experience in the field. This was achieved usually by searching the them in Google. The material itself

was also individually evaluated on how trustworthy it seemed, mostly by observing the quality of the language and if it seemed professional and objective. The criterions were loosened in cases where there was a difficulty to find information otherwise, but a certain threshold of quality was always held on to.

3 Computer Graphics

According to a PCMag (n.d., para. 2) computer graphics are ”The creation and manipulation of picture images”. You can generally divide them either into vector graphics or bitmapped graphics.

Vector graphics are made from a series of points, lines, arcs, and other geometric shapes. Each element of vector graphics maintains their own identity which makes it easy to select and manipulate the independently. 3D images are always vector graphics. (PCMag, n.d.)

Bitmapped graphics also known as ”raster graphics” are something that are created in an image editor or paint program but can also be a scanned document or a photo-graph. Bitmapped graphics consist of many singular pixels. (PCMag, n.d.)

3.1 2D Graphics

2D graphics are common for indie games. According to the PCMag (n.d., para. 1) 2D graphics are ”The creation, display and manipulation of objects in the computer in two dimensions.” Tools like drawing programs are used to draw images as they were drawn on paper. 3D images are possible to create in a 2D program but their view is static which means that they cannot be rotated, only

scaled in size. In addition, any lighting or shadows must be created manually by an artist, as there are not any automatic lighting effects like in 3D programs. (PCMag (n.d., para. 1)

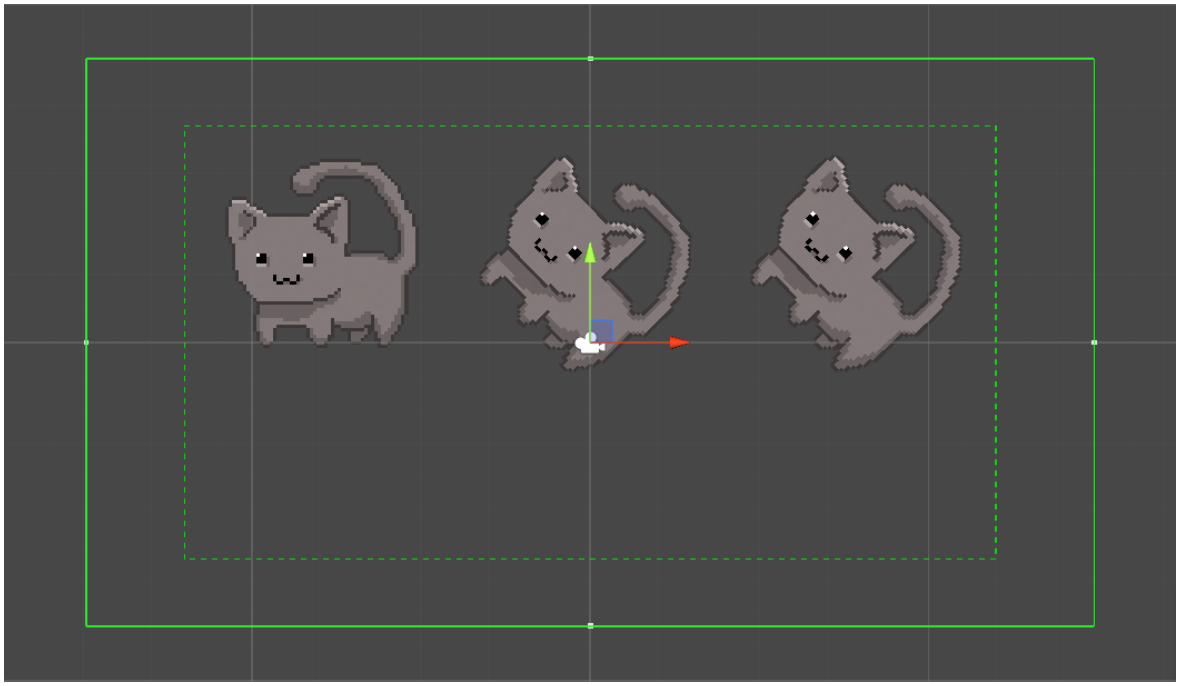

Figure 1 Pixel Graphics

Figure 2 2D Graphics

3.2 3D Graphics

Nowadays new blockbuster games are mainly created in 3D graphics. PCMag (n.d., para. 1) says the following: 3D graphics are “The creation, display and manipulation of objects in the computer

in three dimensions.” PCMag (n.d.) states that tools like 3D graphics programs allow objects to be created on an X-Y-Z scale (width, height, depth) instead of the X-Y scale (width, height) in 2D graphics programs. In addition to being able to be scaled in size, 3D graphics can also be rotated and viewed from all angles, and they can also utilize the automatic lighting in the rendering stage.

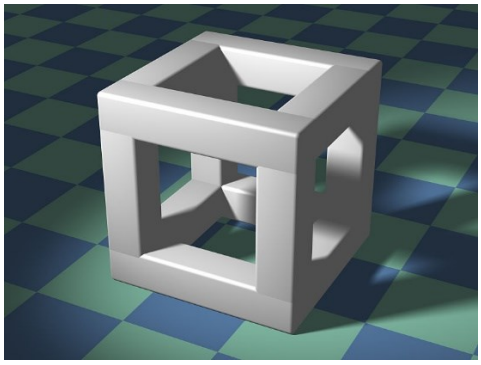

Figure 3 3D Cube

Figure 4 3D House

3.3 Video Game Art Styles

According to Kevurugames (2022) ”Game art style is a harmonious combination of all the visual components of the game perfectly matched to convey the desired atmosphere to the players.” In addition, Kevurugames (2022) says that art styles do not have clear or official categories, but despite this some categorization is possible due to the prominent similarities in visual styles.

Video game art styles are divided first into two main classes: 2D and 3D. These both categories then have multiple other categories under them. Each category has its own pros and cons in terms of visual aesthetic, technology, and gameplay. (Pixune, 2022)

2D Art styles

Kevurugames (2022) lists some common art styles for 2D games on their website such as:

- flat,
- pixel,
- vector,
- realism,
- cel shading, and
- monochromatic.

3D Art Styles

Some common 3D game art styles listed on Kevurugames' (2022) website are:

- realism,
- fantasy realism,
- low poly,
- hand-painted, and
- cartoon.

4 Perspective and Camera

4.1 Common Video Game Perspectives

According to Saltzman (2003) there are 6 different perspectives in video games, which are the following:

- first-person perspective,
- third-person perspective,

- top-down,
- isometric,
- flat/side-view, and
- text-based.

The listed perspectives are explained in detail in the following chapters.

