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Hybrid Animation: The Process and Methods of Implementing 2D Style in 3D Animation

Jerina Kivistö

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ABSTRACT

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KIVISTÖ JERINA
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Technological advancements have made computer generated 3D animations more prominent than ever, switching the dynamics of the animation industry completely in the 21st century. With this major change, a question has emerged: where does hand-drawn animation stand? While 3D methods are efficient and can allow complex animations as a result, it lacks in expressing the same level of artistry that hand-drawn animation is capable of.

Thus, the objective of this study was to consider if hybrid animation — combining 2D and 3D animation — is beneficial in creating an appealing visual outcome without compromising the workflow efficiency and development costs. It also touches on the subject of how 3D renders are used to emulate the hand-drawn style.

Both hand-drawn and 3D methods are examined to acquire an understanding of the strengths and weaknesses of the two media and how they can counterbalance one another in a production. In order to carry out a thorough comprehension on this subject, a research on various hybrid animation methods was made. To conclude these findings, a practical demonstration of the combination of the two media was performed.

The examination proved that the combination of the two can create an appealing visual style while maintaining the workload feasible. It also indicated that while it is extremely hard for computers to imitate the expressiveness of hand-drawn animation style, they can provide a useful tool for artists to assist their hand-drawn work.

Key words: hybrid animation, visual style, animation workflow, 3D renders

CONTENTS

ABBREVIATIONS AND TERMS

Hybrid animation	The combination of 2D and 3D animation
3D	Three-dimensional
2D	Two-dimensional
CGI	Computer-generated imagery
Blender	3D computer graphics software
Mesh	Collection of vertices, edges and faces that defines the shape of a 3D object
Topology	The structure and flow of vertices, edges and faces of a 3D object
N-gon	A face in 3D object that is made up of five or more sides or edges
Wireframe	Displays the topology of a 3D objects in vertices and lines
Extrude modelling	Modelling method when a shape is extended in any direction to a point where a desired shape is achieved
PNG	Portable network graphics, an image file format

1. INTRODUCTION

In the past few decades, animation films have undeniably shifted from hand-drawn to computer generated 3D animation. The decline of 2D in the film industry is evident — with every new animated full feature film released, the audiences expect more and more impressive, highly complex CGI renderings. Simply put: the more complex, the better. With the demand for 3D productions being extremely high, it is no wonder the industries tend to lean towards what brings the money in. After all, from the point of view of an audience, it is hard to want to go back from the impressive renders to the visually simplified world of 2D animation.

However, personally I have always admired the visual simplicity of hand-drawn animations. There has always been something extremely attractive about the freedom and exaggeration of the movement achieved with hand-drawn motion. In comparison, 3D animations can seem overly clean when every in-between frame of the movement is meticulously calculated by a computer. Trying to argue something as subjective as one's preference between 2D and 3D is pointless, but there is something to be said about what hand-drawn animation can accomplish. It is without a doubt that 3D techniques have brought new advantages to animation industry while constantly raising the bar of possibilities — but 2D has its strengths too. It is exactly that simplification of the visual reality, the imperfection that makes hand-drawn animation seem more organic and expressive in comparison to 3D animation. With 3D media alone, achieving this visual stylisation is hard. When the limitations of 3D lie within the software, hand-drawn animation is only restricted by the creativity of the artists behind each scene.

While it is important to acknowledge that 3D animation has allowed the animation industry to evolve, enabling results previously not possible with hand-drawn methods, 2D still has not lost its place in the animation industry. Quite the contrary: while bigger companies have embraced the world of 3D as the norm in feature films, we can see more 2D animations than ever in smaller productions such as television series and indie animations. However, as of late, it is not only

small productions that have brought 2D stylisation back to mainstream animation. With the short animation Paperman produced by Walt Disney Animation Studios receiving an Oscar for Best Animated Short Film in 2013 (USATODAY 2013) and the 2018 release of the massive box office hit and several animation award winning Spider-Man: Into the Spider-Verse (IMDb n.d.) — both of which played with different techniques of implementing hand-drawn style into 3D — something has become very clear: the two mediums complement each other and can achieve astonishing visual results. This is called hybrid animation. Thus, the objective of this study was to consider if combining 2D and 3D animation is beneficial in creating an appealing visual outcome without compromising the workflow efficiency and development costs.

To keep the point of view cohesive, this thesis does not consider the topic from the perspective of game animation. It also for the most part excludes other animation methods, such as cut out, stop motion and special effects animation. Moreover, in this thesis, the term hybrid animation refers exclusively to the combination of 2D and 3D animation, not the combination of live action and animation.

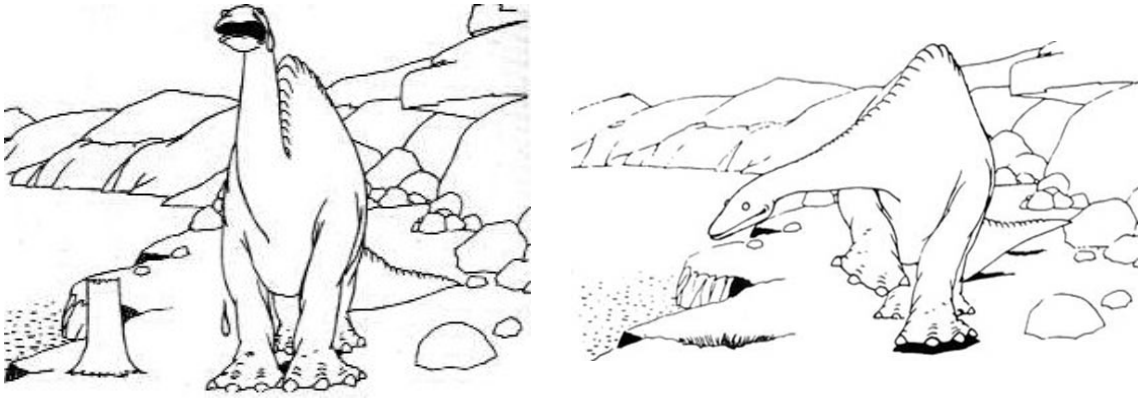
2. HAND-DRAWN AND 3D COMPUTER GENERATED ANIMATION

To fully comprehend the most prominent methods of today's animation industry, it is important to acknowledge how technical limitations and financial resources have always limited artistic expression. Examining the development of these solutions allows a comprehensive understanding of animation industry as a whole, and why animation is as it is today.

2.1. Hand-drawn animation as a medium

As the name suggests, hand-drawn animation is a technique where each frame of the animation sequence is drawn by hand. As drawing by hand is a time consuming process, the most important characteristic of this medium is simplicity. Illusion of reality is not easily accomplished in hand-drawn animations: drawings take a lot more time to replicate cohesively for each frame so the design language was simplified and abstractified for the figure to be drawn over and over again (Telotte 2008, 59-60; Manvell n.d.) Hence, hand-drawn animations predominantly use lines and flattened, unshaded colours for depicting imagery, and especially in the earliest examples, the movement is kept horizontal to avoid having to draw complicated perspective.

Technology has limited the visuality of animations since the very beginning. The first hand-drawn animations in history consisted of each frame being drawn on separate papers. Everything on the picture needed to be drawn again for the next frame and the frame after that — to demonstrate the amount of work this required, one of the earliest hand-drawn animation films Gertie the Dinosaur took as many as ten thousand drawings inked on translucent rice paper, which then needed to be aligned carefully to composite a cohesive animation sequence (Van Eaton Galleries). This technique was extremely time-consuming (Picture 1) and often, despite the careful tracing, resulted in a distracting jittery look as the drawings included human error between the frames.



PICTURE 1. Each frame of Gertie the Dinosaur was drawn on separate papers, requiring immense effort to produce by hand. (Gertie the Dinosaur 1914)

Cel animation revolutionised the development of hand-drawn animation. Instead of paper, animators drew on transparent sheets of plastic called celluloids, removing the need to draw each frame again and allowing the artists to control the amount of certain cels repeated if needed. Backgrounds and other fixed objects were often in the background cel while other cels were changed over and over to simulate movement by animated characters. (Kayo 2017.) Walt Disney's innovative multiplane camera further enhanced this illusion of life by allowing more depth to the work with less effort. It used layers of flat drawings moving past the camera at individual speeds and distances from one another: the further away the object was from the camera, the slower it moved. This is how some very notable Walt Disney's 2D animations were made, including Snow White and the Seven Dwarfs, Pinocchio and Bambi to name a few. (The Walt Disney Family Museum n.d.) Another time-cutting technique is limited animation. It involves reusing parts of existing animated frames while drawing new frames only when necessary, e.g. when a character is speaking but not moving any of the other part of their body or repeating the same walk cycle over and over again. (Sanders 2019.) This is especially frequently used technique in cartoons to cut down expenses but it can often result in a cheaper look if used excessively: the illusion of life suffers if the motion is not constant enough.

