POLITECNICO DI TORINO

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Master's Degree Thesis

Immersive Exploration of the Past through Virtual Reality:
Innovative 3D Animation Techniques for Historical Content Production

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In loving memory of my father and the cherished memory of my ancestors.

Acknowledgments

I would like to extend my heartfelt gratitude to the individuals and organizations who have contributed to the successful completion of my thesis dissertation.

First and foremost, I would like to thank my mother and sister for their unwavering emotional support. Your belief in me and encouragement have been the pillars of my strength. I am truly blessed to have you in my life.

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Thank you all.

Turin, May 2023

Abstract[1]

What if cutting-edge technologies could revolutionize traditional methods of producing animation? This thesis embarks on an exploration of this possibility, with a specific focus on the application of Virtual Reality (VR) technology in immersive historical content production. One intriguing question arises: Can we leverage new technologies like Virtual Reality headsets, originally designed for projecting and experiencing visual media, to also produce animations? This thesis explores the potential of Virtual Reality (VR) technology for 3D animation, meticulously examining its challenges, opportunities, and application in immersive historical content production.

The production phase of the thesis centers around the captivating "Alexander Mosaic," an ancient painting dating back 2,100 years that vividly depicts the epic battle between the Macedonians and Persians. Inspired by this masterpiece, an immersive VR animation is meticulously crafted to breathe life into this historical event. The Quill VR software takes the lead role, chosen for its comprehensive functionality and its ability to support the entire animation workflow. To further enhance the visual quality, the animation workflow combines the power of Quill VR with complementary software like Blender, which adds advanced rendering, lighting, and shading techniques.

Throughout the thesis, a comprehensive exploration is undertaken to address the research question, encompassing theoretical frameworks, practical applications, and the potential implications of the proposed solution. By blending the realms of virtual reality and historical narratives, the thesis seeks to advance our understanding of how VR can be integrated into animation workflows to create captivating and immersive experiences..

This work was carried out as a thesis project at Robin Studio S.R.L., a creative media based in Turin that provided valuable infrastructure support. The partnership with Robin Studio not only ensured the practical implementation of these innovative ideas but also facilitated their integration into real-world industry settings.

[1] **Keywords**: Virtual Reality, VR Animation, Immersive Historical Content, Traditional Animation Methods, 3D Animation, Quill VR, Alexander Mosaic, Blender, Spatial Design, Interaction Design, Animation Storytelling, VR Modeling Software.

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1. Chapter I.

1.1. General Introduction

The field of animation has undergone remarkable advancements in recent years, thanks to the rapid development of technology and its applications. Virtual Reality (VR) has emerged as a groundbreaking tool, offering immersive and interactive experiences in various domains. In this context, this thesis explores the application of VR technology in the field of animation, with a specific focus on immersive historical content production.

1.1.1. Background and Motivation of the Project

As a student of cinema and media engineering at the Polytechnic University of Turin, I found myself at the intersection of art and science, exploring the creative possibilities offered by this multidisciplinary field.

During my studies, I acquired valuable skills in 3D modeling, visual effects, and animation, gaining proficiency in various software programs used for designing and editing. My background in engineering provided me with technical skills in 3D modeling, VFX, and animation, while my passion for vintage and silent cinema fueled my love for storytelling and historical narratives.

The motivation behind this endeavor is twofold: first, to leverage the capabilities of VR technology to enhance the animation process, bringing historical narratives to life in a way that engages and instruct audiences. Second, to bridge the gap between traditional animation methods and emerging technologies, drawing inspiration from history and infusing it with the power of modern tools.

1.1.2.Inspiration and Scope of the Study

This project not only showcases my technical skills and artistic passion but also represents a personal exploration of self-identity. By intertwining my background, interests, and the opportunities provided by the university, I aspire to create a project that reflects the convergence of art and science, while also preserving and celebrating historical narratives.

As a Persian studying in Europe, I was inspired to choose the "Alexander Mosaic" as a focal point for my project—an artistic representation of the clash between two civilizations. This historical event resonates with my personal journey, symbolizing a fusion of identities and cultures. Therefore the project serves as a powerful metaphor, representing the amalgamation of my background in engineering and my love for art.

It became evident to me that Virtual Reality (VR) could serve as a powerful tool to bring historical narratives to life, providing immersive and engaging experiences for viewers. Motivated by the transformative power of VR technology, I aim to explore how it can enhance the animation process and provide immersive experiences that transport viewers back in time. By leveraging VR's capabilities, I seek to create compelling and educational narratives that pay homage to traditional animation methods while pushing the boundaries of storytelling.

1.2.Alexander Mosaic

1.2.1.Overview and Preliminary Presentation

The Alexander Mosaic is an ancient Roman artwork, discovered in the House of the Faun in Pompeii, Italy in 1831. It portrays a battle scene between Alexander the Great and King Darius III of Persia, measuring approximately 5.82 meters by 3.13 meters and composed of thousands of tesserae (with maximum size of 3mm) in various colors.[2]

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2 Ada Cohen, The Alexander Mosaic: Stories of History and Defeat, (Cambridge: Cambridge University 30 Press, 1997), 1.

The Alexander Mosaic is a 2100 years old artwork, considered to have great art value due to its exceptional attention to detail, dynamic composition, historical significance, and influence on later artists. (It is made up of tiny squares of marble rather than being a painting or fresco)

Figure 1. The Alexander Mosaic, on display on a wall in the Naples Archaeological Museum. Image from *Smarthistory*

Although believed to have been created in the late 2nd century BC, over a century after the actual battle, the Alexander Mosaic is considered one of the most outstanding examples of ancient Roman art, believed to be a copy of a now-lost Greek painting.

The artwork is thought to be a product of the Hellenistic period, a time of great artistic and cultural achievement in ancient Greece. During this period, artists were interested in depicting a sense of movement and emotion in their works, and the Alexander Mosaic is a superb example of this style.

The mosaic creates a vividly realistic and dynamic representation of the combat, depicting Alexander charging towards King Darius on his horse, Bucephalus, surrounded by soldiers and horses engaged in violent conflict. The mosaic conveys a sense of drama and emotion through the expressions of the figures, capturing the chaos and violence of the battle in intricate detail.

Today, the artwork is displayed at the National Archaeological Museum in Naples, Italy, where it continues to attract visitors from around the world who marvel at its exceptional artistic and historical value.

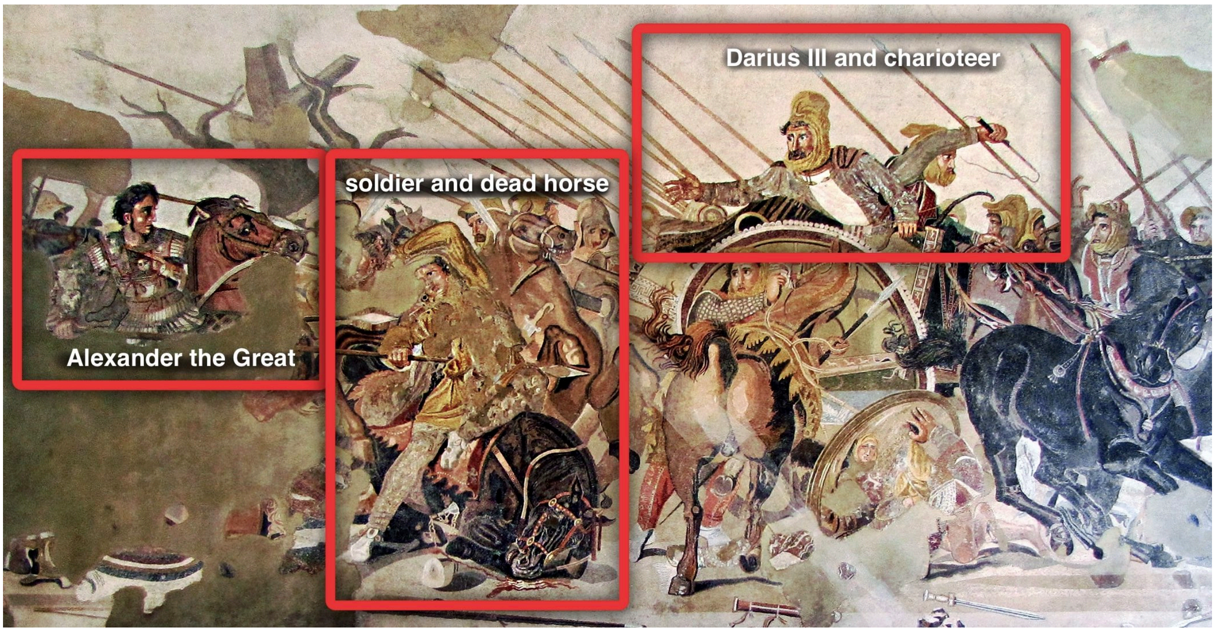


Figure 2. Annotated detail, *Alexander Mosaic*, created in the 2nd century B.C.E., from the House of the Faun in Pompeii, reconstructed in the National Archaeological Museum, Naples

The artist who created the mosaic was able to depict a sense of realism, movement, and emotion through the use of tesserae, or small colored tiles, which allowed for the creation of intricate patterns and details.