4.2 First-Person Perspective

First-person perspective is one of the most common ways a video game is displayed. The player experiences the game world through the eyes of the playable character. It basically puts the player in the boots of the protagonist. It can make the intense moments more intense and is popular especially in shooter games. (Stefani, 2020)

Figure 5 First-person Perspective in Bioshock Infinite (2K Games, 2013)

4.3 Third-Person Perspective

As seen in Figure 6, in third-person perspective the player can see the whole playable character on the screen. This makes it possible to see the environment and the actions of the character better than in first-person perspective. (Saltzman, 2003)

Stefani (2020) says that the third-person perspective is a very broad category of perspectives. Generally, you are playing as the character, but you are not supposed to be them, like you are in games with first-person perspective.

Ironbirdcreations (2022) says ”The third-person perspective describes a game in which you can see your character in front of you, typically directly from behind or over their shoulder. It allows you to see a wider range of the environment around the hero”.

Figure 6 Third-person perspective in Uncharted: Drake’s Fortune (Sony, 2007)

4.4 Top-down Perspective

Very common in strategy games. This perspective works has the camera located above the game scene, aiming down towards the action. (Saltzman, 2003)

Figure 7 Top-down perspective in Stardew Valley (ConcernedApe, 2016)

4.5 Isometric View

Saltzman (2003) notes that isometric perspective is a view that has the camera above, aiming down on the action. It has a slightly tilted view which gives an impression of 3D. This perspective is also often mixed up with top-down view.

Figure 8 Isometric perspective in Hades (Supergiant Games, 2020)

4.6 Side-View

Like the name suggests, this perspective gives view of the action from the side. It has become less popular since the rise in popularity of 3D. (Saltzman, 2003)

Figure 9 Side-view perspective in Oddworld: Abe's Oddysee (Oddworld Inhabitants, 1997)

4.7 Text-Based Games

According to Documentary Site (2019) a game being text-based means that in the game everything is conveyed through text. This includes scene-setting, character development, and action. While some of these games include images, they are generally inessential.

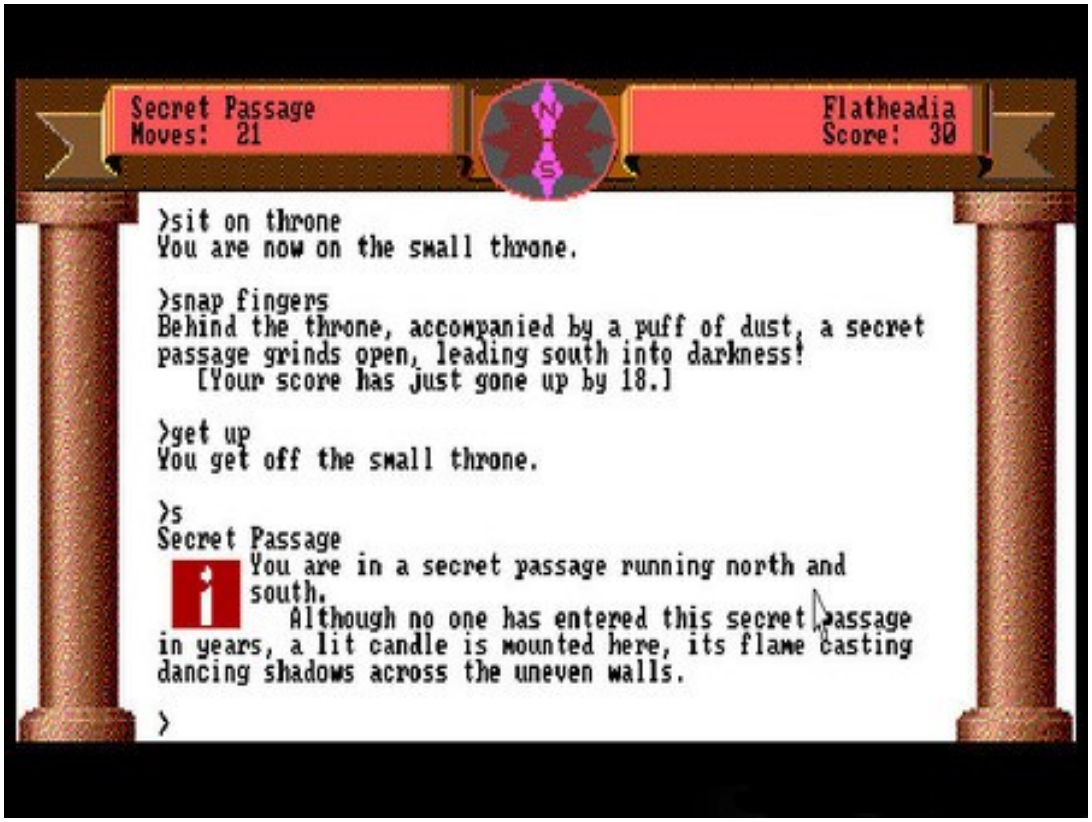

Figure 10 Example of a Text-based game: Zork Anthology (Activision, 1989)

5 Player Character

5.1 Definition of Player Character

Dictionary.com (n.d., para. 1) defines player character as ”a character in a role-playing game or video game who is controlled by the person playing the game.” The player character is the vehicle for playing the game. The game shows the impact of the player on the game world through the player character. (Smith, 1999) Essentially the player character is the character in the centre point of the screen and the one that the player controls.

In the next few chapters, Link from Legend of Zelda is examined as an example of a video game character’s visual evolution and transition from 2D to 3D.

5.2 Example of a Player Character's Evolution

5.2.1 Legend of Zelda

In Figure 11 is the first version of Link from Legend of Zelda. He looks flat and has only a small number of details. The important parts of the character are still recognizable. This kind of simplistic art style is the result of the console which the game was released on. Nintendo Entertainment System can only draw graphics in the resolution of 256x224 pixels with only 56 colours available. However, those all colours are not available to use simultaneously. A single sprite is 8 pixels by 8 pixels and it can use only 3 colours plus a transparent colour. Sprites can be combined to get more detail but there is a limit of 64 sprites on the screen before problems arise. In addition, these sprites are limited to use only 4 different 3 colour palettes at the same time. (BitBeamCannon, n.d.)

Figure 11 Early 2D Link from Legend of Zelda (Nintendo, 1986)

Figure 12 Later 2D Link from Legend of Zelda: A Link to the Past (Nintendo, 1991)

5.2.2 A Link to the Past

This version of Link from Legend of Zelda: A Link to the Past is already more detailed than the previous version, as seen in Figure 12. There are more pixels and more colours. It is a lot easier to recognize the character. It is no wonder, since according to SnesLab (n.d.) Super Nintendo Entertai ment System has a total of 32, 768 colours available.

Figure 13 Early 3D Link from Legend of Zelda: Ocarina of Time (Nintendo, 1998)

5.2.3 Ocarina of Time

The version of Link in Figure 13 is from Legend of Zelda: Ocarina of Time and the character is now in 3D. Here he has the look of an early 3D game character. Low number of polygons and simple textures. However, the design is more realistic looking than the previous pixel art 2D Links.