Nowadays 2D animation shares many of these same principles and methods. However, instead of using physical celluloids or a multiplane camera, they are often simulated with the help of computers. Often modern 2D animations are

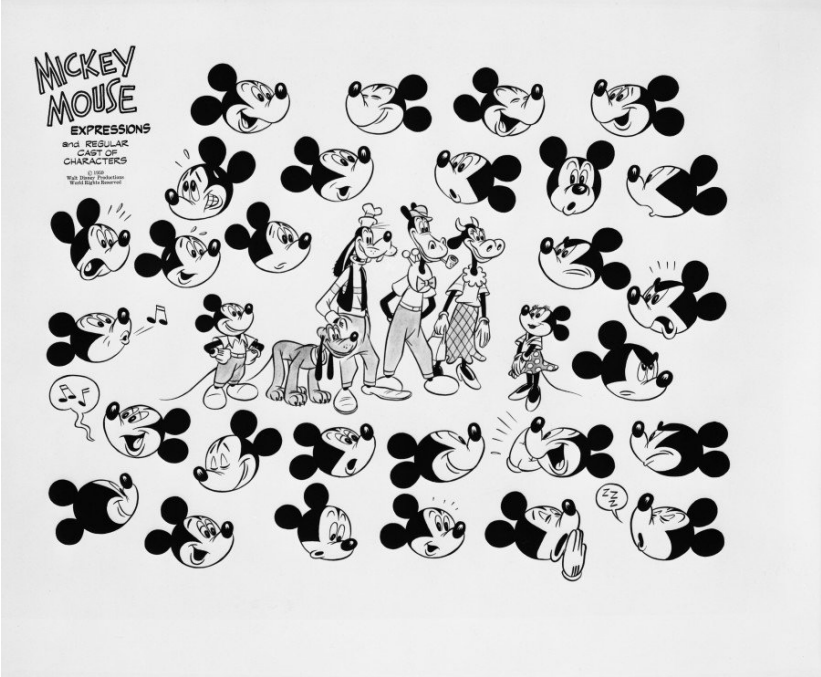
still drawn by hand but digital softwares speed up the process (Heginbotham n.d.). Computers can calculate and simulate in-between frames of movement with ease, reducing the production time and cost remarkably. 2D characters can also be rigged for a quicker and cheaper way to produce 2D character animations. Moreover, hand-drawn animations can also use computer technology to enhance the visuality of the animation. Klaus by Spanish SPA Studios is an example of modern hand-drawn animation that uses digital technology for volumetric lighting and texturing (Sarto 2019). Volumetric lighting is a technique often used in 3D graphics to scatter light in a way that it appears almost as if it has volume. These gave the movie an innovative look, appearing almost 3D-like while maintaining a hand-crafted feeling (Picture 2).

PICTURE 2. Digitally created volumetric lighting and textures are often only seen in 3D animation. This made Klaus appear more 3D-like despite being fully 2D. (Klaus 2019)

Due to the need to keep the work feasible, simplifying is always required. Simplified style can be achieved by taking or separating elements from something that exists in the real world and transforming it to its bare minimum, allowing human mind to fill in the gaps of the design. For example, instead of drawing every strand of hair on a human character, it can be depicted as a mass with only few details.

2.1.1. Advantages of hand-drawn animation

Maybe one the most notable advantages of hand-drawn animation is how it is — due to the way its made — often more expressive if compared to 3D animation. 2D animation has shaped its own abstract visual language: in order to create appeal in simplistic and flat imagery, hand-drawn animations are very heavily stylised as they are not bound to reality. 3D has harder time imitating this, as the limits are set by the 3D software. (PowerHouse Animation Studio 2014.) If you look at how traditionally animated Mickey Mouse is and compare that to a real mouse, or even a human, the differences are obvious: Mickey Mouse's design language is based mostly on circles due to the fact they are simple to animate. Moreover, his round ears tend to always point forward to the camera (Picture 3).



PICTURE 3. Mickey Mouse model sheet. One of the key features about Mickey Mouse's stylised design is that its ears always face forward to the camera. (Amidi 2019)

Compared to 3D, hand-drawn animation feels inherently more organic and human. Although based on subjective feelings, it can be argued that since every frame needs to be constructed by hand, you can feel the artist portrayed in every scene — the efforts of the artist and the extent of human practice and

talent is evident (Venkatesan 2016). Moreover, although incredible effort is required, if resources are not considered, the only thing limiting the visuality of 2D animation is the skills and imagination of the artist. Therefore, the expressiveness and the artistry of hand-drawn medium is unparalleled (Picture 4).

PICTURE 4. A variety of visual styles exist in hand-drawn animations, indicating the versatility of the technique. (The Secret of Kells 2009; The Tale of the Princess Kaguya 2013; Loving Vincent 2017)

Moreover, for smaller productions, 2D can be a cheap and quick way to produce animation. Unlike in 3D, often no special softwares or software knowledge is required, making it is more accessible to produce for small studios and independent creators. The production lead time for non-complex productions is lower and it is quicker to produce due to the straight-forward pipeline and simple visuals, often making it a cheaper alternative compared to 3D. (Mak 2018.)

2.1.2. Disadvantages of hand-drawn animation

However, hand-drawn animation is not without its faults. As it requires physical labour that takes a lot of time, precision and skill, it is not a very cost-effective method for constantly bigger and bigger productions of today's world. Since the industry started to shift towards 3D, there has been less and less demand for 2D animations in films. Treasure Planet, one of the last 2D features of Walt Disney Animation Studios in 2002, illustrates how 2D has a hard time bringing money in to cover the costs. Despite its enormous production budget of $140 million, it only grossed a little over $105 million (Sahota 2011). While it is not so straight-forward to say the failure is entirely because of the shift in the industry, as a business, it is easy to draw the conclusion that 2D animation does not even out the production cost as effectively as 3D movies do. As for Walt Disney Animation Studios, Treasure Planet was followed up by two more hand-drawn animation movies: Princess and the Frog and Winnie the Pooh, both of which grossed significantly less than the studio was expecting (Stein 2017).

On top of the disinterest to make more 2D feature animations by admittedly the largest animation studio in the industry, further arguments can be made against hand-drawn animation. Unlike in 3D, changes to the animation are harder to create and the assets can hardly ever be reused for future, unlike the ones in 3D animation. Moreover, it can be argued that in comparison to CG graphics, tbe stylised reality of 2D can be perceived as rather boring and dull looking. Drawings can go only so far. Although it is one of its strengths, the artists behind the work also are the limitations of this method. Humans have a hard time competing with consistency and efficiency of 3D results, a tool that has a greater level of accuracy. 3D allows an animator to do what a pencil has a hard time accomplishing. As animation is often about businesses making profit as much as it is a form of storytelling, it is important to consider what is the most efficient media for each situation. Shortly: when there is a faster alternative and more reliable technique around, it is no wonder 3D is preferred to 2D animation. (Riki n.d.)

2.2. 3D computer generated animation

To understand what the term 3D animation implicates, it is important to take a closer look at how it is made. 3D animation is a process of generating three-dimensional moving imagery in a 3D computer software. 3D objects have volume, and they can be moved, rotated and scaled in virtual three dimensional environment, resulting in realistically portrayed illusion of depth and space (Picture 5). The lighting and how the objects react to said light can be controlled to alter the appearance of the animation, and simulated physics can be added to automate movement.

PICTURE 5. Despite stylisation, the objects and characters in 3D animations appear photorealistic in depth and space: something that could exist in our world. (Moana 2016; Love, Death & Robots 2019; Despicable 2010)

If pre-production phases such as storyboarding or layout are not taken into consideration, the approach to making 3D animation is not quite as

straightforward as the one in hand-drawn animation. Unlike in hand-drawn animation process, where the movement is translated into drawings on paper, which are then cleaned up and composited, 3D animation pipeline consists of multiple steps: object modeling, surfacing and shading, as well as rigging. The process can then proceed to animation, followed by shading and lighting — and only after everything is finalised, the product can be rendered and composited to the final look when the post production work can begin (Breck 2017; Toy Story - CGI making of 1995).

Animating 3D objects is often keyframe oriented. The animator can add keyframes for objects from pose to pose, like in traditional animation. However, the computer does the in-betweens: it calculates the movement around the information it is given. (Animation Mentor 2014). Another way to animate in 3D is by importing motion capture data and applying it to a character rig, which can reduce the costs of keyframe-based animation. However, traditional animation elements such as stretch and squash, exaggeration or anticipation need to be added by hand, as realistic movement can look plain in animation media. (Animation Courses, Ahmedabad 2018). Animation can also be created by the 3D application's built-in physics engines, often utilised for example in hair movement and other particles.

2.2.1. Early examples of 3D in animation

Although the first known computer generated 3D animations were made as early on as the 60s — example of such is a rendering of a planned highway produced by Swedish Royal Institute of Technology (Tekniska museet 2009) — it took two more decades for entire animations to be produced in 3D. The Adventures of André and Wally B. by the Graphics Group was the first computer animated short film made in 1984. It was the first time completely 3D characters and backgrounds were seen in film. (Smith 1984). It was followed by the first feature film completely made in 3D, Toy Story in 1995 by the same company, now named Pixar Animation Studios. The development of Toy Story greatly defined the pipeline for 3D animation production to what it is even up to date (Toy Story - CGI making of 1995.)

However, before any fully 3D animated feature films were made, 3D was often used as a tool to help artists draw realistic perspective in complicated imaginary scenes in 2D animation. Although 3D computer animation is far less common in Japanese animations than it is in the West, a very early example of 3D being used in a film is a helicopter sequence in an anime feature film Golgo 13. Although the sequence was not blended together with the art style of the rest of the movie, at the time of its release in 1983 it was revolutionary: such things had not been seen on screen. (AnimeEveryday 2017.) Later on, even the Japanese Studio Ghibli utilised 3D in their notoriously traditional animation productions. In the film Princess Mononoke, released in 1997, computers were used to help animate the complicated particles of the cursed boar god (The History of 3D Computer Graphics in Anime 2016).