1.2.2.In-Depth Analysis of the Mosaic

Here are several instances showcasing the meticulous attention to detail evident in the Alexander Mosaic:

✤ The Depicted Facial Gestures and Emotions:

The artist was able to convey a wide range of emotions on the faces of the soldiers and horses, from fear to anger to determination.

Figure 3. a diverse array of emotions, encompassing feelings of fear and anger.

✤ The Armor of the Soldiers:

The intricate patterns and textures of the armor worn by the soldiers are depicted with great precision, down to the individual scales or plates. Note the head of Medusa as an apotropaic symbol on Alexander's cuirass *(coriaceus)*. The eyes of Medusa stare in the same direction as Alexander.

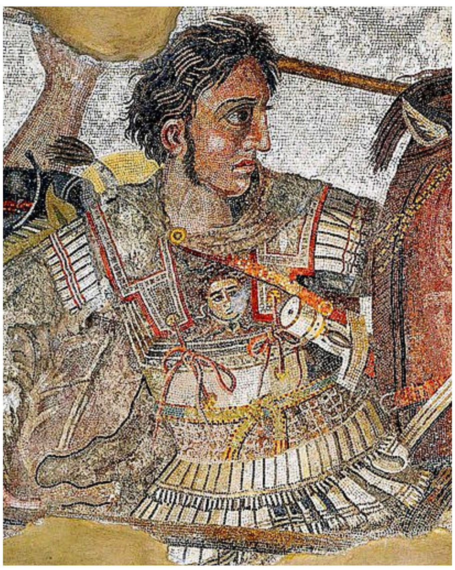


Figure 4. Armor Details

The highly elaborate Mosaic provides such intricate details that modern artists today could meticulously reconstruct armors, capturing a high level of precision and accuracy.

Figure 5. Reconstruction of Alexander armor also known as Linothorax

✤ High Level Details:

The Alexander Mosaic showcase an impressive level of detail, and here I provide some specific examples to highlight this:

- The artist was able to convey the fine details of the horses' reins and bridles, including the stitching and clasps.

Figure 6. High Level Details in reins and bridles of the horses

- The spears and weapons of the soldiers: The artist depicted the intricate details of the spears and other weapons used by the soldiers, and the spear in the foreground is parallel to the diagonal line.

Figure 7. Spear and Sword details

- The depiction of the collapsed horse beneath the Persian, speared by Alexander, showcases the skillful use of Opus Vermiculatum[3] in the mosaic artwork. The technique is also employed effectively to represent the flowing blood emanating from the horse, further demonstrating the artistry of opus vermiculatum in capturing intricate details.

- The mosaic also includes a horse with all four hooves off the ground and its head turned to the right. (Figure 8)

Figure 8. Horse with Hooves in Air

Figure 9. Opus Vermiculatum

3 Opus Vermiculatum literally means Worm-Like-Work is an ancient Roman mosaic technique characterized by the use of small, tightly fitted tesserae. It allowed for the creation of intricate and detailed designs, often depicting figures, landscapes, and mythological scenes. This technique was highly valued and commonly used in prestigious buildings during the Roman Empire.

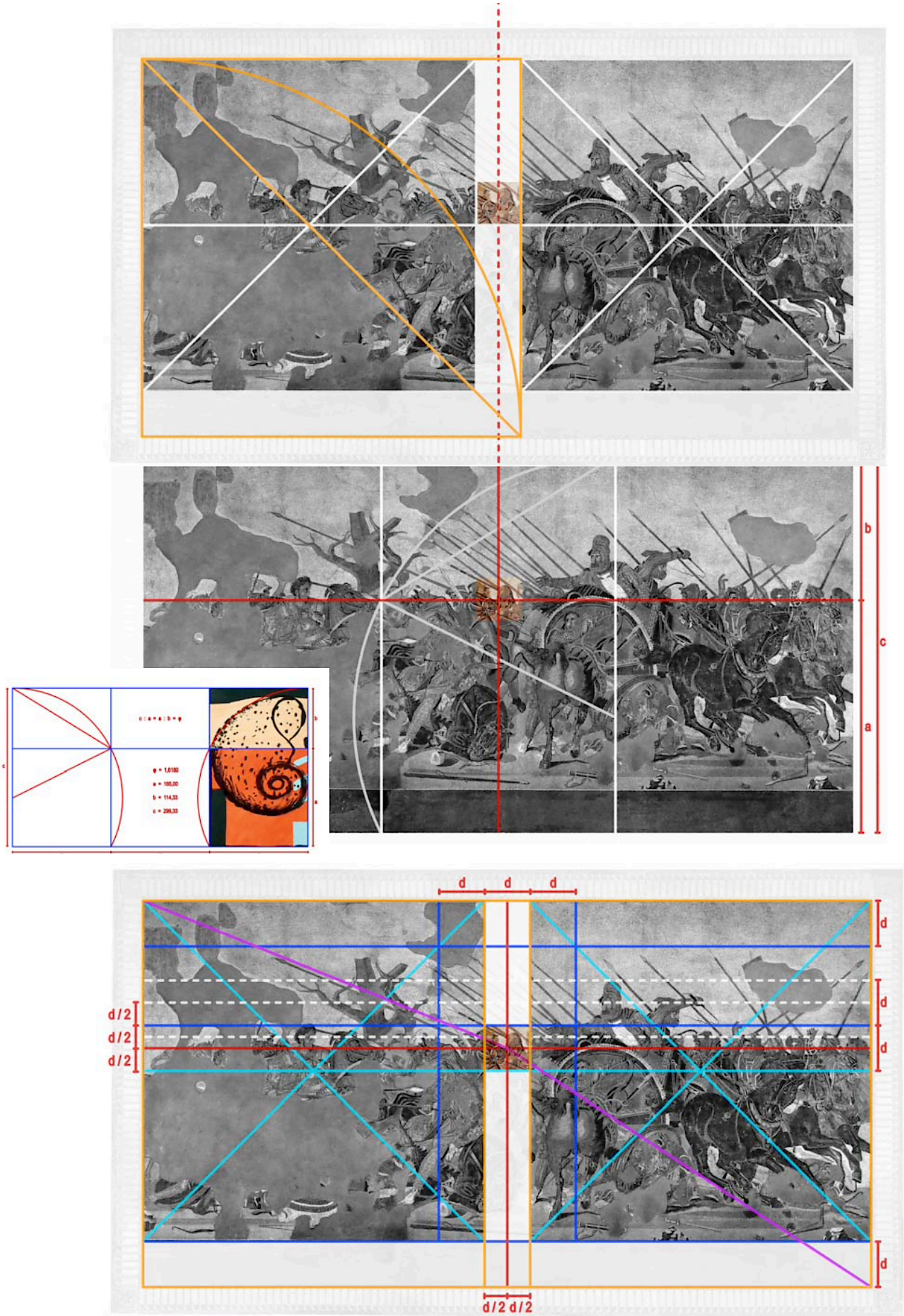


Figure 10. Composition and Use of Geometry. The Images Copyright © Luisa Ferro.