Figure 14 Later 3D version of Link from Legend of Zelda: Twilight Princess (Nintendo, 2006)

5.2.4 Twilight Princess

The last version of Link from Legend of Zelda: Twilight Princess, a later game in the series is seen on Figure 14. The later 3D version of the character has gained a lot more details than his earlier counterpart. All the belts and wrinkles of his uniform and the engravings of the shield can be easily seen. He also does not look blocky at all anymore, like in the previous picture. Yet, even with all the details Link has gained during the years, he has many of the distinguishable features from the first game. Pointy ears, green tunic and cap, a belt, a shield, and a sword. The basic design of the character has stayed recognisable throughout the years.

6 Technicalities of Digital Art

6.1 Clip Studio Paint

Clip studio paint is a “The artist’s app for drawing and painting” according to themselves (Clip Studio Paint, n.d., Front page). On their website (Clip Studio Paint, n.d., Functions page) they have listed that their software can be used for:

- concept art & painting
- character art
- illustration for design
- comics, manga & webtoons, and
- animation

6.2 Blender 3D

According to their website (Blender Foundation, n.d., The Software section), Blender is a free and, open-source application. It is a 3D creation suite. Blender supports all phases of a 3D pipeline. Blender has the ability to do:

- modelling,
- rigging,
- animation,
- simulation,
- rendering,
- composing,
- motion tracking, and
- even video editing and game creation.

Essentially you can do everything you need for video game 3D models inside Blender from the basics to more complicated things.

6.3 Drawing tablets

Graphic tablet is a gadget, more specifically a computer input tool, that can be used for many different purposes. (Javatpoint n.d.) Common ways to call a graphic tablet include: digitizer, digital graphic tablet, pen tablet, drawing tablet, external drawing pad, or digital art board. The most common purposes for a graphic tablet are to draw images, animations, and graphics. The gadget has a rough surface which the user utilizes with a pen-like stylus to draw in a similarly as they would draw on a paper. A graphics tablet can also be used as a mouse. Usually, the image is still displayed on a regular computer monitor, but there are tablets with built in monitors too. For drawing digital paintings, a graphic tablet is probably the best tool to do it. Both, a drawing a tablet with a display can be seen in Figure 15, and a drawing tablet without a display in Figure 16.

Figure 15 Huion Kamvas Pro 12. A drawing tablet with display.

Figure 16 Wacom Intuos Small. Graphics tablet without display.

7 2D art

7.1 Sketching

Sketching is the starting point for most digital art. Britannica (n.d.) defines sketching as follows: “sketch, traditionally a rough drawing or painting in which an artist notes down his preliminary ideas for a work that will eventually be realized with greater precision and detail. The term also applies to brief creative pieces that per se may have artistic merit.”

Nguyen (2017) describes sketching as something that is about just getting the basic concept on the paper. She also sees it as a good method of brainstorming. With sketching there is no need to worry about the small details or mistakes as the drawing will build upon itself.

7.2 Line art

This part of 2D art is a bit more challenging to define and discuss about. There isn’t as much of a defined topic here as with sketching. In this case line art means drawing the outlines of the character or object as they appear in the finished version. There are other possible names for them such as line art or inking. According to Okuha (2023) line art works as a structural outline for the different elements of a drawing. It commonly consists of defined lines and curves. Line art is drawn

guided by the sketch and on top of it. Thus, the general purpose of line art is kind of like being the constrains of the object that is being drawn.

Good line art is much more than just a constraint though, as seen in an illustrated comparison by Nguyen (2017) in Figure 17. She says that the lines of artwork can work as a guide to the eye. Thicker lines draw more attention. They can also be used to illustrate light, depth, or weight in art-work. It is safe to say that the lines of art are not only construction pieces, but they also contribute to the look of the final piece.

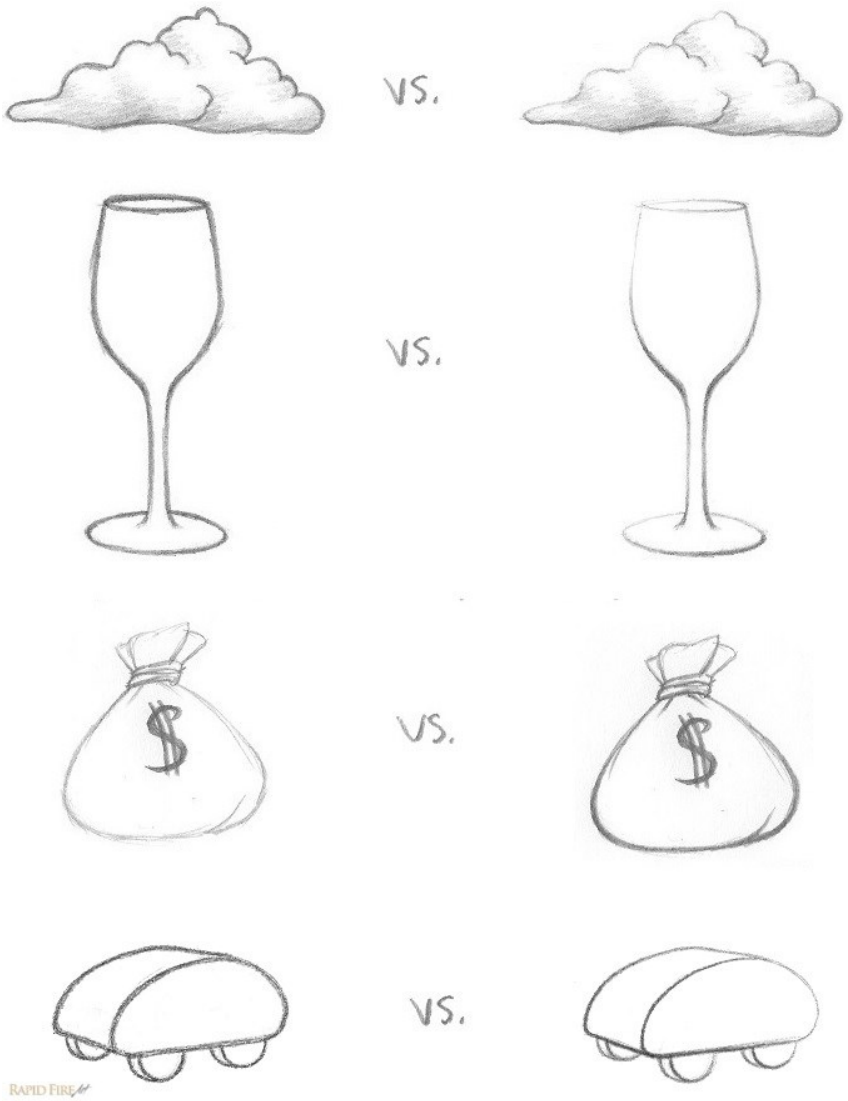

Figure 17 Demonstration of the effects of line art (Nguyen, 2017)

7.3 Colour and Shading

The final step to finish the art piece is to add all the colour to it. Shading is a close subject to colouring as, depending on the methods and workflow, they can happen at the same time. According to Alhayek (2022) colouring can be the same between traditional art and digital art, but digital art brings in the possibility to use programs as a help in this step. There are different ways to colour. One can start by adding in the flat colours and adding the shading and highlight on top of it but there are also alternative methods such as using 3D programs or gradients or patterns to combine these steps in one.