Walt Disney Animation Studios had also used CG to help create the ballroom dance scene in Beauty and the Beast in 1991 (Failes 2016). For the same purpose, the studio created a technique called deep canvas for Tarzan, released in 1999. It was developed by the art director of the movie Dan St. Pierre to help alleviate the limitations set by 2D animation. Utilising it allowed artists to make 3D objects that gave the 2D scenes more realistic depth that the characters could interact with, and created cameras that would then move around those objects with ease. This was then painted over on computer to achieve the desired art style (Picture 6). (Daly 1999.)

PICTURE 6. In Tarzan, utilising 3D allowed the complex tree structures of the jungle being animated smoothly with character interaction. (Tarzan 1999; The Art of Deep Canvas n.d.)

2.2.2. 3D technology changed animations

3D has affected the dynamics of animation industry largely. The extremely successful Toy Story by Pixar Animation Studios was just the starting point for how far the possibilities of computer-generated animations would go. At the beginning, the developers had to solve numerous problems set by technological limitations. The most obvious obstacle was computing power required for rendering: Toy Story took as much as 800,000 machine hour s (History of Computer Animation: Toy Story). Pixar developed a software specific to this purpose: Renderman. There were also multiple technical problems the studio had to face: such as how to animate human characters in Toy Story, how to handle fur in Monsters Inc, and how to convey an underwater world in Finding Nemo. The more 3D films they developed, each facing different problems, the better the technology got to meet the requirements. It is fair to say 3D animations have come a long way since then at Pixar (Picture 7). (Phillips & Desiderio 2019.)

PICTURE 7: The comparison between the dog from Toy Story 1 and the cat from Toy Story 4 demonstrates how much 3D technology has evolved along the years. (Toy Story 1995; Toy Story 4 2019)

Simultaneously, live action movies have also profited from 3D technology. 3D animation has enabled photorealistic renders which aim to be indistinguishable from what is real (Dreamworks 2012.) Nowadays, CGI has made a permanent place in modern motion picture productions.

Due to the shift of 3D becoming the industry standard, despite having been one of the most prolific traditional animation studios in the world, Walt Disney Animation Studios laid off numerous employers in the early 2000s due to the fact that computer-generated movies did better financially than the hand-drawn style animations. At this point, the studio claimed they were not going to stop making hand-drawn animations, but they simultaneously reserved a notable budget to retrain their traditional animators to learn 3D animation, implying a big change was coming for Disney. (Eller & Verrier 2002). However, as previously mentioned, when their upcoming traditionally animated movies continuously failed to bring back the money, the productions for hand-drawn animation feature films were eventually a thing of the past for the company. This became even clearer when in 2013 the company stated there were no 2D feature films in development at the company, its hand-drawn division was eviscerated and many veterans let go. (Ebiri 2019.)

The rise of 3D however has not meant the end of hand-drawn animation. Despite Disney's disinterest in making more hand-drawn features, it remains well alive in TV series. Moreover, Japanese productions are still using traditional methods in their productions. For instance, the animated feature Your Name made more than $350 million worldwide in 2017, suggesting there is still an audience to 2D animations across the globe. (Ebiri 2019.)

2.2.3. Benefits of 3D animation

What 3D truly excels at is its realistic feel of the imagery. (Schoonen 2015). Walt Disney stated, "Animation can explain whatever the mind of man can conceive" (Randi 2006, 411). This gives an insight as to why 3D animation is so powerful a tool: since the visual language of 3D animation is highly bound to reality, it truly has the power to bring imagination to life. 3D also has the advantage to use lighting and surfacing techniques to heighten this realistic imagery. Thus, things previously thought not possible are constantly appearing on the screen, each animation being visually and technologically more impressive than the other.

On top of that, another benefit 3D animation has is its accuracy and consistency. To animate complex shots with complex objects, a high level of technical skill is required with traditional methods. Take for example a rotating panning shot in a scene — a human would have a hard time rendering the same results as cohesively as what the computer can do with ease. This automatic in-betweening and ease of camera work makes 3D a powerful tool in animation as the computer can render dimensionality with ease (Madmind 2007.)

Moreover, 3D animation allows room for changes: as the computer renders the final shots, adjustments can be done throughout the development of a scene (Design Night… 2014.) In comparison, this would be extremely difficult and wasteful to do in 2D animation. Also, unlike in hand-drawn animation, all the assets can be reused and repurposed in other scenes (Finkelstein 2003).

2.2.4. Limitations of 3D animation

As proficient as 3D animation can be, it also has its disadvantages. When compared to traditional methods, 3D animation is restricted by the limitations of the media as it is more bound to realism: it would look disturbing if certain rules of realism were broken. In 2D animations, viewers can accept abstract events such as change in the setting or the colour of the character, or even ornaments popping in the scene seemingly out of nowhere (Picture 8). In this regard, 2D animation has more visual freedom than 3D animations as almost anything can happen in the scene without causing rejection in the viewer, as it is not the reality we know. (Madmind 2007).

PICTURE 8. In 2D animations, especially in anime, the viewer can accept abstraction without disturbance. (Full Metal Alchemist: Brotherhood 2009)

On top of that, as already established, 2D animation is appealing because it is very human and thus, imperfect. In comparison to the hand-drawn, 3D animation looks very clean — lacking the same quirkiness and character that drawings have (Grobar 2016.) If we make a computer calculate a line, it does it more precisely than a human could. Mistakes are what humans do by nature, while computers calculate without errors. Utilising this can result in an empty feeling, and although it is subjective, the passion and the expression of the artist behind the animation feels lost.

Additionally, as the pipeline of 3D animation has more steps than 2D, it takes more effort and time to produce. On top of that, CG productions require specific softwares and thus, software expertise as well. 3D animation also takes large amounts of computing power and render time. Consequently, if the production has a small budget and limited time frame, 3D animation might not always be the most efficient method to use.

2.3. Combining the two media: Hybrid animation

It is clear that both 2D and 3D methods have their advantages and disadvantages. However, there is an ocean of possibilities of what can be achieved if the pros of 3D would solve the cons of 2D, and vice versa. In modern animation, it is not uncommon to see both methods being used together. The combination of 2D animation and 3D animation is called hybrid animation. As already mentioned, 3D has been used as a tool in hand-drawn

animations early on. Nowadays, hybrid animation is often made by giving a 3D object a 2D appearance or by simply merging them together (Mohammadi 2019.)

Utilising both methods can be very beneficial to a production: it is a question of what media is the best means to tell the story in question to reach the right appeal and visual style. Derald Hunt, CG Animation supervisor, put it this way: "If all you know is 2D, you are missing out on the efficiencies that can be won by incorporating 3D into your pipeline. If all you know is 3D, you miss out on great traditional animation style and the speed that can come from 2D animation" (O'Hailey 2010, 29). Similarly, Patrick Osborne, a director at Walt Disney Animation Studios who has on projects such as Paperman and Feast, stated that the expressiveness of a design that is filtered through a human brain is what makes an illustrated style appealing and more interesting than making something that looks realistic — while also understanding that 3D animation is more directable than 2D animation since adjustments can be done without starting the process from beginning (Picture 9). (Design Night… 2014).

PICTURE 9. Paperman combined the expressive stylisation of 2D animation with the stability given by 3D.

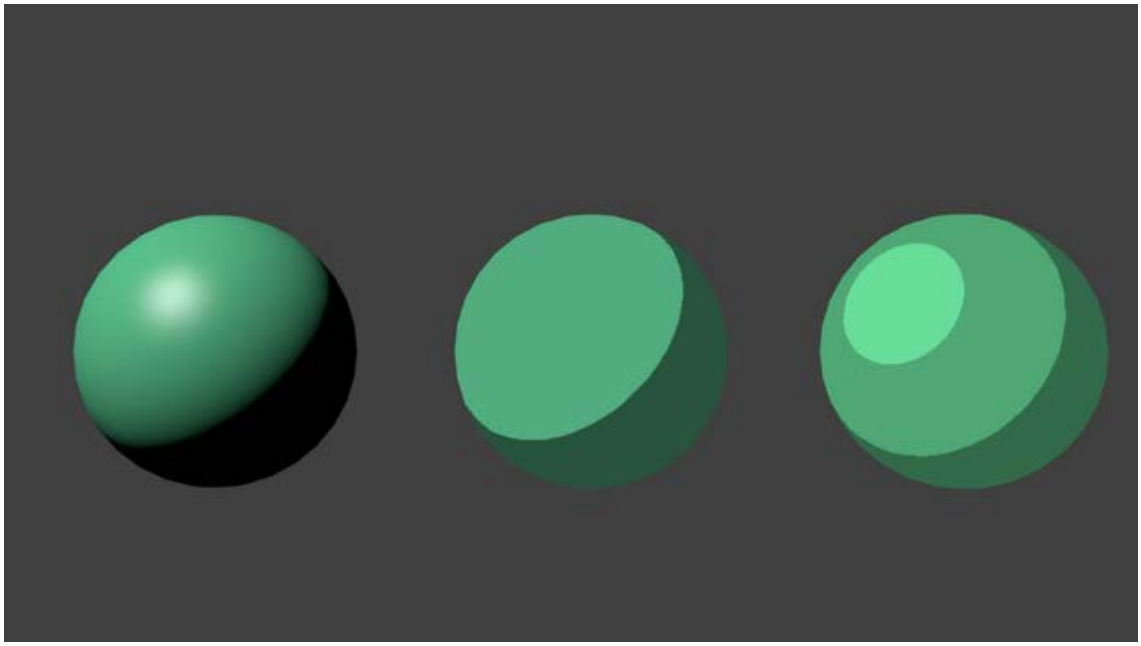
Merging 2D style in 3D can achieve astonishing results: the massive success of hybrid animation films like Spider-Man: Into the Spider-Verse (IMDb n.d.) and the short film Paperman (USATODAY 2013) suggest there is a demand for hand-drawn styles in 3D saturated animation. This has especially heightened as mainstream 3D animations have offered very little variety stylistically, which can be perceived as lack of creativity. (Mohammadi 2019). Even Disney, despite their previous disinterest, stated they are open to making 2D feature films in the future (Pearson 2019).