✤ **Illusion of Depth (Three-dimensionality):**

The artwork resembles a painting rather than a traditional mosaic, displaying a heightened three-dimensional quality. It achieves a realistic depiction of the scene by employing techniques such as foreshortening, accurately representing the proportions of the horses based on the viewing angle, and creating a sense of depth through overlapping and three-quarter views.

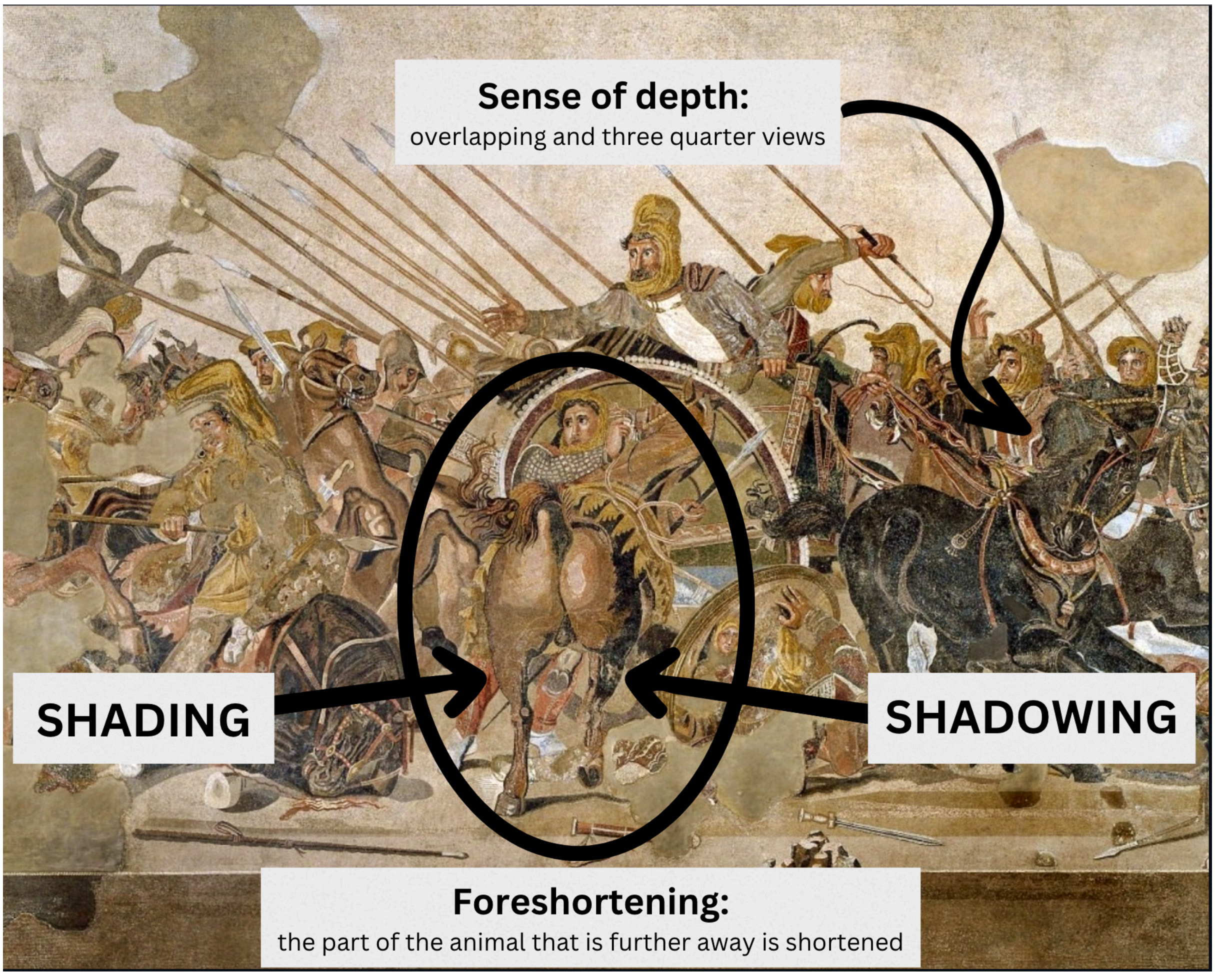


Figure 11. The landscape features only a tree, while depth is created through foreshortening and overlapping

✤ **Use of Space and Geometry[4]:**

The artist skillfully employs Euclid's geometrical theories, known as the "Composer of Elements," to manipulate geometry and space. The axis of vertical symmetry and the horizontal secant line obtained through the rule of *proportional medium* (the point of intersection of which

4 Ferro, L. (2018). The Alexander Mosaic and the House of the Faun (Pompeii VI, 12, 1-8): Geometry, Proportions, and Art of Composition.

is indicated by the unknown character) are the matrix of the painting's geometries. The distance between the parallel lines that define the main symmetrical squares provides the module that divides the space occupied by the battle scene. The rotation of Alexander's Spear also find an explanation within this modular grid. (Figure 10)

✤ **Symmetry and Symbolism:** [5]

As Alexander's gaze falls upon the two figures towering above, the most significant one is the Persian King Darius, positioned on a chariot. Interestingly, Darius appears to be in retreat, although this is merely a deliberate artistic choice to create symmetry with the presence of a dead tree. The interpretation of the dead tree varies, but one perspective suggests that its branches perfectly mirror the outstretched arm of the standing general and that of his charioteer. As the losing party now retreating, they, too, resemble a lifeless tree, symbolizing the decline of an empire on the verge of demise.

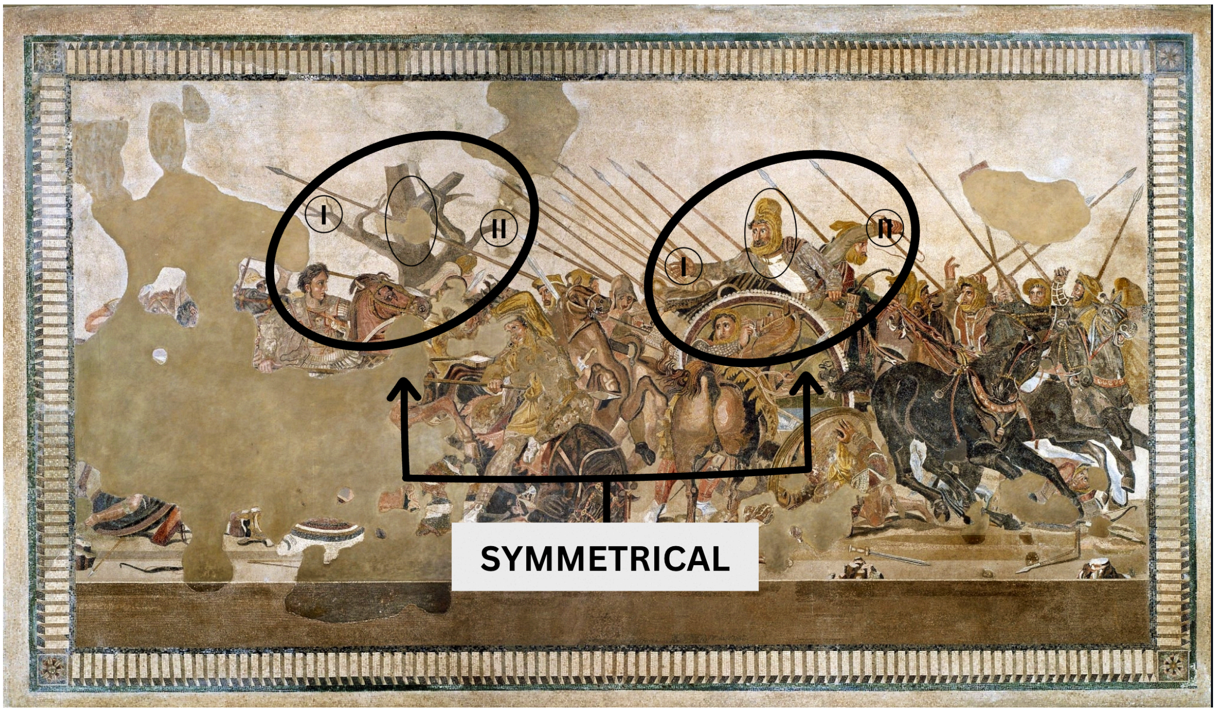


Figure 12. Symmetrical Essence of the Alexander Mosaic

✤ **Composition:**

5 Tuccinardi, M. (n.d.). L'albero secco nel mosaico pompeiano di Alessandro Magno. Engramma. Retrieved from https://www.engramma.it/eOS/index.php?id_articolo=2146