8 Game Engines

8.1 General Information About Game Engines

Today it is common for game developers to use a ready-made game engine. There are many advantages using them over one creating their own engine from scratch.

Gregory J. (2015) says that the term ”game engine” started in the mid 1990’s. The definition of a game engine is not always clear as even games themselves can be treated as game engines in the case of ”modding”. Modding is a practice of someone else taking an existing game and developing something new with all-new assets. Essentially, they just use the technical core of the game. This is the beginning of the concept of game engine. Later some games were released with customization and reusing in mind and the licensing of the engine software was used as a secondary income stream. Nowadays it is possible to license a game engine and use the key components of the software. Essentially a game engine is a piece of software which is designed to be extensible and a foundation for different games without big modifications.

Game engines could be thought of as shortcuts for developers to use as an existing technical core to build the game around, instead of starting from the ground up.

Crivello (n.d., para. 1) says that ”Game engines give game developers a framework for developing a video game without creating all systems, such as the physics, graphics, and AI, from scratch.” According to Crivello (n.d.) game engines are an essential part of game development and there are both third-party game engines and in-house game engines built by the developers themselves.

In addition to the already existing parts of a game engine, there are also plug-ins and such to customize a game engine. Some game engines also have pre-built asset libraries to make game development even easier and faster. Game engines also standardize development which makes it easier for developers to help each other. One additional major benefit is workflow organization. The development is faster when all the tools are kept in the same place. Crivello (n.d.)

Game engines come in different forms, but many have the capabilities to work in many different fields. These fields are 2D game engines, 3D game engines, mobile game engines, AR game engines, and VR game engines. Crivello (n.d.)

8.2 Unity Game Engine

Unity is one of the popular game engines today. It is very common to see the Unity logo especially at the start of indie games. Schardon L. (2023) says that when Unity came out in 2005 to bring access for more developers to game development tools, which wasn't very common in that time.

Schardon L. (2023) says that even today, the Unity game engine has a robust offering of features while still focusing on the availability and accessibility. It is still completely free of charge to use, unless you earn more than $100,000 with your project. The fact that unity has a lot of users correlates to a big community. The size of the community of Unity makes it very easy to network with other Unity users and to find help online with problems.

As mentioned before, Unity has a great offering of features. According to Schardon L. (2023) these key features include:

- 3D and 2D graphics support,
- easy-to-understand architecture,
- Unity Scripting API,
- cross-platform build support,
- virtual reality (vr) & augmented reality (ar) capabilities,
- large asset store,
- Unity developed packages,

- rendering pipeline options,
- animation tools
- adaptability to other industries, and
- analytics tools.

9 Creating a 2D Video Game Character

The aim is to compare the process of making a character ready for animating. The character is designed to be used in a sideview perspective game. Starting with a 2D character is beneficial because the process of designing a character often starts with creating 2D drawings regardless. The 2D character also works as a reference for the 3D model. It can be thought as a similar guide as a sketch is for line art in digital painting.

9.1 Initial Setup

In the creation of the 2D character a drawing tablet is needed, as a mouse is not usually precise enough for digital drawing. In addition, a digital drawing software is needed. The researcher uses a Wacom One M drawing tablet and Clip Studio Paint digital painting software for this character creation. Rigging, giving the character bones that can be used to manipulate the sprites to create animation, is the final step. In this instance, an application named Spine will be used for rigging.

9.2 Character Desing & Concept Art

The first step is to create concept art of the character. The goal is to keep the design simple to streamline the compatibility between 2D and 3D. The art style of the character is cel shaded with a cartoony influence, which is also considered in the appearance of the character.

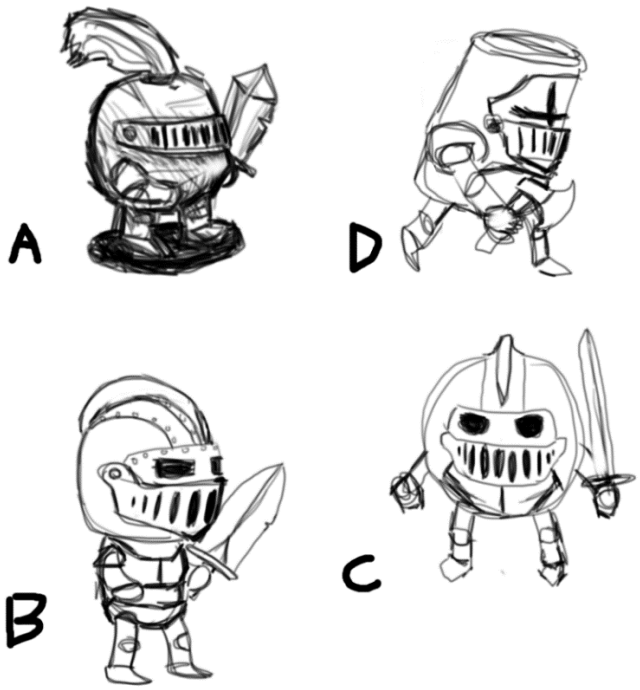

Figure 18 Character design concept art (Juho Ollila, 2023)

After creating 4 designs for the character that are visible in Figure 18, design “D” is chosen as the final one.

9.3 Outline

Sketch

The sketch of the final character drawing is done next, using a softer brush. The goal in this phase is to roughly draw out the general shape and design of the character. This makes it easier to draw the line art next, as the sketch can be used as a guide to draw on top of. The character is drawn with its limbs apart because each of them will need to be drawn as their own sprites. This makes it easier to animate the character afterwards.