3. TECHNIQUES USED IN HYBRID ANIMATION

In order to create an animation that utilises the best of both worlds, it is important to understand the ways of how this merging can be done in practice. In the following chapter, several different methods of merging 3D and 2D are examined with concrete examples of productions that have used these means.

3.1. Cel Shading

Cel shading, also known as toon shading, is a non-photorealistic rendering that aims to recreate the look of 2D animation cels with the use of flat colours for shading 3D objects. Cel shade renders using flat colour bands rather than by creating smooth gradient shade (Tran 2018) (Picture 10). Although it is a technical term referring to the way lighting is rendered, it often can be used to indicate an art style and method since it simulates the one of 2D animations made with cels, with flat colouring and outlines. (Luque 2012, 1.)



PICTURE 10: The difference of a render with realistic shading (left) and cel shading (middle and right). (Blender Render Cell Shading 2017)

Cel shading is a fairly frequently occurring technique that is made use of entirely 3D animation stylised and more cartoon-like. Although there are a lot of

published examples of cel shaded animation, especially so in anime, a very popular and more recent example of cel shaded animation in western production is the Dragon Prince by Wonderstorm. It utilises cel shading animation style for cost effectiveness, as rendering detailed characters in 2D style would require more resources. They were trying to bend towards using a computer generated pipeline with cel shading but techniques that made it feel more hand-made and artful. The head writer of the series Aaron Ehasz states in an interview that “we wanted details on the character designs, in the costumes and sets, that you really can’t get in traditional 2D animation.” (Robinson 2019.) (Picture 11).

PICTURE 11. Cel shaded 3D models allowed the character designs in the Dragon Prince be more detailed and intricate. (The Dragon Prince 2018)

However, a common criticism a lot of these cel shaded animations have received is that they seem uncanny — they are close to being realistic but there is something slightly off, causing discomfort to the viewer by breaking the immersion. One possible explanation for this is that while it is not a problem with entirely 2D characters that have a completely different design language to begin with, when these designs are translated to 3D, the viewer understands the characters are supposed to be realistic. But because of this awkwardness, it is perceived as fake resulting in rejection. (Basile 2016.) (Madmind 2007.)

Even cartoons that mostly rely on 2D tools have used cel shading in their productions. Such examples can be seen in Futurama and Family Guy (Picture 12). In these examples, cel shading is usually limited to singular objects, such as cars and other mechanical gadgets that require a lot of details and knowledge of perspective when drawn by hand (Lennox 2011).

PICTURE 12. Even traditional cartoons are known to utilise the benefits of 3D to help animate complicated objects (Family Guy 1999)

3.2. Frame rate

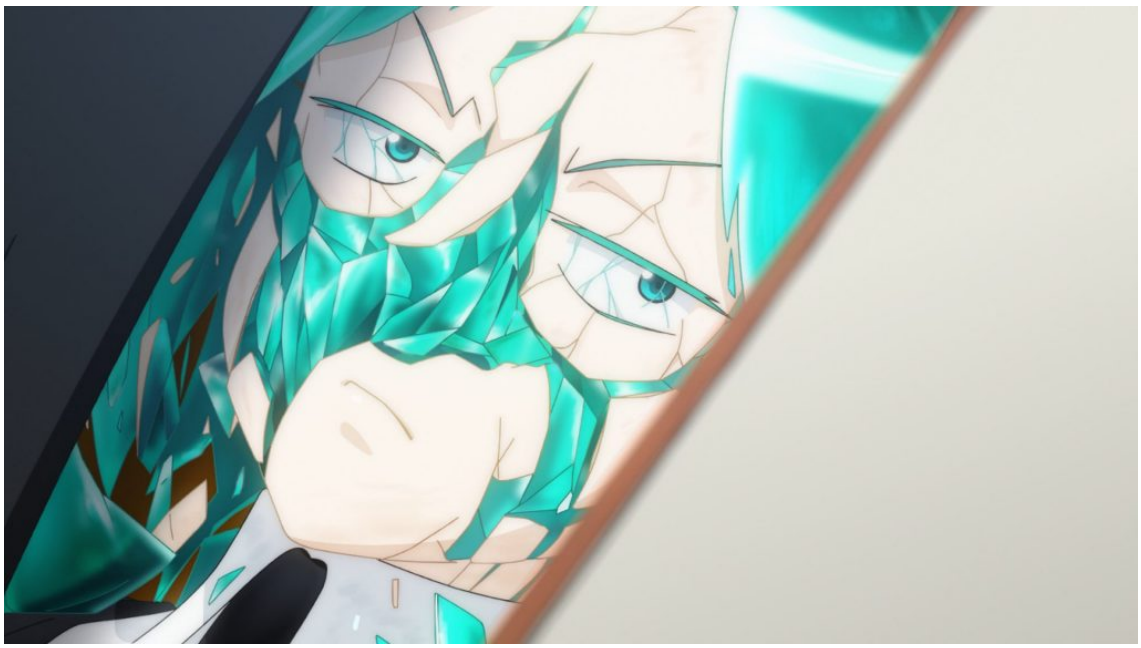
If CG animations is to be animated on 24 frames per second, it means the computer renders 24 individual images per second. As hand made animation requires a human to do this all work, they are often animated on twos, often resulting in a less fluid motion. This means that there is 12 unique drawings per second instead of 24, one image holding for two frames rather than one. Similarly, animating on threes means a unique image will hold for three frames and so forth. Mixing the number of frames is a way to help create the illusion of a realistic and smooth or stylised movement. For example, faster movement gets a new picture for each frame to show that there is more change in the position and for slow movement new frame is required less often as the position is not changing much between them. (Chew 2019)

Animating on twos or more is a simple way to make CG resemble its hand-drawn counterpart, removing the fluidity of motion and replacing it with organic imperfection to make it feel more hand made and imperfect, and to give the motion more weight and impact. Despite the success of Dragon Prince in its visual art style, it received criticism about its frame rate. The deliberate decision to animate on twos caused the motion to seem off-putting and choppy to the audiences. The studio reacted to the feedback and adjusted their production: they still kept animating on twos but now with the addition of ones according to the scene and motion in question to lessen the jaggedness, which seemed to satisfy their audience. (Robinson 2019.)

3.3. Mixing 2D and 3D

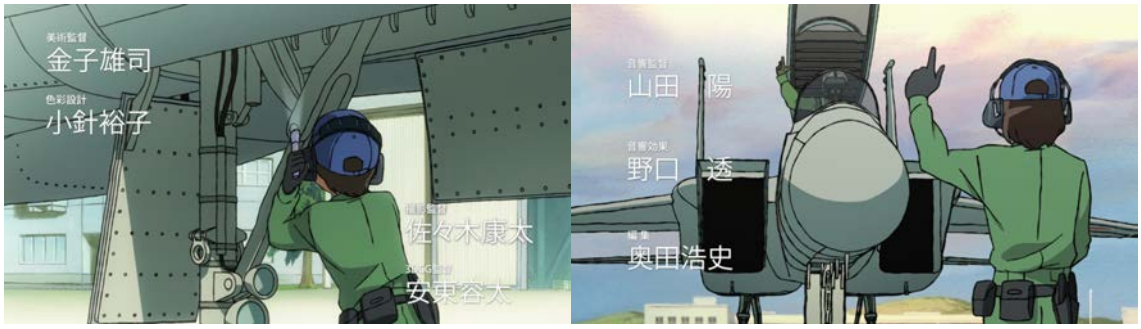
As already established, a common problem CG has when emulating hand-drawn style is its uncanniness. So far it seems to be so that it is hard to emulate the human touch in animation with the help of a computer alone. Another way that has been used to achieve hand-drawn style is to use 3D rendering as a base and then draw elements on top of it to help merge them together more seamlessly.

One great example of this technique is in the Japanese CG anime Land of the Lustrous, where the main characters are gems in a humanoid body, 2D animation was used where CG could not effectively portray nuance and feeling. This included most of the closeup shots that required delicacy, as well as character faces which are very distinguishably expressive in anime style (Picture 13). The production team was aware that the delicacy of the movement was not fine-tuned enough in CG, and that hand-drawn art is more appealing in a closer look. However, regular movement in production was predominantly CG, as was the hair lighting and motion which were fundamental to the character design of the series as traditional hand-drawn methods were not efficient enough to portray the way light played with translucent gem-likeness. (Land of the Lustrous Production Notes 2017).