The composition of the mosaic is intriguing because it is almost empty at the top and weighted towards the bottom, as it would have been intended to be viewed vertically on a wall. The composition of the mosaic is dominated by diagonals. The center is dominated by the intersecting diagonals of the Persian speared by Alexander and the Persian restraining the rearing horse. Two other sets of intersecting diagonals are provided by the figures of Darius and his charioteer and by Alexander and the wounded Persian. The lances in the background of the picture also carry on the diagonal motif. [6] The painting's composition incorporates both frontal and planar elements, strategically positioning the armies and depicting Alexander's dynamic charge as he disrupts the ranks.

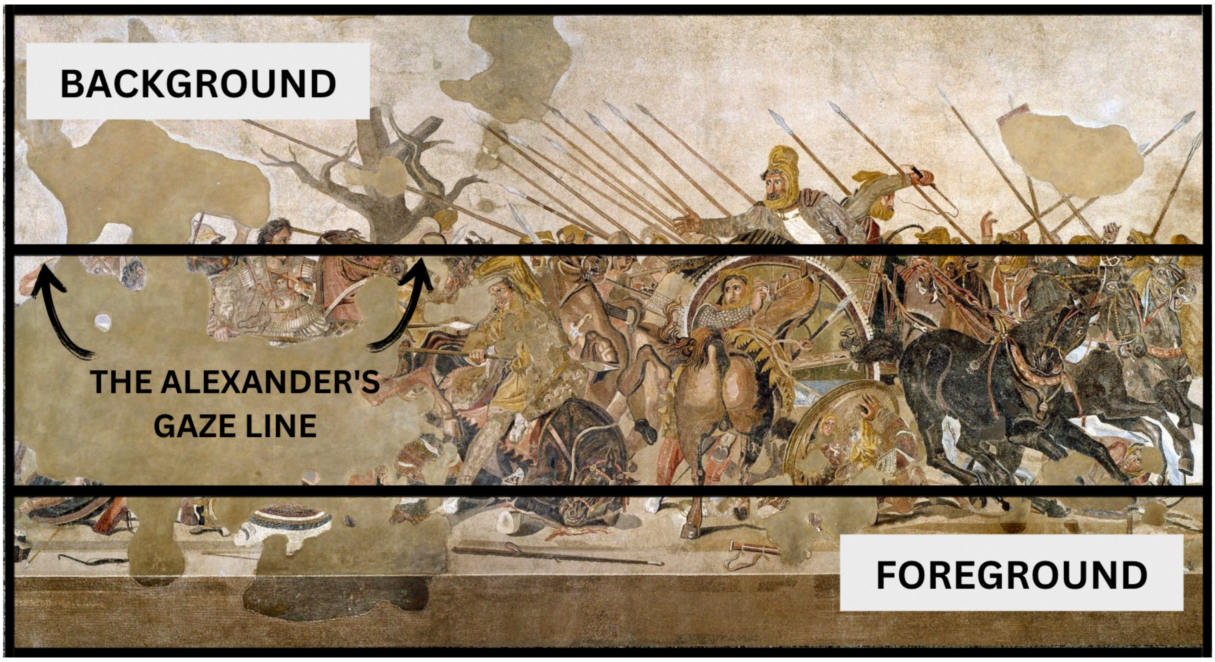


Figure 13. The Alexander's Gaze Line

In this artwork, the Persian King holds the central position, elevated above the others, while Alexander is positioned slightly lower but still above the figures on his side. Darius extends his arm while Alexander raises his spear, and their connection is conveyed through their gestures and intense stares. Alexander is depicted with an intense and wild-eyed expression, while Darius is portrayed sympathetically, showing a sense of dismay. The remaining elements of the artwork depict a chaotic scene of soldiers, weapons, and horses, symbolizing the chaos and confusion of battle. The focus of the artwork draws inspiration from Greek art, with a central

6 Van de Weijgaert, R. The Great King and his lifelong companion: Alexander III of Macedonia and Bucephalus. Retrieved from https://www.astro.rug.nl/~weygaert/alexandermosaic.html

emphasis on the human participants. The horizontal line that corresponds to Alexander's gaze (Figure 13) is slightly above that of all the human figures in the background, all aligned on the same horizontal line. [7]

✤ The Reflections:

A notable example is shown in a scene where a person is knocked down by a chariot. In a moment of self-reflection, the person looks at their own face reflected on a shield, perhaps considering their imminent death. The artist skillfully portrays these dynamic moments with lifelike precision.

Figure 14: Persian soldier reflected in a shield. Credit: Brewminate, 2021

✤ The Expressions:

7 Ferro, L. (2018). The Alexander Mosaic and the House of the Faun (Pompeii VI, 12, 1-8): Geometry, Proportions, and Art of Composition.

Alexander is depicted as youthful, but not young. The artist captured the intensity and determination of Alexander the Great's expression, conveying his leadership and heroism. His widened eye (they are exaggerated and intentionally magnified likely to emphasize his intense focus and concentrated mental state) is trained on Darius; Alexander appears confident as he approaches Darius, who looks fearful and is gesturing towards him, perhaps pleading for his soldiers' lives.

Figure 15. Close up of Alexander

In a crucial moment during battle, a man jumps in front of Alexander's spear intended for Darius, reflecting the shock and fear on Darius' face as captured by the artist. With widened eyes filled with horror, Darius gazes to the left, witnessing his bodyguard's kinsman impaled by Alexander's spear.

Figure 16. Close up of Darius.

Now in order to gain a comprehensive understanding, it is essential to shift our focus from the key elements to the right side of Darius. Directing our attention away from the damaged figure in the standard, as it is unlikely to provide significant insights, we should instead delve into the hidden philosophy embedded within the entire image. The first detail to be noted is that below the standard, the Persian rider has a different attitude: he does not panic at all, he just observes and puts his hand on his head in a quiet gesture of resignation. His horse shows something indicative, the pendant decorating its ear is a white cross (Figure 17).[8]

Figure 17. The Alexander Mosaic, Particular with Cross. Copyright © René Seindal

[8] Mureddu, Nicola. "The Gorgon and the Cross: Rereading the Alexander Mosaic and the House of the Faun at."

1.3. Animation Methodologies

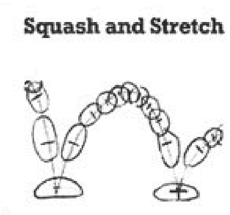
Before delving into the vast possibilities that new technologies offer to the animation and film industry, it is essential to gain a fundamental understanding of the core principles of animation. By establishing a solid foundation, we can better appreciate the advancements and explore the boundaries of what can be achieved in this dynamic field.

1.3.1. Principles of the Animation

The 12 principles of animation are a set of guidelines or techniques used in the field of animation to create more realistic and appealing movements. They were developed by Disney animators Frank Thomas and Ollie Johnston[9] during the golden age of Disney animation.

1. Squash and Stretch:

Through the distortion of shape and form, animators can convey weight, impact, and flexibility, enhancing the realism of the animation.

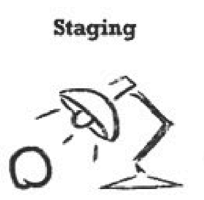


2. Anticipation:

By introducing subtle movements or reactions prior to an action, anticipation builds audience engagement and amplifies the impact of subsequent events.