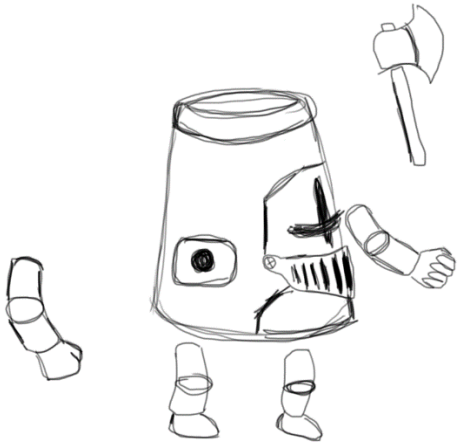

Figure 19 Character sketch (Juho Ollila, 2023)

Line art

The line art is now created by drawing over the sketch in a new layer and with a more refined and harder brush. This will be used as the guide of the shape and part of the appearance of the final design so the art should be clearer and more detailed this time.

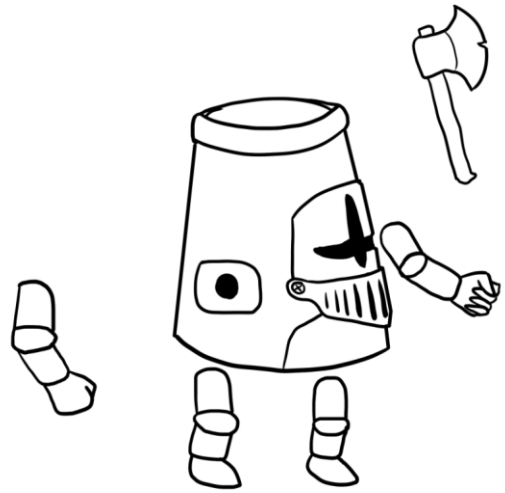

Figure 20 Character line art (Juho Ollila, 2023)

9.4 Colour & Shading

Using the line art as a guide, the character is now given the final details with colouring and shading it. First step is to add the base colours. A new layer is placed below the line art layer to keep it visible over the colours. When the colour are added, shading is drawn on top of it in a new layer set to multiply mix mode. A separate lightning and shine layer could be added if more detail is

wanted. In this case they were omitted from the process to save time. The shading is drawn in a cartoonish cel shading style where the edges of the shadows are hard. Now the character is ready and each limb, the body, and the axe are exported as PNG files to be used as the sprites in Spine for rigging. The results of this part can be seen in Figure 21, with separate limbs on the left and the put together version from later in Spine on the right.

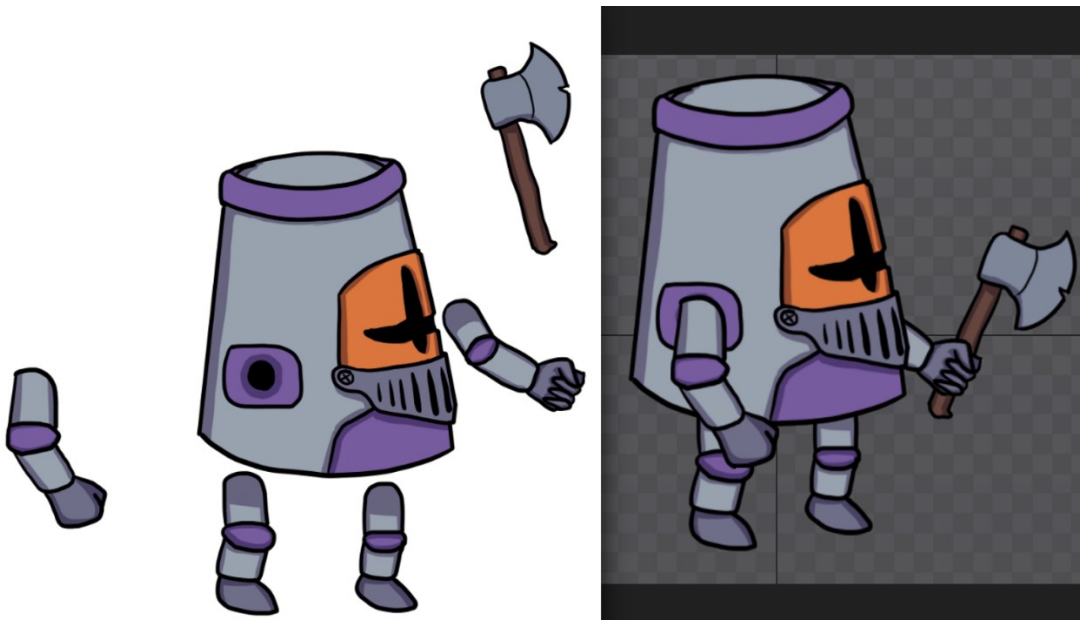

Figure 21 Coloured Character with separate limbs and put together in Spine (Juho Ollila, 2023)

9.5 Rigging

The character needs to be reconstructed first from the separate sprites. After the everything is in place, new bones are added for each part of the body. Each limb was drawn as single sprite, so they only have one bone each, as seen in Figure 23. This means that they will not have any joints which limits how the character is animated. However, such simple animations are sufficient in this case because this character is aimed for a sideview side-scroller game where the character isn't very close to the screen. Each bone is parented to their respective sprite. The bone in the body is used as the main bone which all the other bones are connected to as its children. This means that

the main bone can be used to move the whole character. The hierarchy of the bones can be seen in Figure 22. Now the 2D character is finished and it would be ready to being animated in Spine.