PICTURE 13. Although Land of the Lustrous was primarily animated in 3D, the exaggerated facial expressions typical to traditional anime style were made in 2D. (Land of the Lustrous 2017)

Mixing the two media can be very similar to the one of Disney's Deep Canvas Technique: an object is rendered in 3D, and then drawn or painted over to blend it with the rest of the animation. This is what Dragon Pilot: Hisone & Masotan used in their production: thick linework — a recurring element — was applied to CG models to make the animation seem cohesive with the overall visual style, making the usage of 3D less obvious (Dragon Pilot: Hisone & Masotan Production Notes 2018). (Picture 14)



PICTURE 14. The CGI planes blend with the hand-drawn characters when a thick linework is drawn on top. (Dragon Pilot: Hisone & Masotan 2018)

3.4. Motion Tracking

Computer calculated motion tracking can be utilised when adding hand-drawn elements on top of 3D. This is fairly similar to an old animation technique called rotoscoping, which usually is done by hand. In rotoscoping, animators trace over the movement of live action footage frame-by-frame to either copy the motion entirely or to use it as motion reference (Bracio & Dickey 2017). Similarly, in motion tracking a computer tracks the movement of an object and the tracking data from that source can be applied to another object — e.g. linework in this instance (Motion tracking overview and resources 2018). The Oscar winning short movie of Walt Disney Animation Studio's Paperman is an excellent example of a production where tracking computing was a solution to help creating an appealing visual style in 3D.

John Kahrs, the director of Paperman, wanted to find a way to bring back the expressiveness of 2D style animation while hanging onto the benefits of computer animation. Searching for a way to merge 2D and 3D, Kahrs found a solution from a software called Meander: a hybrid vector and raster based drawing and animation system. (Failes 2013). This system allowed animators to combine the strengths of CG with the expressive line-based visuals of traditional animation. The process started like any other cel shaded 3D animation, but artists then drew linework on top of the 3D. The system then calculated the in-betweens for the linework using vector fields derived from the 3D footage (Picture 15). If needed, the artists could then tweak the in-betweens for a cleaner look. This way, the final visual look was in the hands of the artists, allowing them to utilise their creativity fully (Whited etc n.d.) The outcome of this method is extremely unique and it was well received with audiences and critics, resulting in becoming Disney's second short animated film to win an Oscar (Koch 2014.) Disney later published a short animation Feast, another highly stylised CGI movie that used Meander in colour for the first time in a line free style (Wolfe 2014.)

PICTURE 15. Paperman's workflow consisted of 3D renders, calculated motion fields, hand-drawn strokes to reach the final render. (Whited etc n.d)

3.5. Mixing multiple techniques

In order to get the best possible results and visually compelling outcomes, a number of techniques can be used to forge 3D footage into 2D style. Although there are a lot of productions of all sizes that have built their own approach to the subject, one of the most notable examples of this is from a multiple award winning animation, Spider-man: Into the Spider-verse by Sony Pictures Animation and Columbia Pictures. It was well received and praised for its striking animation that took inspiration from the world of comic books and old cartoons. (Rotten Tomatoes n.d.)

To name a few examples of the techniques used, the frame rate of Spider-man: Into the Spider-verse altered between ones and twos: fast and smooth motion was depicted on ones to emphasise the high skill level of the character, and on twos when the character was being clumsy or unconfident. This not only worked as a stylistic choice but also a visual indicator and storytelling method. Moreover, if you pause the movie at any time, it will look like an illustration with hand-drawn touches. They layered 2D strokes on 3D to give it a hand-drawn look for instance on face details and in action-lines during fast movement and instead of motion blur, which is often utilised even in 2D computer animation, they opted for using a technique called smear. This stems from old cartoons, where multiple drawings of the same object were on the same frame to create the illusion of movement. (How 'Spider-Man: Into The Spider-Verse' Was Animated 2019).

On top of that, they used a variety of comic book elements from print media: depth of field was created by utilising half-toning that uses dots to create colour and gradients. Shadows were emphasised by hatching — drawing various parallel lines on the surface of the area. They used panels to split the screen as a storytelling method, and even opted to use onomatopoeia to write out sound effects, similarly the ones seen in comics. The visual outcome was outstanding and something the world of animation had never seen before. (How 'Spider-Man: Into The Spider-Verse' Was Animated 2019). (Picture 16).

PICTURE 16. Spider-Man: Into The Spider-Verse used multiple techniques to achieve its unique visual style. (Spider-Man: Into The Spider-Verse 2018)

3.6. 3D with 2D appearance

Hybrid animation is often made by giving a 3D object a 2D appearance: as in cel shading, the object can be rendered in a way that resembles 2D art styles. As well as non-photorealistic rendering techniques, this could also mean modelling or post-processing techniques. For instance in the short animation film Suits from Netflix's Love, Death & Robots series, they used a lot of hand-painted textures on the models. Moreover, they needed to break the reality of lights; most notably the rim lights that needed to stay consistent and independent from other objects appearing in the scene. This resulted in a design that emulated an illustrative style (Picture 17). (Milligan 2019).

PICTURE 17. Suits used a lot elements typical to 2D art. (Love, Death & Robots 2019)

Another good example of making 3D resemble 2D visually is Moominvalley, a new 3D TV adaptation of Tove Jansson's classic stories of Moomin. However, their approach to creating the animation was rather different: the characters were stylised 3D renders that were matched with a hand-painted 2D matte painted environment (Picture 18). The team believed an entirely 3D production wouldn't translate the subtle emotion of Tove Jansson's original work. While 3D allowed them to create lighting and an atmosphere that conveyed the sense of environment from Tove's work easily, 2D elements would to convey the illustrative expressiveness of the original art style better. (Harris 2019)

PICTURE 18. The use of stylised 3D models in a hand-painted environment played a key part that allowed the visual style of Moominvalley to stay true to its origins. (Moominvalley 2019)

4. IMPLEMENTING THE TECHNIQUES

In the remaining part of this thesis, I applied the techniques discussed in the previous chapter and put them into practice to see whether they would provide useful solutions without being too time-consuming. This practical demonstration also allowed a deeper understanding of the process of creating a meeting ground for hand-drawn style in 3D renders. In order to grasp a full comprehension of the techniques, the findings were implemented in three separate animated samples. The first sample focused on explaining the workflow of cel shaded animation with hand-drawn animation on top with a simplistic character animation. The second demonstrated how to further utilise the advantages of 3D media by applying a more complex animation for the same technique and background elements. The third one tested if a computer can contribute to the hand-drawn process by utilising a free software Ebsynth that renders the in-between frames of the hand-drawn style on top of the 3D animation. These results are then compared to the hand-drawn version to draw conclusion if these techniques can imitate the hand-drawn style.

4.1. Goals and Preparation

In order to create a demonstration of a process of merging hand-drawn into 3D, a solid visual design that could be utilised through both media had to be performed. The demonstration would aim to point that a visually compelling end-result that matched my artistic vision is possible by combining the abstract nature of 2D seamlessly with the realism of 3D. Moreover, the goal was to combine the two in a way that was beneficial to the visual style without compromising the workflow, which in a studio setting would result in a higher development cost. The focus of this demonstration was solely on the visual aspect, so elements such as story or any further depth in the character design were secondary to the experiment.

To execute these goals, a plan for two animation sequences was created. The basis for the first two animations was made in 3D creation software Blender which supports the entirety of the 3D pipeline steps. After rendering the

animations in cel-shaded PNG image sequences, hand-drawn animation elements were integrated to improve the visual style. This method is similar to the one of Paperman but the 2D elements are added manually without the vector linework tracking tools. In the third animation, this process is replaced by a computer animation software Ebsynth that converts video footage into “motion paintings”.

The first animation focused on simple character animation, demonstrating each step of the workflow of this method. The second animation utilised even more of the advantages of both media by bringing in background elements alongside a more complex character animation. The third one reproduced the first animation to study if computer calculations can produce a similar quality of the hand-drawn work.