3. Staging:

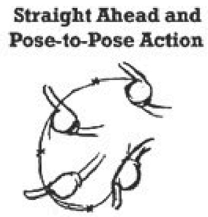
Effective arrangement of elements within a scene, employing composition, framing, and timing, ensures clear communication of ideas or actions to the audience.



9 Thomas, F., & Johnston, O. (1981). Disney Animation: The Illusion of Life.

4. Straight Ahead and Pose to Pose:

Animators can choose between animating frame by frame from start to finish (Straight Ahead) or planning key poses and filling in intermediate frames (Pose to Pose) to create a desired flow and structure in the animation.

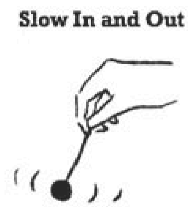


5. Follow Through and Overlapping Action:

The principle of Follow Through depicts the continued movement of different parts of a character or object after the primary action, while Overlapping Action involves the independent movement of various body parts, adding realism and dimension.

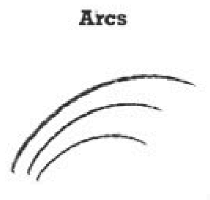
6. Slow In and Slow Out:

Gradual acceleration and deceleration, achieved by manipulating the number of frames at the start and end of an action, replicate real-world physics and contribute to a sense of weight and believability.



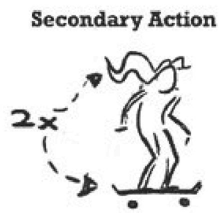
7. Arc:

The incorporation of arched or curved trajectories in animation mimics natural movement, infusing sequences with fluidity and organic motion.

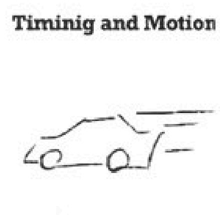


8. Secondary Action:

By incorporating additional movements that enhance the main action, animators deepen the animation's richness and depth. Secondary actions contribute emotions, contextual information, and visual appeal.

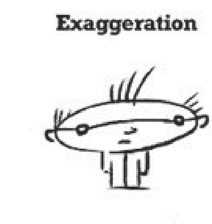


9. Timing:



The precise control of frame duration dictates the speed and rhythm of actions, enabling animators to create desired effects, whether comedic timing or establishing dramatic impact.

10. Exaggeration:



Animators employ exaggeration to push certain aspects of movement, expressions, or actions beyond reality, adding emphasis, appeal, and visual interest. Exaggeration can effectively convey emotions, create memorable performances, and captivate the audience.

11. Solid Drawing:

Mastery of solid drawing allows animators to create characters and objects with a three-dimensional presence, taking into account form, weight, balance, and volume, resulting in more believable and tangible figures.

12. Appeal:

The principle of appeal centers around developing characters that are likable, interesting, and relatable to the audience. Elements such as design, personality, and charisma are carefully considered to ensure a strong emotional connection between viewers and the characters.

These principles serve as a comprehensive toolkit for animators, providing them with a framework to create animations that are visually compelling, emotionally engaging, and technically proficient. While originally developed for traditional animation, these principles can be adapted and applied to various animation techniques, pushing the boundaries of artistic expression and storytelling in the world of animation.

1.3.2.Old-School Animation Approaches

Maureen Furniss, is a respected animation historian, scholar, and professor who has written extensively on the subject of animation. In her comprehensive reference book "Animation: From Concept to Consumer,"[10] provides a thorough exploration of the animation industry and its practices, covering every aspect from conception to distribution. A central topic in the book is the categorization of various animation techniques, with Furniss offering a detailed analysis of the five primary groups of techniques used to produce animation features.

- The first group of techniques is **classical animation techniques**, which rely on manual creation of each frame by hand, typically on paper. Examples of traditional animation techniques include cel animation, rotoscoping, and stop-motion animation.Cel Animation:

Cel animation: also known as traditional or hand-drawn animation, involves drawing and painting each frame of the animation on transparent sheets called cels. These cels are then layered together with backgrounds to create the illusion of motion. It is a labor-intensive process but allows for artistic flexibility and creativity.

- The processes of Cel animation include:
    - Storyboards
    - Voice recording
    - Animatic
    - Design and timing
    - layout

10 Furniss, Maureen, Animation: From Concept to Consumer. Bloomsbury Academic, 2019.

- Animation
- Digital ink and paint.
- Pencil tests
- Traditional Ink-and-paint and camera.

As evident, every stage involved in the production of cel animation demands significant effort and time, which is why television programs like The Simpsons rely on collaborative teams to efficiently accomplish the tasks.

Figure 18. Disney animator Frank Thomas is drawing Ichabod Crane. 1949

Rotoscoping: Rotoscoping is a technique where animators trace over live-action footage frame by frame. It involves projecting the footage onto a surface, such as a glass panel, and then drawing the outlines and details of the characters or objects based on the projected images. Rotoscoping provides a realistic and accurate movement, as it captures the nuances of live-action performances.

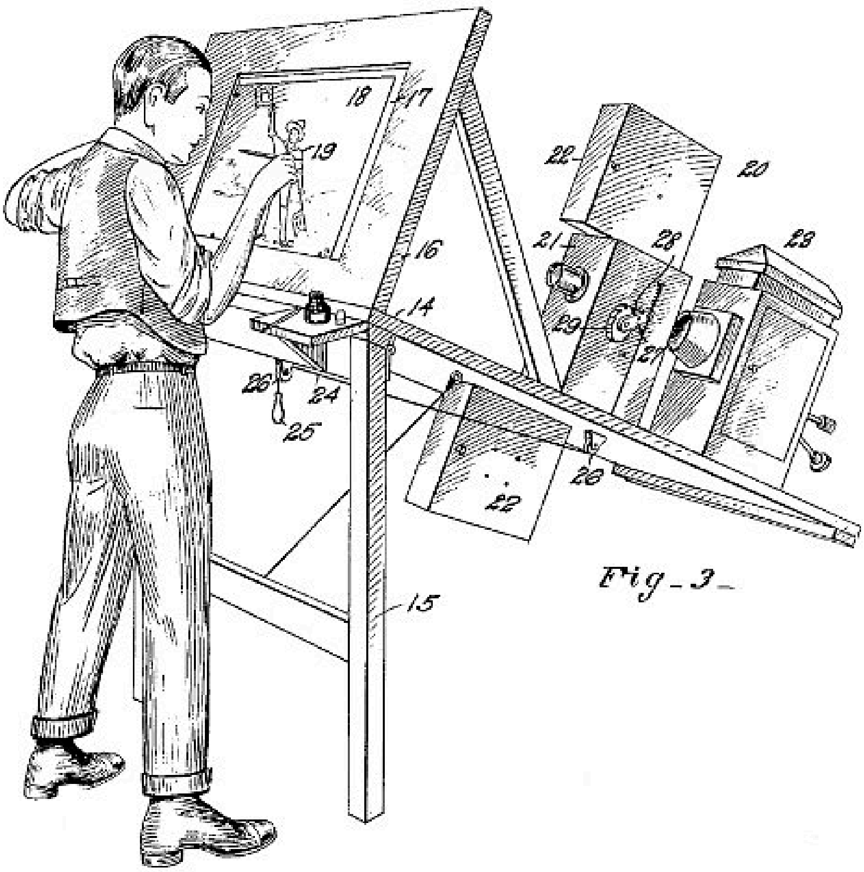


Figure 19. Rotoscoping Technique Copyright by Max Fleischer

Stop-Motion Animation: Stop-motion animation involves physically manipulating objects or puppets and capturing individual frames with slight adjustments between each frame. When played back, the frames create the illusion of movement. It can be done using various techniques like claymation, puppet animation, or object animation. Stop-motion animation requires meticulous attention to detail and patience, as animators have to carefully position and adjust the objects for each frame.

Figure 20. Stop-Motion Animation from behind the scene of Frankenweenie 2012

- The second group is **computer animation** techniques, which utilize software to create and manipulate images to produce animated sequences. Examples of computer animation techniques include 3D animation, 2D vector-based animation, and motion graphics. Referring to photo below (Figure 21), we can observe a motion graphic animation on the left side, skillfully crafted by artist Bruno Mangyoku. While on the right side, we have the groundbreaking "Toy Story 1995" produced by Pixar, widely acknowledged as the pioneering computer-animated feature film.