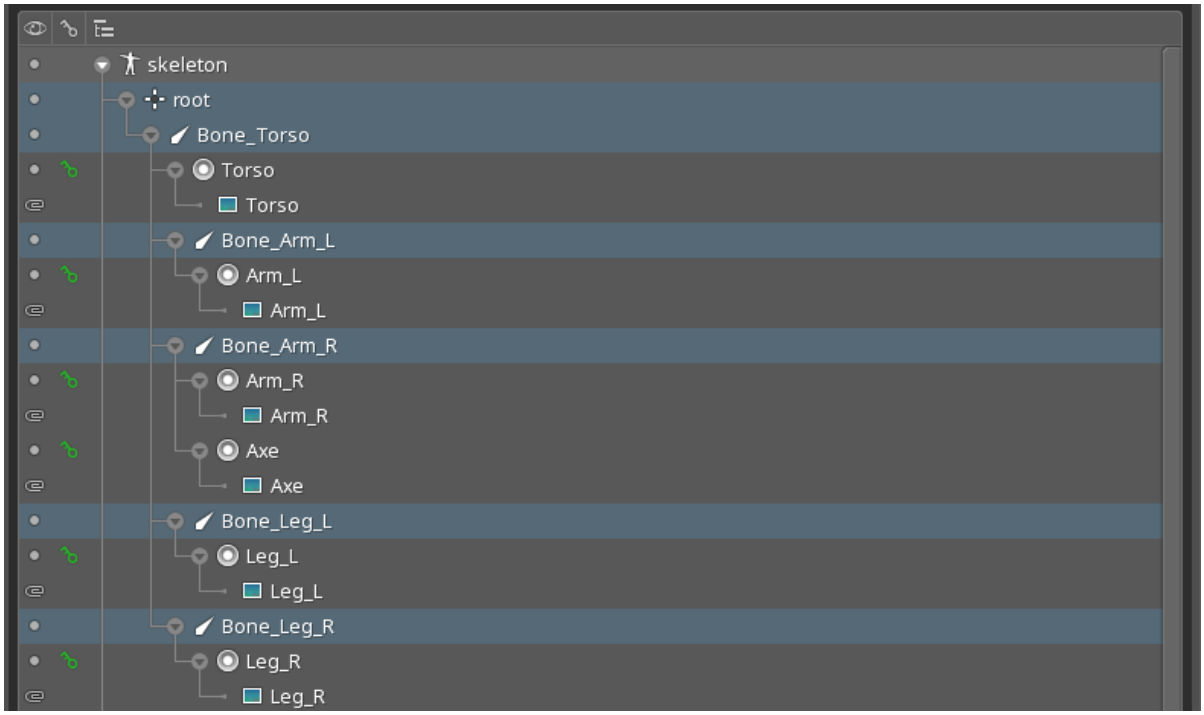

Figure 22 Armature bone hierarchy in Spine (Juho Ollila, 2023)

Figure 23 2D character with armature (Juho Ollila, 2023)

10 Creation a 3D Video Game Character

10.1 Initial Setup

This stage uses some of the same tools that were used in the creation of the 2D character. A drawing tablet is heavily utilized in many different parts. In addition to using the 2D character as a reference in this phase, Clip Studio Paint is also used again to draw more reference sketches from different perspectives of the character. Lastly, Blender 3D is used for all the phases of creating the different parts of the 3D character.

10.2 Perspective References

To create a 3D model of a character, it is helpful to have reference pictures of the model from different perspectives to demonstrate the shape from different views. Rough reference pictures are drawn directly from the front, back and side with addition of a side view without arms, to give a clearer view of the character's body shape. Again, this reference is only used to guide the creation of the shape of the 3D model, so the drawing does not need to be very detailed. Simple sketches are enough.

10.3 Base Shape

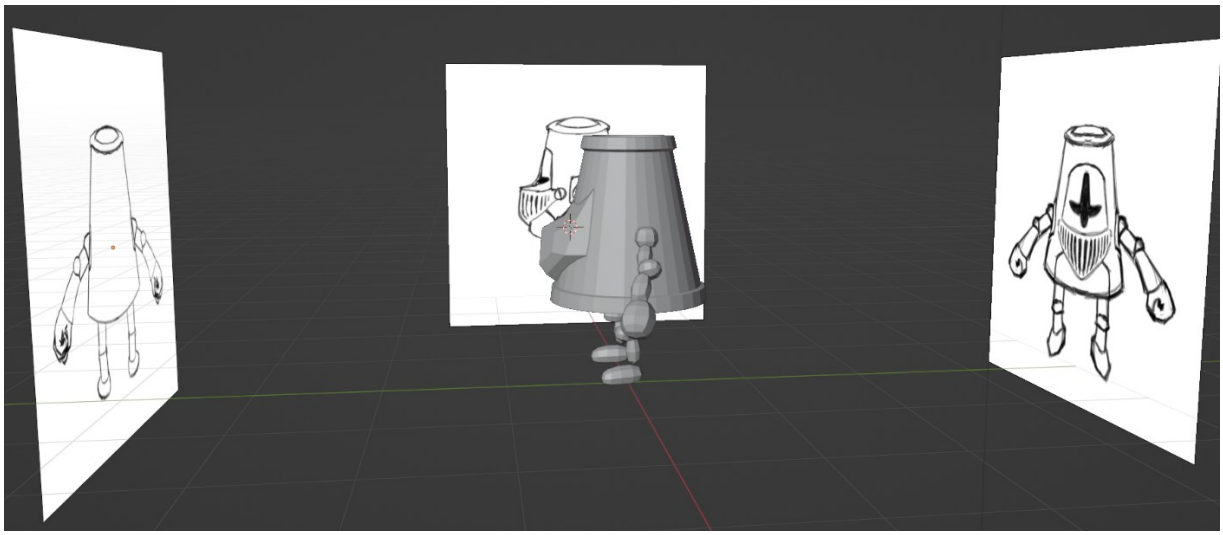

Figure 24 Perspective references and base shape of the model (Juho Ollila, 2023)

As a first step of bringing the character from 2D to 3D, the base shape is created by adding simple cube meshes to the scene in blender. The perspective references are imported to unity and placed

in the scene next to the character. The character is in front of the references and cubes are added and their shape is manipulated according to the references. It would be beneficial to start with the body of the character if it is symmetrical. This way a mirror modifier can be added to the limbs from the other side of the body to automatically create them to the opposite site. Using orthographic view makes it easier to edit the shapes. When needed, loop cuts are made to give the mesh more vertices to get the shape match the reference better. However, only a rough shape is needed at this stage so the goal should be to keep it as simple as possible. The results of this phase with the reference pictures can be seen above in Figure 24.

After the shape is sufficient what is left is a character that is formed from multiple separate objects. There would be benefits in merging most of these into a single object consisting of one connected mesh, but in this case the character is left into separate meshes for each part of the body. This decision is elaborated on later.

10.4 Sculpting

The base shape model itself has very few vertices giving too little surface to draw fine details. This is why the sculpting phase starts by enabling dynamic topology, which makes it possible to add details dynamically where needed. The shape is refined to match the reference pictures as close as possible. Remesh is done on the on the objects to even out the spacing of vertices. At this point the smallest details are added by using dynamic topology again. This time the detail size can be set to a smaller scale as the work is done on small details. The last step is to do a final remesh, again to make sure that vertices are evenly spaced though out the objects.

10.5 Retopology

After the detailed sculpt has been created, it is usually beneficial to create a lower detail model. The first step taken in this process is duplicating the higher detail character, as that version is also needed later. Basically, the duplicated version will be made into the lower detail version of the character. For optimal results this would be done manually by essentially building the character from ground up by manually extruding new faces on top of the high detail model that would form the new low detail model. In this case however, it is done by automatically retopologizing as it is arguably faster.

Remesh is used to retopologize the character. As this character is designed to be used in a game, the number of vertices needs to be decreased, since the number of vertices increase the amount of computing power needed to render the character. Correct amount of detail is found by trial and error. The remesh must be done and undone again many times with while adjusting the voxel size. The goal is to find a satisfactory amount of detail through trial and error. Only a rough version of the character is needed at this point. At this stage, the shapes don't need to be smooth and small details such as scratches, cracks or crevices do not need to be visible yet. When the result is satisfying, it is a good idea to go over the meshes in edit mode and check the result in more detail. Small manual adjustments made now in the topology can make a big difference at later stages. However, automatic retopology will not match the quality of manual one, so results will not be perfect.