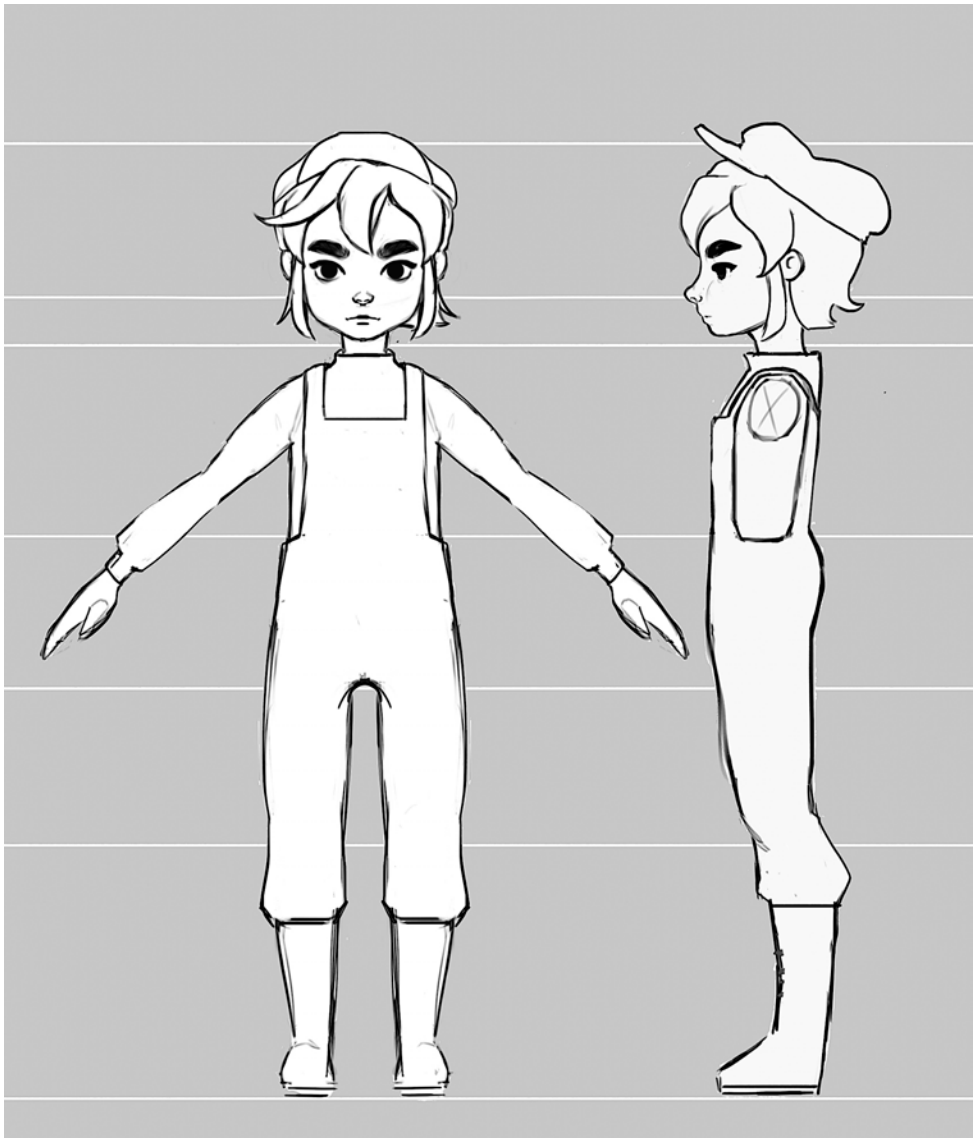
4.2. Challenges in Design

In order to create a character design that could emulate the abstract nature of 2D, the key factors that make a character readable as such were kept in mind. Even though the focus of this practical demonstration was not at character design, a few important factors needed to be kept in mind when designing the appearance. Firstly, the character design took reference from cartoons by adopting certain simplification and exaggeration to the features, such as proportionally large head and big, expressive eyes. All stylistic choices were kept simple, had a low level of detail and displayed non-realism in order to maintain a credible hand-drawn style.

Secondly, like in all hand-drawn animation, the visual design needed to be kept practical in order to make the task feasible. According to author and animator Christopher Hart (1997, 89), although one shouldn’t limit themselves when designing a character, after creating it, an attempt at simplifying the character without destroying its personality is recommendable. To establish an art style that was easy to work with in both 3D and 2D, the character was to be stripped from all of its detailing that was deemed unnecessary. (Picture 19)

PICTURE 19. In order to create a design that would keep the hand-drawn animation work feasible, simplifying the initial character concept drawing by removing unnecessary detailing was required.

After settling down for a concept that supported not only 3D production but also 2D art style, a character sheet was drawn. Character sheets for 3D modelling have stand-up poses from front and side views that clearly illustrate the proportions and features of the character. This ensures the resemblance of the model is as close to the original design despite the shift in medium (Picture 20).



PICTURE 20. Character sheet for 3D modelling.

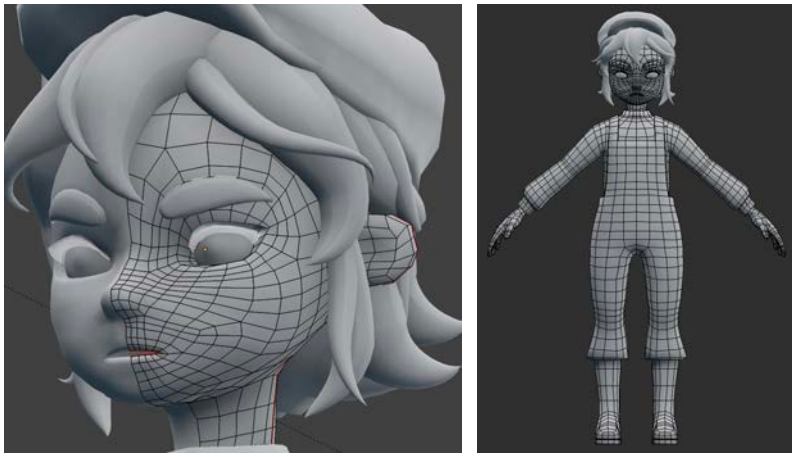
4.3. 3D animation workflow

In order to start animation process in any 3D software, a lot of preparation is necessary before animating can begin. The base for all 3D animation is in modelling a mesh — a collection of vertices, edges and faces that defines the shape of the 3D object — that is suitable for animating and rigging it with a skeleton assigned with appropriate weights which allow the mesh to move in a desired manner. Only then can the animation be created. After the 3D mesh is

brought to life, settings such as light properties are defined. This will strongly affect the final look of the rendered product.

4.3.1. Creating the 3D character mesh

When all the visual design phases were finalised and the character sheet was drawn, the sheet was imported to Blender to serve as a reference image for the 3D character modelling process. The mesh of the character was built by using extrude modelling method around the reference image, keeping the the polygonal count low, which suited the needs set by the style. Moreover, when creating a 3D model for animation purposes, it is important to keep the topology as clean as possible while still maintaining a sufficient level of detail in the wireframe (Picture 21). Clean topology aims at four sided polygons with measured use of triangles if needed. N-gons should be avoided to prevent the mesh from deforming in movement and avoiding unwanted render artefacts. Another general rule when creating a 3D model for animation is adding more polygonal faces in surfaces that are expected to undergo the most deformation during movement such as joints of the limbs and facial features (Slick 2018).



PICTURE 21. Low poly character mesh with topology suitable for animation.

The hair strands of the model were created by using individual curves, which generate surface geometry that is influenced by a weighted control point and the shape can be adjusted. Controlling and modifying the volume and direction of curves was more efficient than modelling the hair strands with extrude

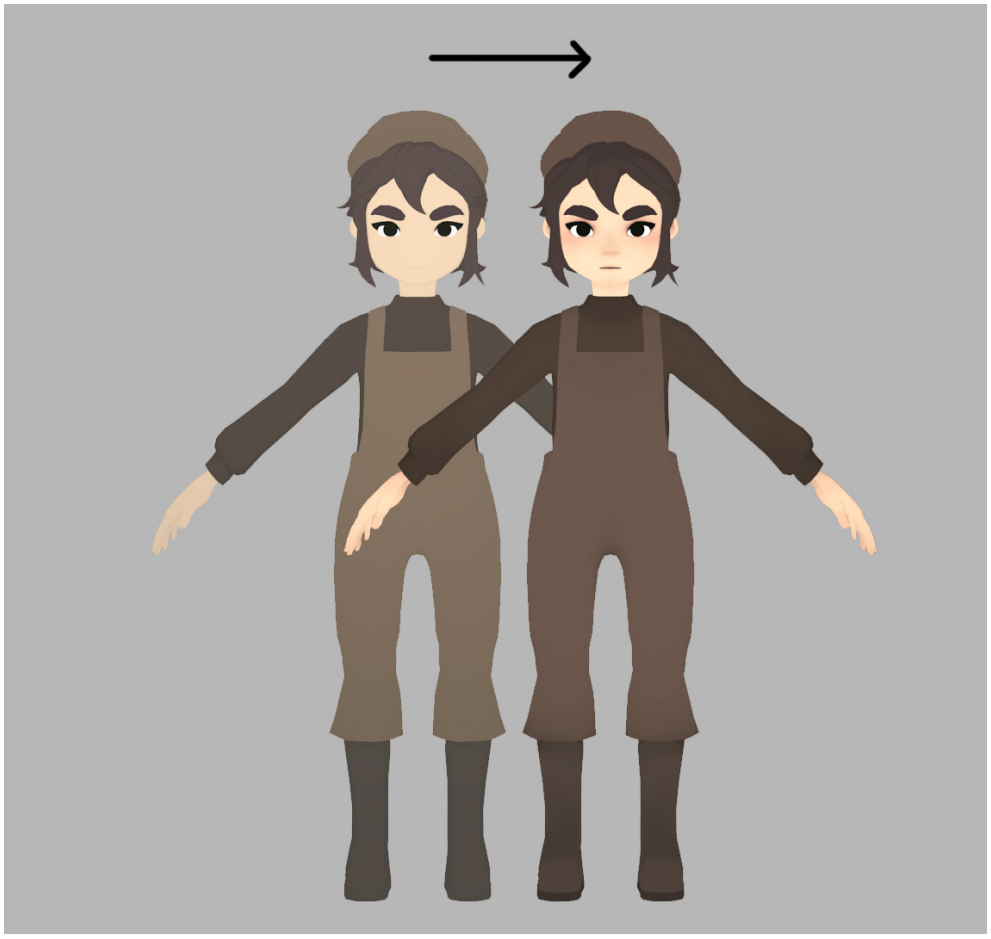
modelling method, making it the optimal tool for attaining the look of clumped cartoon hair (Picture 22).