Figure 21. Two Examples for Computer Animation Technique

- The third group is **motion capture** techniques, which involve recording the movements of real actors or objects and using that data to animate digital characters or objects. Examples of motion capture techniques include marker-based motion capture and marker-less motion capture.

Figure 22. Tom Hanks's motions recorded with a motion capture system. Polar Express (2004)

- The fourth group is cut-out animation techniques, which involve creating characters and objects from paper or other materials and manipulating them to create an animated sequence. Examples of cut-out animation techniques include collage animation and silhouette animation, where characters are formed from solid shapes and their movements are captured frame by frame.

Figure 23. Behind the scenes of 'Paper Plane'. A paper cut-out animation by Giangrande.

- The fifth and final group is **experimental animation** techniques, which push the boundaries of traditional animation to create unique and unconventional animated sequences. Examples of experimental animation techniques include sand animation, paint-on-glass animation[11], and experimental stop-motion techniques.

Figure 24. Example of Sand animation art photo Charlene Lanzel Sand Animation Artist

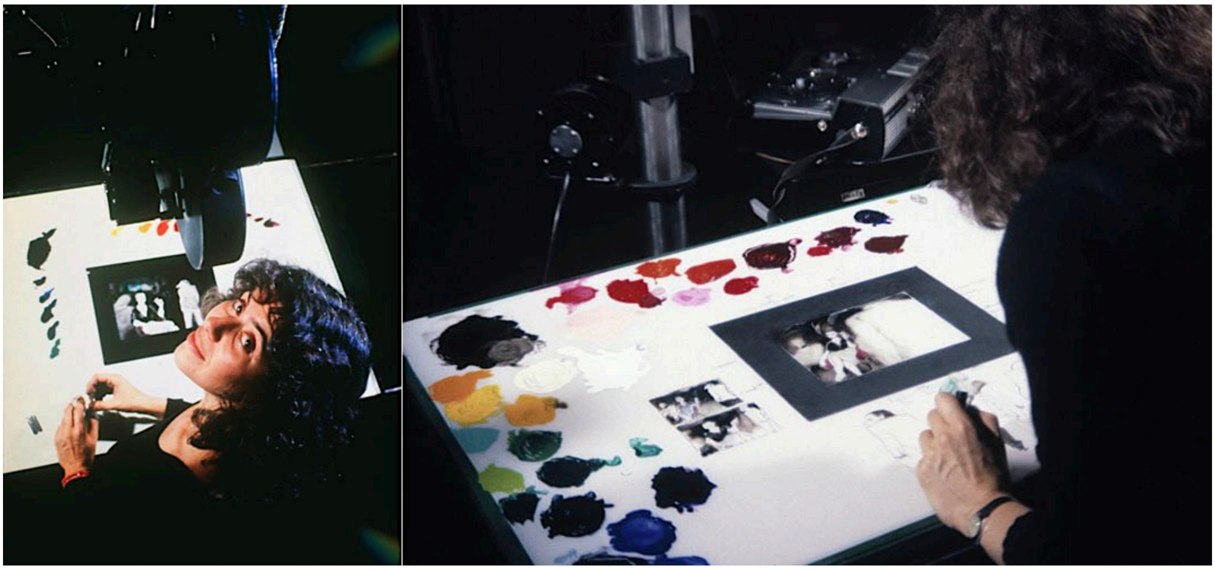


Figure 25. Example of Paint-on-glass Animation techniques photo webneel.com

[11] For more information about these techniques visit https://alltimelouise.wordpress.com/2014/02/04/sand-and-oil-on-glass-animation/

2. Chapter II.

2.1. State of the Art: Technology

As we enter the digital era, artists and designers have embraced new tools, moving away from traditional pen and paper to software applications like Photoshop and 3D software for concept art. However, the evolution does not stop there. Virtual Reality (VR) has emerged as the next frontier for artistic exploration. In this section, I will explore the advantages of incorporating VR into the artistic process, examine the tools available for working in VR, and discuss the decision-making process between 2D and 3D approaches for concept art. Understanding these advancements in technology and the choices they present, had helped me make informed decisions for my thesis project.

2.1.1. Choosing between 2D and 3D

When it comes to making an animation, artists and designers often face a challenging decision of whether to opt for 2D or 3D techniques. This decision is best approached by considering one's experience and knowledge in the respective areas. For instance, if the primary consideration is completing the assignment swiftly, 2D animation may prove to be the more favorable choice due to its typically faster production process. On the other hand, when the goal is to prototype a physical set or create a tangible prototype, 3D or virtual reality (VR) can offer the ideal solution. These advanced techniques allow artists to visualize and manipulate three-dimensional objects with greater precision and accuracy.

Ultimately, the choice between 2D and 3D animation techniques relies on the specific requirements of the project and the artist's or designer's proficiency in each realm. By carefully assessing the project's needs and their own skillset, artists can make an informed decision that aligns with their vision and the desired outcome.

2.1.2.Advantages of Virtual Reality

Virtual Reality is the next step in the evolution of art and design. It offers unique advantages, including a sense of scale and prototyping possibilities, that neither 2D nor 3D can provide. While the decision between 2D and 3D depends on the project requirements and the artist's or designer's skillset, VR provides a new option that combines the best of both.

VR offers several advantages over traditional 2D and 3D artwork. VR provides a unique sense of scale: when users put on a VR headset, they feel as if they are present in the environment, resulting in an immersive experience that cannot be achieved with 2D or 3D artwork alone. This sense of scale is crucial for artists as it allows them to prototype their designs in VR and gain a comprehensive understanding of the total scale of the product or set they are designing. It serves as a practical solution for artists by enabling them to prototype their designs in VR before investing in physical materials, thus saving time, money, and resources.

Furthermore, VR provides artists with the ability to make changes to their designs on the fly, which is not possible with physical prototypes. This flexibility is a significant advantage of VR, allowing artists to refine their designs more quickly and efficiently.

2.1.3. How VR is Expanding the Art Toolscape

When it comes to tools, VR is still relatively new, and the options available to artists and designers are limited. VR tools are more expensive than traditional 2D or 3D software. This is due to the advanced technology required to create and support the immersive VR experience. The specialized hardware, such as VR headsets and motion controllers, along with the software development involved, contribute to the higher cost of these tools. However, as VR continues to gain traction and attract more practitioners, the demand for VR tools is increasing, which is expected to drive innovation and the development of more affordable options in the future.

As the VR art world continues to grow and more artists and designers embrace this medium, an increasing number of tools are becoming available to support their creative endeavors. Notably, there are already existing tools that cater to VR art, such as Google Tilt Brush, which provides artists and designers with the ability to create within a VR environment.Or Gravity Sketch is a 3D creation tool specifically designed for manipulating and creating models in the VR space.

Creating art in VR presents unique considerations for artists and designers, as it offers an immersive experience for the viewer. Factors like movement and perspective play significant roles in crafting VR artworks, and creators must carefully consider these aspects to enhance the viewer's experience. Furthermore, VR art is often a collaborative process, requiring designers to collaborate with programmers and developers to create technically and aesthetically compelling VR experiences. This collaboration ensures that the VR artworks meet both the artistic vision and the technical requirements for a seamless and engaging user experience.

2.1.4.Using VR in the Design Process[12]

Virtual Reality (VR) has been around for quite some time, but it is still perceived by many as a novelty or gimmick. However, VR has unique abilities beyond traditional design tools. It provides spatial interaction, full-body inputs, real sense of scale, and telepresence. VR can help interaction designers experiment with new designs, and it can help architects and designers test out their designs at scale.

Using virtual reality (VR) in the design process faces various challenges, despite its potential. Designers may encounter difficulties in getting started, find it overly complex, or lack the necessary technical skills. Additionally, some designers may view VR solely as a gaming tool and dismiss it as a passing trend.