In Figure 25 sculpted high detail model "A" is on the left and the low detail model "B" resulted from the retopology process is on the right. The inefficiency of auto retopology is evident in the body of the character. The vertices are evenly spread throughout the mesh, while a much smaller number of vertices would be enough in most parts of the body. Higher detail densities should be reserved to areas such as the face, where there will be more actual detail in the model.

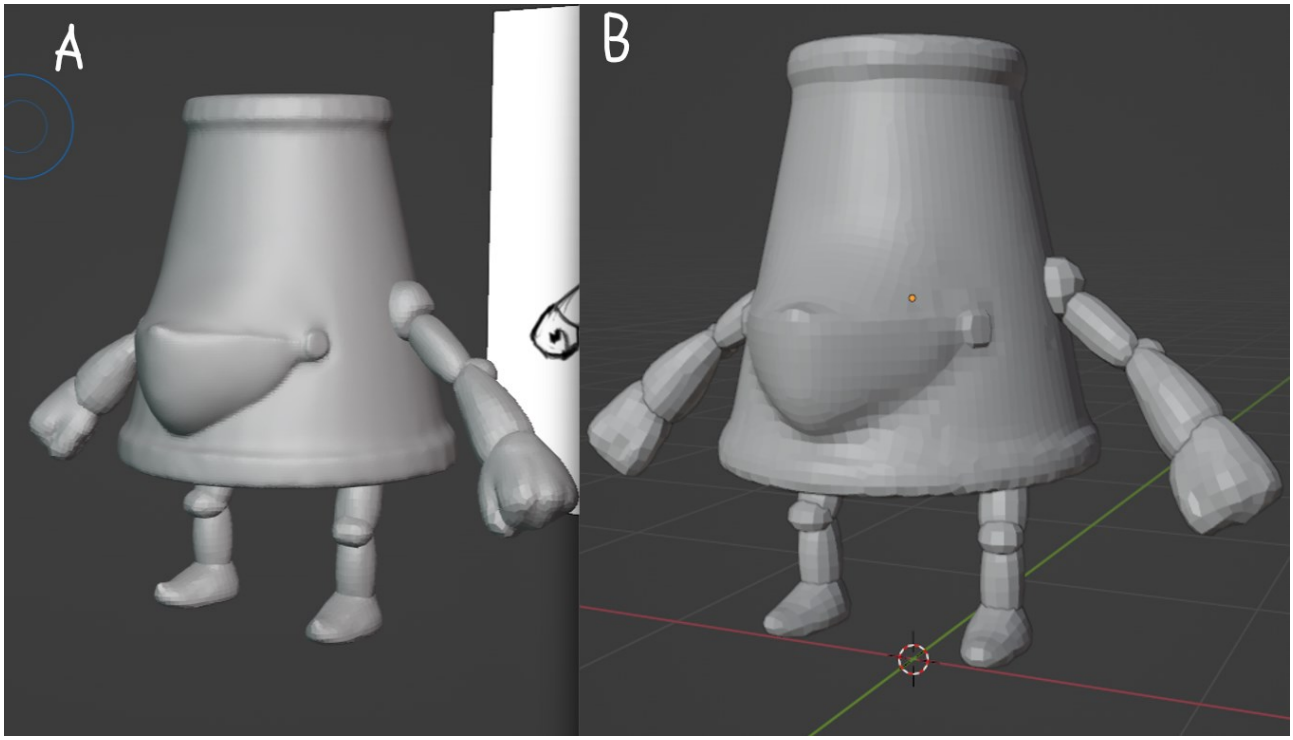

Figure 25 Comparison between Sculpted model and retopologized version (Juho Ollila, 2023)

10.6 Creating UV Maps

This phase is where all the details from the high details character are added to the low detail character. The first step is to create UV-maps of all the character's parts. Selecting all character parts in object mode, then going in edit mode and selecting all vertices of each of the objects, UV-unwrap can be done. This can be viewed in texture mode that lets the user see the maps in 2D. Seams should be made to make the skinning results of the objects more accurate. The maps essentially flatten out the 3D objects surface onto a 2D image with the seams marking the cutting points that make it easier for the program to flatten the surface.

By enabling view stretching in the UV editor the places of inaccuracy can be seen. Adding seams in the map or increasing vertices in these high stretch areas help clear them out. As a last step the size of the of the parts in the shared UV map of the character parts can be adjusted. This way larger parts and parts that require more details can have larger islands on the UV map and other less important ones have smaller ones. This way details are distributed efficiently where needed.

10.7 Baking and Painting Details

In this phase the low detail character receives more details. The 2D version of the character is used as a reference to guide what kind of result is looked for in the smaller details of the character.

Using the UV Maps

The objects' UV maps are now used for adding the details to the character. This is also the part where the high detail character is needed. A material is created for both the high and low detail characters. Each character has only a single material covering all their parts.

Normal Map

Normal map is created first to bring the lighting information from the high detail model to the low detail model. This will give the character smoother look without actually adding details to the mesh itself. First, in the shader graph, an image texture node is added, and it is connected to the normal part of the of the Principle BSDF node. Next, an image texture is created. This texture is added to the node, and it will become the normal map.

The normal map will now be baked. First, both high and low detail models are selected with low detail selected as active. Then in the rendering panel, in the baking tab, the bake type is set to normal and selected to active box ticked. The normals can now be baked to the active object. This baking process is repeated to all parts of the character.

Cavity Map

To be able to copy all the details of the high detail model, its material needs to be adjusted. In shader graph, with the high detail material selected, a geometry node is added. The pointiness value of the geometry of the object is taken and with an added colour ramp node, the value from this node is usable for baking details to the low detail character model. By adjusting the blacks and whites in the colour ramp, the detail of the cavities can be adjusted. Finally, the cavity map can be baked into the low detail material, with diffuse bake type. It should be ensured that the cavity map is selected in the shader graph instead of the normal map. Other than that, this part is almost done in the same way as normal map and repeated on each part of the character.

Colour Map

With colour map, the basic colours are first added for the character. This time these do not need to be baked; they will simply be painted on the character material in texture paint mode. By using the fill tool, the base colours can be added first. After that additional details are added to the character with more delicate brush tools. Many of the different parts of the character's body could be beneficial to add as separate objects, like for example the visor in front or the different coloured parts on sides and front, but they are part of the same mesh this time. At this stage they are painted on the colour map. Essentially, they are just flat textures on top of the mesh. More detail to them will be added in the next steps.

The colour map and cavity map are both connected to the colour part of principle BSDF node. A mix colour node is needed to use both at the same time. It is set to overlay mode which allows the colours of the colour map be used and details from the cavity map.