PICTURE 22. Hair clumps were created with curves.

After the character mesh was brought to completion, a rig was created to enable the animation process. The facial rig needed to be complicated enough so that the character could act and convey credible expressions. The hair strands around the character's face would also need to be rigged so they could reach to the movement appropriately and further sell the image of real movement. As further examination of the rigging process was not relevant to the topic of the demonstration, the final rigging used in this project was outsourced and commissioned from 3D animator Waltteri Lahti.

4.3.2. Surfacing and lighting

UV mapping — a flat representation of the 3D surface — was created for textures. This process is referred to as surfacing — it determines what the surface of the mesh indicates about consistence of the material and how it interacts with light. As the goal was to make the 3D model portray the more simplistic and abstract nature of a 2D character, the texturing was to be kept minimal. Moreover, further details were to be depicted later on in the hand-drawn animation phase to maintain a desired outcome. As the simplifying cel-shading method would play a key factor in the final exterior of the 3D render, subdued shading gradients were the only textures added to the 3D model to further define the mesh (Picture 23).



PICTURE 23. As the mesh needed to maintain a flat look and further detailing would be added in the hand-drawn step, texturing was kept minimal.

In order to convey a style with a more 2D resemblance to the 3D mesh, rendering style settings needed to be adjusted. Cel-shading rendering method

was exploited by using the in-built Toon BSDF in Blender Cycles Render. Each material was given a specific value that controlled the sharp appearance of the shading, while softening the edges of the tone shifts slightly to help smoothen out any errors caused by low poly mesh deformation. On top of that, the main source of light was planted in an angle that resulted in a desirably flat and clean look typical to hand-drawn animations, while still reacting to the movement of the mesh in a logical manner. This helped the appearance to read as more 2D than a photorealistic shaded rendering style, while still using the benefits of computed lighting (Picture 24).

An advantage that 3D tools have over 2D animation is the capability to create complex lighting with ease. For 2D animation, lighting conditions have to be hand-adjusted for each frame, which has resulted in hand-drawn animation often having limited steps in shading. In 3D animation, multiple light sources can be used and moved in the 3D scene during the animation creating conditions that would be laborious to render in 2D animation. This feature was made use of by placing another, brighter source of light behind the character, creating a visually interesting rim light to both animation sequences (Picture 24).

PICTURE 24. Photorealistic shading versus cel shading. Cel shading gives the mesh a more hand-drawn style while the rim light makes the lighting more visually interesting.

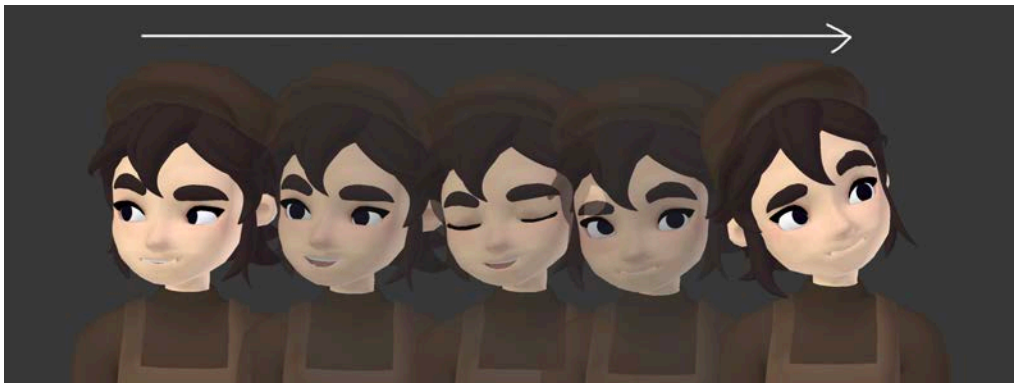
Adding synthesised linework in 3D is a method that is often exploited with cel-shading technique. In Blender, this is often made with an in-built engine called Freestyle. However, this result often lacks any abstract interpretation. As the Freestyle lines are based on the 3D mesh data, it often appears too stiff to resemble the more illustrative language of hand-drawn lines. To compare the results, two tests shots of a keyframe were made. One render was with linework from the calculations of the 3D engine, and the other was a test drawing for hand-drawn linework. The comparison proved that Freestyle severely lacked the expression needed to achieve the desired visual result. Thus, a decision to leave out the freestyle linework from the 3D render was made (Picture 25).

PICTURE 25. Linework comparison between Freestyle and hand-drawn.

4.3.3. The first animation sample

A simple a head turn was chosen as the movement for the first animation. To begin with, the key poses of the animation were blocked to create a solid basis for the head turn. Blocking in animation means creating key poses relevant to convey the right timing of poses in the animation, allowing the animator to clearly see the keyframes and development of the animation without any automated interpolation between the keyframes. This creates a solid basis for the animation to be built upon. (Picture 26). After blocking the animation, the

interpolation mode was changed from constant to bezier curves, allowing the computer to calculate the in-between frames.



PICTURE 26. Blocked keyframes.

Although the methods of 2D and 3D animations are vastly different, the principles of animation are always the same. Timing is important even in simple movements as the result will often look robotic if not done correctly. One regularly used technique to break that illusion is ease in and ease out, meaning the movement starts slowly, accelerates in the middle and slows out again towards the end. This was exploited in the head turn: the character keeps its beginning pose and end pose for more frames contrasted with less frames in the middle of the action. Moreover, in anticipation of the movement, the character's eyes moved before the head.

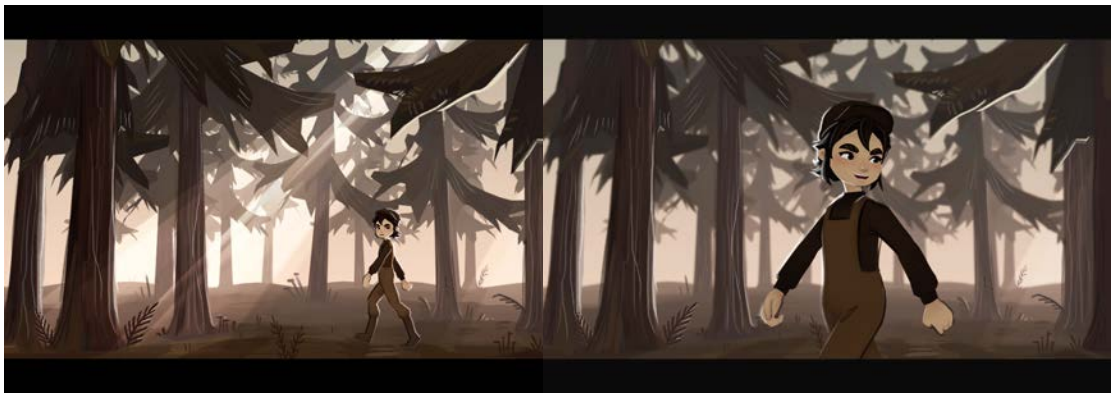
To further refine the credibility of the motion, exaggeration was applied. In animation, a lot of the expressed movements are synthesised, simplified and exaggerated from their real-life origins as naturalistic action looks too weak in comparison (Whitaker & Halas 1981, 28). Therefore, instead of just tilting the character's head from one position to another like a person would in reality, the movement was pushed further to deliver the expression. To begin with, anticipation is added: the character is readying for the head tilt by exaggerating the position it is already in. Its head first goes slightly to the opposite direction before it goes down. Before the character's head started to turn upwards again, it is squashing to anticipate the upcoming movement. This was further emphasised by making the character blink simultaneously (Picture 27). Although these movements happen within less than a second, the result is

more appealing than if the character had gone linearly from the beginning to the end pose. After the adjustments were ready, the animation was rendered as a PNG sequence at 24 frames per second.

PICTURE 27. Although the action is simple, small adjustments emphasise the movement and add weight to the expression.

4.3.4. The second animation sample

For the second animation experiment, a scenario was chosen that could demonstrate the implementation of background elements. To start with, a scene of the character walking in a forest was planned and a walk-cycle was created (Picture 28). Similar to the first head-turn animation, the process started with animating the character by blocking the keyframes which were then converted into keyframes with interpolation and polished by adding details such as ease-ins, ease-outs, anticipation and exaggeration for a more appealing outcome. To make the walking more interesting and the character seem more alive, details such as blinking, head-turns and flexibility in limbs were added to fine-tune the final walk to completion.



PICTURE 28. Layout for the second animation experiment.

An advantage 3D tools have over hand-drawn animation is the ease of accurately rendering movement that has perspective. This was utilised in the experiment by placing and moving the camera in an angle that would allow the character to walk closer, creating a shift in perspective that would require more time and effort to convey accurately and consistently with hand-drawn methods. An illusion of the character walking forward was created by animating the character's position in the scene towards the camera in a speed that seemed natural to the movement of the feet. A invisible plank that acted as a ground was placed in the scene for the character to seemingly walk on, allowing the shadow of the mesh being cast on it in the final render (Picture 29).

PICTURE 29. Keyframes from finished walk cycle with camera movement, and cast shadows that would match the environment.