[12] Matt Schaefer, VR as a design tool, http://www.mattschaeferdesign.com/designing-in-vr

Fortunately, numerous tools and resources exist to help designers overcome these obstacles. For instance, Unity provides built-in tutorials that enable designers to learn directly within the software itself.

To inspire designers to explore VR and incorporate it into their repertoire of tools, here are some imaginative examples of utilizing VR in the design process.:

2.1.4.1.Spatial Design

VR sketching is a great example of how VR can be used in spatial design. With VR, designers can create sketches in 3D and have clients and team members experience it at scale.

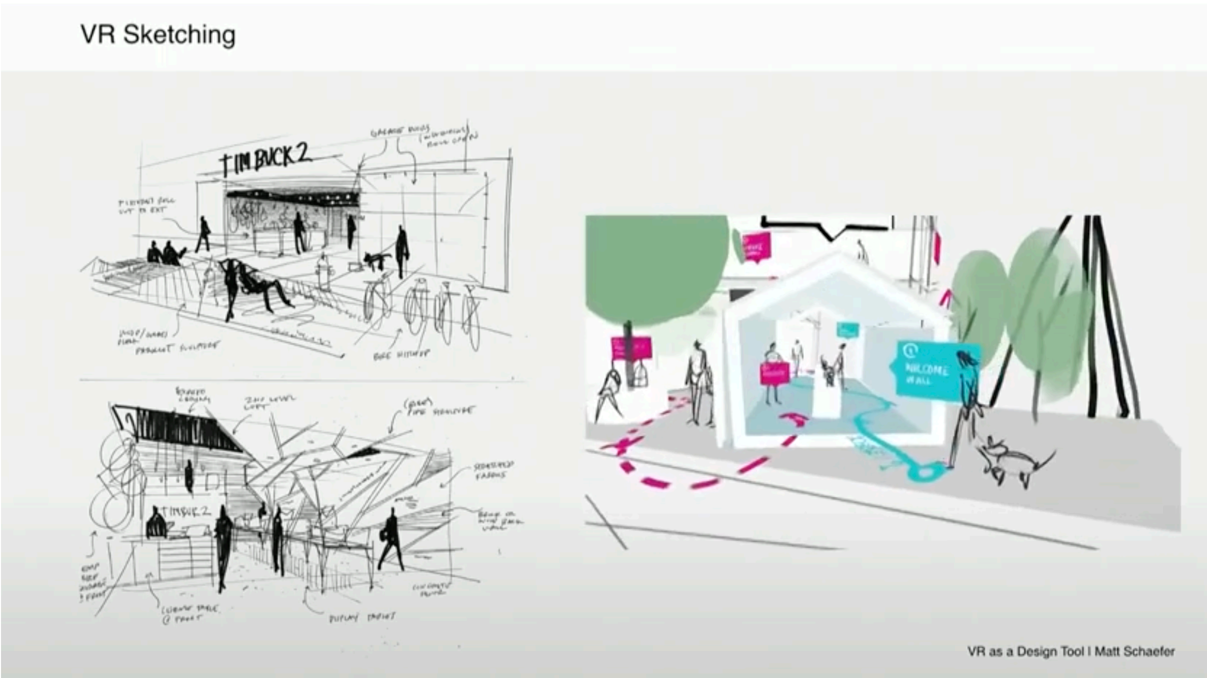


Figure 26. Sketching in VR Copyright Matt Schaefer

VR sketching takes some practice, but with the added benefit of having a 3D artifact, designers can use their sketches to communicate their vision more effectively.

Sketching in VR requires a comparable amount of time to sketching on paper, but the notable benefit is the creation of a 3D artifact. Consequently, the design can be easily shared with clients or team members, enabling them to engage in an immersive experience. They can experience the design at full scale or reduce it to a smaller model size.

An additional illustration of spatial design involves employing conventional tools such as SketchUp to explore fixture concepts for clients, then by utilizing tools like Inkscape, designers can effortlessly transition into VR and instantly immerse themselves in their designs at their intended scale.

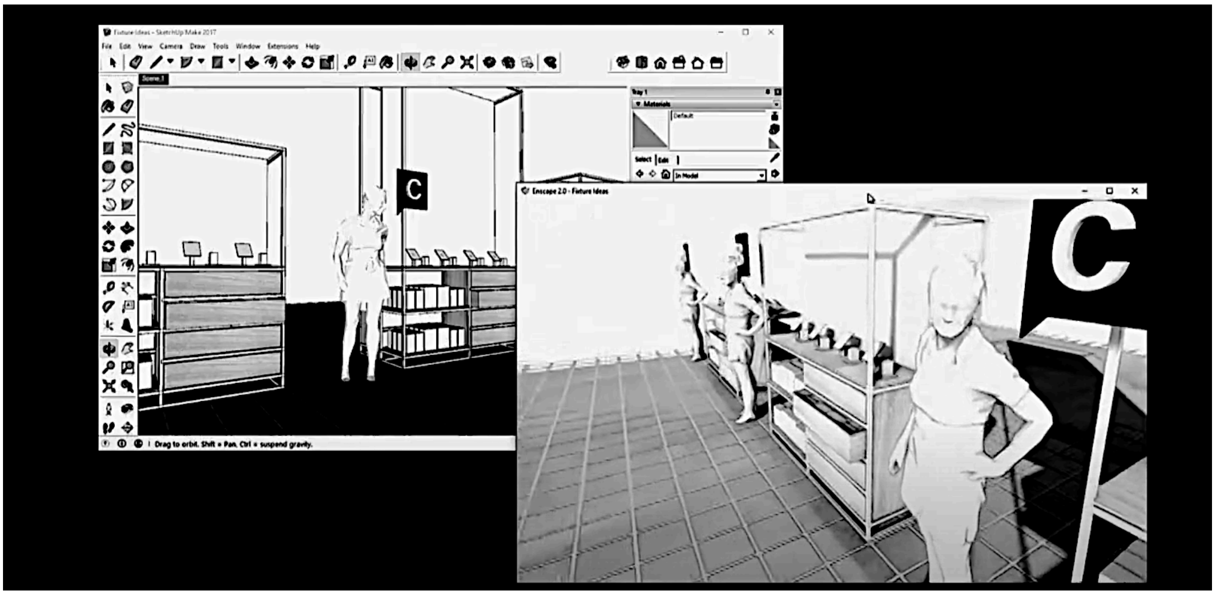


Figure 27: Conventional Sketching in SketchUp (Left) and an Immersive VR Version of it Created by Inkscape (Right), that Allow Users to Navigate freely within the Scene.

2.1.4.2.Interaction Design

VR provides designers with full-body inputs, allowing them to experiment with new interaction designs. For example, designers can use VR to create distraction devices for burn patients. The device takes over the patient's sight and sound, providing a bit of distraction during painful procedures. VR can also be used to create empathy and help designers understand how users interact with their designs.

2.1.4.3.Animation and Storytelling

VR can also be used to create immersive animations and stories. For example, designers can use VR to create a virtual tour of a building or a walk-through of a design concept. VR can provide an immersive experience that is not possible with traditional tools.

One of the main benefits of utilizing virtual reality as a tool in animation is the ability to transition from a state-based animation style, which involves setting up key frames, to a performance-based approach that is more similar to puppeteering. This is due to the abundance of inputs available to the animator. It is recommended that animators take full advantage of this feature.

Furthermore, it should be noted that the technology of virtual reality is inherently enjoyable, and it is advised that individuals experiment and have fun with the technology while exploring its capabilities. As an example, in the Quill application, layers or folders can be manipulated using hand gestures, allowing the artist to spatially check where strokes land while painting.

2.2.State of the Art: Inspiring Case Studies

In this section, I examine the current animation landscape by studying existing works that employ techniques similar to those I plan to use for my thesis project. Impressive animations like "The Black Pharaoh" and "Lunch Break" highlight the distinctive visual and technical aspects of a particular artistic style. Additionally, series such as "Remedy" and "Nightmara" showcase the wide array of creative possibilities within this animation style. Through the study of these animations, I gained valuable insights and developed a comprehensive understanding of the unique qualities and potential of this style. This aided me in refining my own thesis project and served as a source of inspiration.