Metallic Map

The metallic value could be adjusted for the whole material universally, but the axe handle is not metallic and it needs to be excluded. A metallic map is created. It is just a blank image texture that is connected to the principle BSDF node in shader graph. To start the whole map can be black which makes everything metallic. Now the axe handle can be selected from the map and painted

white which makes it entirely non-metallic, which is what is needed as the handle is made of wood. The remaining parts are left to full metallic value to save time. However, It could add more detail if varying metallic values were used.

Roughness Map

Roughness map is the last map to be added. Roughness value of the material basically controls how shiny the character appears. This time each part is painted by hand to have different roughness values between each object, but also in different sections of the same objects. This is an efficient way to give the character more detail with for example making scratches in the surface of the axe rougher that makes them look more realistic. Also, the different parts of the main body that were given their own base colours in the colour map are given more detail by adjusting them and the area surrounding them to have different roughness values.

The roughness map is done similarly to the metallic map. An image texture is first added with a base colour of middle grey which gives everything a basic smoothness. Everything is then hand painted to have the wanted roughness. Now the character itself is finished and the results can be seen below on Figure 26. While the character ended up looking more realistic, especially with the style of textures used, its design and shape are still cartoony.

Figure 26 Finished 3D character (Juho Ollila, 2023)

10.8 Rigging

The process of creating the rig is the final step in completing the character for the sake of this research. With the rig the character can be manipulated to create animations. First an armature object is added. The bone that is created by adding the armature object is then placed in the middle of the character in the body. This bone works as the main bone that all other bones are connected to. The body mesh is also connected to the bone. The connection is done by setting the bone as the parent of the body mesh.

New armature objects are added for both arms and legs. The first bones of the limbs are then parented to the main bone. The remaining bones needed for the limbs are extruded directly from the initial bones of each limb and are adjusted to their correct positions in edit mode. Each new bone is automatically parented to the bone it was extruded from. When the armatures of each limb are set, the final step is to set each part of the limbs their respective bones as their parents. There are many additional steps to make animating the character better if needed, but at this stage, the character is ready to be animated.

11 Results and Conclusions

The main objective of this research was to help solo and indie game developers on choosing either 2D or 3D graphical style. Goal was to compare the process of creating a video game character in 2D and 3D to find benefits of both sides, and to find ways to ease animation of these characters after their creation.

The practical implementation is now finished, and a video game character was designed and then created in both 2D and 3D graphics. The use case for the character was a game with a sideview perspective. The 2D character was created first in Clip Studio Paint, assuming it would be quicker and would work as a base guide for the 3D character as well. This approach was probably beneficial. 3D work in Blender 3D took more time and effort and likely benefited from having a clearer vision for the character from having it been designed and created it in 2D already.

Character creation in 2D was quick and simple for the most part. Clip Studio Paint was intuitive and simple to use. However, since the character was designed to be used and animated within a game, it slightly complicated the workflow. Still, the number of steps and their scale remained reasonable. It was easy to achieve an adequate visual quality. For a solo game developer 2D workflow

does save time if the visuals and gameplay are not too complex. When the character needs a lot of different animations, drawing the character once and from one perspective might not be enough. Many sprites from different angles could be needed, but unfortunately the scale of this research was not enough to create them. 2D graphical work is fairly rigid, without quick and easy ways to make adjustments and additions later. Using vector art instead of rasterized graphics would probably be more efficient.

3D character required much more time and work than the 2D character. The number of steps alone in the 3D part show how much more effort it required. Using Blender 3D is a very technical process, but it being open-sourced and free means it has a lot of users which makes finding help online easier. Arguably the efforts could pay off later in development, depending on the game. If a lot of animation is needed, a 3D model would arguably be flexible for adding those animations without having to modify the model. The same model can be used with different perspectives and positions. Also, it is easy to make modifications to 3D models at any time, at least smaller ones. Unfortunately, the desired art style was not fully achieved due to the challenging workflow. The character's art style looks cartoony in design and shape but has realistic materials and shading. While the results are satisfactory, it still deviates from the initial design.

For animation side, both 2D and 3D characters can be animated with armature models. With armatures, animations can be created by manipulating the position of the bones of armature which are connected to the character moving along the armature. In case of 2D this is still limited by the design perspective of the sprites. For example, a top-down view cannot be created with sideview sprites as they are static and cannot be rotated. A 3D model will often be more flexible to be animated in any way as the whole character is usable instead of just one perspective of it. Still, clear topology and quality UV-maps are crucial to avoid visible stretching when animating 3D. In any case, these armatures are one effective way to help to create new animation and to modify existing ones, regardless of the graphical style.

2D graphical style might be the more reasonable choice for most solo developers, unless developing a game which focused heavily on visuals and has a lot of animations. For a sideview perspective, 2D should more beneficial. With 2D one can create simple visuals quickly with an easy workflow. 3D on the other hand could save a lot of time if numerous different animations are needed or if characters need to be visually modified a lot in-game. In some cases, this choice might be

about deciding the aesthetic style of the game. It is also likely that the existing skills of an individual end up being the deciding factor between these two graphical styles. Developers with more technical skills while lacking in art skills might gravitate towards 3D. On the other side more artistic people without a technical background might want to choose 2D. However, there are many ways to create both 2D and 3D art in addition to the methods that were used in this research and those could change the results of this sort of comparison. Especially using vector art for 2D could make animating and later modifications easier. Unfortunately, alternative workflows were not demonstrated here due to the lack of time and the broadness of the scope, preventing more detailed research.

The research topic was clearly too broad, as is evident from the shortcomings of this research. Many of the subjects included in the research could have been focused more on. Both the 2D and 3D character suffered from compromises made for the sake of being able to finish the research. The literature review could not go much in-depth in any of the topics as there were so many necessary ones. The topic of video game graphics for characters and in general, as well as solo and indie video game development need to be researched further. These together are a largely under researched area in the field of games industry. Video games industry is growing and the amount of academic research on these topics are not keeping up with that growth, despite the rising popularity of indie video games.

12 Research Ethics

The biggest ethical problem in this research is the quality of sources. Academic peer reviewed research of 2D and 3D game art were hard to find. The same is especially true for solo or indie video game development. Many of the sources used in this research are direct homepages of the software manufacturers or blog posts by industry professionals or just general articles. These often include opinions mixed in with facts and the difference is not always clear. Additionally, some of the sources could be biased, for example in the case of a homepage of a commercial product. Improper use of sources and subjective handling of information are a concern too.

To ensure the research integrity and that everything was done according to academic requirements, the researcher has followed Jamk's Project Reporting Instructions through the whole re-

search process. Also, the researcher has participated on a Research and Development course during which crucial skills of academic research, such as research ethics, were taught. Throughout the research honesty, precision, and objectivity were strived for.

A research permit was not necessary for the work. No personal data was processed during this thesis and there was not a commissioner.

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