To create a background without adjusting the lighting conditions of the character model, a new forest scene suitable for the visual style was built for the

environment. In the character sequence, the strongest source of light came from behind the subject which created a rim light. Imitating this condition in the environment, the main light source was placed behind all the tree objects to create backlight. Mist was added for atmospheric perspective so that the focus would be in the foreground where the character was to be situated. In addition, to make the final animation look as cohesive as possible, the silhouette-like appearance of the background needed to be broken, therefore the scene required environmental light setting to be turned on in order to bring out more details in the foreground elements (Picture 30).

PICTURE 30. The finished 3D setting for the walk sequence.

To create an illusion of the environment moving in sync with the character, animating the background was executed by giving the camera a movement matching the length of the walk. The background scene was then rendered as PNG sequence at 24 fps. The two parts of the animation would later be composited into one cohesive scene.

4.4. Applying hand-drawn keyframes and compositing

When both of the 3D renders were finished, the PNG sequences for both character animations were opened in Adobe Photoshop and converted into keyframes. To reduce of the overly smooth movement of the 3D animation, the frame rates were adjusted for a more organic and flawed outcome. This also

simultaneously lowered the workload, making the hand-drawn process more efficient. The original 24 fps was changed to be animated on twos by deleting every other keyframe and duplicating the remaining keyframes resulting in 12 unique frames per second. However, with the head turn animation, the keyframes in the middle were left without a duplicate to emphasise the speed of the movement. For the second animation, the background was left at 24 fps for a smoother panning effect.

For each frame of both animations, stylised linework were painted on a separate layer using several artistic techniques. A brush that allowed line weight was used to make the linework portray more artistic expression. Line weight in drawing implies the strength, darkness and thickness of a line (Picture 31). Altering the weight reinforces dimension to the image and emphasises the importance of the elements (South 2019). In order to create a clearer indication of volume, this was utilised in the linework that defined edges, the rim lit areas and shaded areas such as the strands of the hair and hatching — shading with closely drawn parallel lines — over the cheeks. Slight distortions in the mesh, such as the jagged shading in the hat were painted over to give the final render a clean result. (Picture 31)

Another hand-drawn element that was added was overlapping action. When the character moves its head, the 3D hair mesh only moves in large chunks attached to the head. Although it had its own keyframes that reacted to the movement appropriately, the overall appearance had room for improvement due to the limitations set by the mesh and the lack of assigned physics. To enrich the main action — the head movement — small hair strands were animated to accompany the hair mesh, following the path of action a few frames behind and following through the action, making the whole animation appear more believable and interesting to the eye. (Picture 31)

PICTURE 31. The hand-drawn details were used to enhance and clean up the 3D rendered frames.

For the second animation, the rendered 3D background needed hand-drawn elements to achieve a compatible outcome when merged together with the character animation. Unlike in the character animation, the only movement between the frames was a linear panning motion meaning the added 2D elements could be completely static. This meant that no step-by-step keyframe animation was required and the elements could utilise motion tracking to pin them to their designated position. However, because objects that are farther from the field of view appear to move slower where as the ones that are close move faster, the elements needed to be added in layers for them to be able to move at different speed in the final composition.

After every frame of both animations were painted over, they were exported into After Effects, an animation and compositing software by Adobe Systems. The background was compiled together with the second character animation and the framing was adjusted to match the movement better. Slight adjustments to the colours and contrast were added on both animations as final touches and the finished products were exported as video footage (See Appendix 1).

4.5. The third animation sample: hand-drawn style with Ebsynth

In the third part of this practical demonstration, a software called Ebsynth was used to generate hand-drawn style on top of 3D rendered footage.

Ebsynth is a free tool created by a company called SCRTWPNS that claims to bring your paintings to life (Ebsynth Website 2019). It uses video footage — either live action or 3D renders — and one or more stylised keyframes of that footage to generate the entire sequence in that style. For this experimentation, the sequence that was already stylised by hand in the first animation experiment was used. The plain 3D render and the final hand-drawn keyframes were the source files for this demonstration. Furthermore, since the animation had already been made by hand, Ebsynth allowed a useful comparison of how consistently a computer could execute a similar stylisation. If it was able to compute the task without errors, it would be a powerful tool to use in hybrid animation productions.

The keyframes of the first head-turn animation were entered into the software, and Ebsynth calculated the stylisation first on based just one stylised keyframe. This provided good results in the first half of the animation before the character had turned its head — however, as soon as the source material changed too much from the entered sample keyframe, the stylisation got messy (Picture 32). Thus, a new keyframe was entered, starting in the middle to see if this would provide better results. In an attempt to get even cleaner results, the original 3D rendered keyframe was entered to the programme as a mask to protect the 3D render from distortions. This improved the results: the lines followed the motion more consistently than when the mask was not applied (Picture 33). However, the linework was not without errors: some disappeared altogether while some moved in a less than desired manner.

PICTURE 32. The linework produced Ebsynth with one just keyframe entered to the system. First half of the animation (left) provided consistent results but since the source material changed enough, the second half (right) got messy.

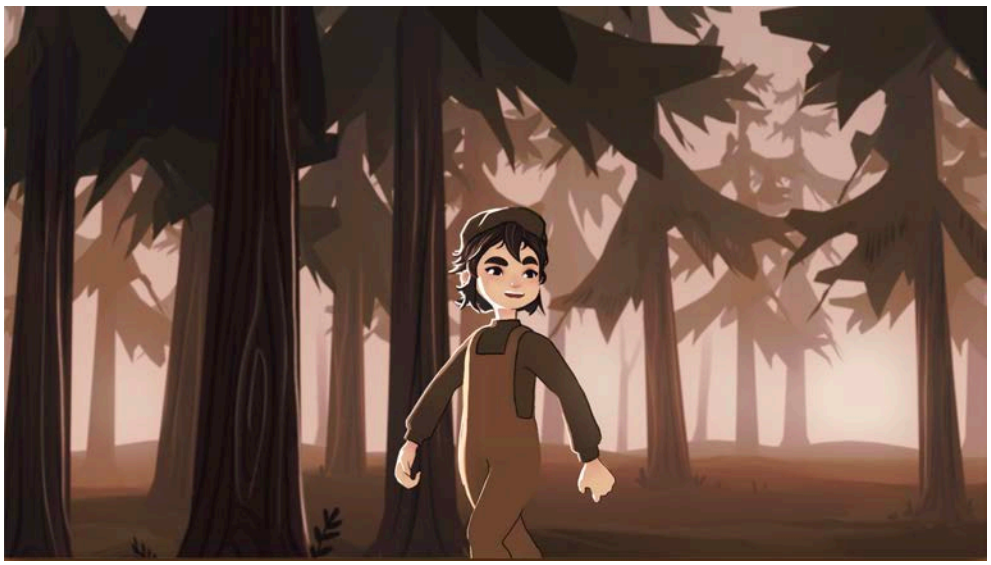
PICTURE 33: When another example keyframe was entered to the system along with a mask, the consistency of the linework improved.

Secondary action that was entirely animated by hand could not be produced in the software as there were no cues in the source material for these additions.

4.6. Final Products

Adding hand-drawn details gave the animation sequences an evocative and rather unique visual outcome (See Appendix 1). The end result was made attainable by using the strengths of both media and combining them together: the consistency of animating in 3D and the artistic expressiveness added by 2D animation. The hand-drawn style was further enhanced by adjusting the frame rate on twos and ones accordingly for weight and impact as well as by animating further details by hand. The workflow was feasible, and considering the results, the additional time spent on the hand-drawn part polished the final outcome was convincing, appealing and consistent. (Picture 34 and 35)

PICTURE 34: Screenshot from the finalised first animation sample.



PICTURE 35: Screenshot from the finalised second animation sample.

The experimentation with Ebsynth software provided a solid base for the hand-drawn animation. However, comparing the results side by side, it was clear that the hand-drawn version was more consistent and fluid (Picture 36). Understandably, when animating by hand, the artist is in full control: with the software, the control is given to the computer. However, although the frames produced by Ebsynth would need further refining to reach the same level of accuracy compared to the hand-drawn version, the results were consistent enough to conclude that Ebsynth could potentially be used as a base for any stylised animation with a similar pipeline, easing the workload immensely. In a similar production, instead of having to make the hand-drawn animation completely from beginning to end, this software could be used to produce the initial line drawings on top of 3D that could then be refined and cleaned by hand, taking less time than completing the task completely by hand.

PICTURE 36: A keyframe from the results of Ebsynth (left) compared to the hand-drawn version (right).

5. CONCLUSION

In any animation, it is important to consider what is the best tool and method to tell each story. Since both 2D and 3D have their strengths and weaknesses, hybrid animation provides a cost effective way to make visually appealing and interesting animation that conveys the organic expressiveness of hand-drawn animation while utilising the controllability and accuracy of computer calculated 3D animation.

The practical demonstration proved that combining non-photorealistic rendering and hand-drawn details was a powerful method. The workflow was kept feasible, considering the effort it would have taken to produce similar imagery in 2D alone, yet it allowed more room for artistic stylisation than a strictly 3D animation pipeline would have done. The final product proved that combining the two can get needed and visually appealing results.

With the help of Ebsynth, any 3D animation could still attain a pleasing style with little effort, even if the results were not quite as accurate as the ones made by hand. However, utilising computer software to aid the hand-drawn process could potentially cut the production cost immensely: in the future, this could mean more and more productions might be able to create unique looking and expressive animation without giving too much work-load to the artists behind them. Moreover, small animation studios without substantial budgets could also benefit from utilising this method in their production.

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APPENDICES

Appendix 1. The final results of the animation samples

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