2.2.1.Case I: "Four Stories"

Nick Ladd created a film named "Four Stories" based on the characters they had previously designed. The film was unique in the sense that it did not happen around the viewer in 360 degrees but instead occurred in front of the viewer, emphasizing the sixth dimension of VR: the ability to walk around.

Figure 28. VR animation FourStories made by Nick Ladd

In this VR experience, multiple scenes featuring the same story unfold simultaneously, creating a unique viewing opportunity. All four movies play concurrently, overlapping one another within the VR environment.

The building in the film was designed in a way that each wall was storyboarded separately, resulting in four full-length storyboards. There are Four main colors in the building red, green, yellow and blue. Each Story represented by a different color.

Figure 29. Building of The FourStories Animation

These four stories were specifically designed from the ground up to be a VR experience. Spatial VR sketching was employed to provide the designer with an understanding of where and how viewers would perceive the stories.

Figure 30. VR Sketching for FourStories. Storyboard by Marty Martin

Although the overall duration is approximately three minutes, the length is effectively extended because each of the four stories stands independently. Therefore, watching all four stories four times results in a 12-minute narrative.

The VR experience encompasses seven main characters and around 15 side/background characters, bringing depth and richness to the storytelling.

Figure 31. The main characters of FourStories made by Nick Ladd

The audio production for the four stories presented an intriguing challenge. The aim was to maintain the simultaneous presentation of all four stories while ensuring that the audio from other storylines did not disrupt the focus on a specific scene. To tackle this, spatial audio columns were implemented. These columns provide viewers with audio that is tailored to the area they are currently observing, creating an immersive experience without audio distractions from other parts of the story.

2.2.2.Case II: The Black Pharaoh

"The Black Pharaoh" is a VR animation for Oculus, created by artist Wenkai Wang, that shares similarities with my project in reviving historical atmospheres and utilizing innovative techniques.

Figure 32. A comparison between the size of Viewer (same as Slaves) and the The Black Pharaoh

In this VR experience, viewers are immersed in a dimly lit environment, encountering a slave kneeling on the ground, evoking empathy and historical context. As they explore, a 360-degree turn reveals a grand staircase with slaves, highlighting the era's hierarchy and vastness. However, the focal point lies ahead, where a towering black pharaoh commands divine authority with outstretched arms. These meticulously designed elements transport viewers to a significant moment in ancient Egypt, engaging them in the historical ambiance.

The viewer is equipped with a menu accessible through their right hand. The menu provides a brief description of the animation and offers six different perspectives to navigate and explore the 3D space, allowing the viewer to observe the scene from various angles.

Figure 33. The Black Pharaoh menu to select different perspectives

One unique perspective simulates following a trail as the camera smoothly arcs from right to left, covering a 180-degree range. It offers viewers a sweeping, panoramic view of the scene, capturing its grandeur and scale. By selecting this perspective, viewers gain a comprehensive understanding of the layout, appreciating details and spatial relationships, enhancing immersion for a captivating experience within the virtual environment.

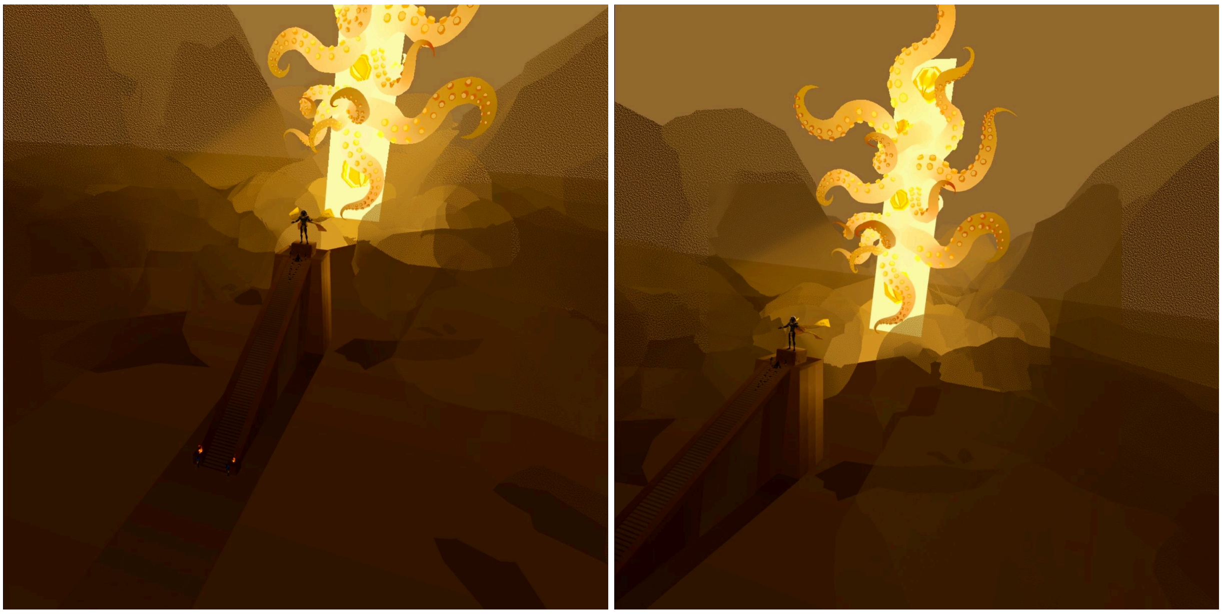


Figure 34. Special Point of View: as the camera smoothly moves from right to left, intricate details and spatial relationships of the animation would be discovered

Speaking of the animation aspect of this product, it is quite intriguing. While everything remains static, using only three dynamic elements brings everything to life: the viewer, the tentacles & eyes of the octopus creature behind the big Pharaoh, and the simulated wind of the Sahara.

Figure 35. Different Point of View in the VR animation the Black Pharaoh

Additionally, the music is designed to dynamically enhance the immersion. When selecting a perspective closer to the Pharaoh and the monk, their speeches become more distinct and clear, enriching the overall experience.

Figure 36. the VR animation the Black Pharaoh: Moving monster behind the massive temple

3. Chapter III.

3.1.Virtual Reality Animation

3.1.1.Virtual Reality Technology and its Applications

VR animation combines VR technology with animated content to create an immersive and interactive experience for the audience. Using VR headsets and handheld controllers, viewers can explore virtual environments, interact with objects and characters, and engage in a dynamic and stimulating experience. This technology enables a deeper level of engagement, allowing users to navigate and manipulate elements within the virtual world, resulting in a highly interactive and captivating encounter.

3.1.2.3D Animation Techniques in Virtual Reality

To create VR animation, a technical process is employed, which combines conventional animation approaches and specialized VR software.

Initially, animators utilize 3D modeling software to construct the characters and objects present in the virtual environment. Thereafter, the animation is programmed to react to the viewers' interactions, necessitating the use of specialized coding and programming expertise. Finally, the animation is rendered in real-time, facilitating uninterrupted viewer engagement and interaction within the virtual setting.

VR animation offers a significant benefit by creation of an entirely immersive experience for the audience. This is achievable by providing an opportunity for the viewers to enter and interact with the virtual environment, which creates a sense of engagement and presence that is unachievable through traditional animation. Therefore, VR animation provides greater freedom and interactivity to the viewers, as they can explore and manipulate the objects present in the animation according to their own pace and direction.

3.1.3.VR Storytelling

VR animation storytelling is a form of storytelling that uses VR technology to create immersive and interactive narratives. This technology combines traditional animation techniques with specialized VR software, allowing creators to create virtual environments that audiences can enter and interact with. Unlike traditional storytelling methods, VR animation storytelling offers a unique level of engagement and interactivity, allowing audiences to become part of the story rather than just passive observers.

VR animation lies in its potential to facilitate storytelling. Through the creation of a wholly immersive and interactive environment, animators can generate a more captivating and memorable narrative that captivates viewers and allows them to experience it in a more intimate and emotional manner. Moreover, this technology can be utilized to produce educational and training materials that offer learners a more practical and interactive experience.

There are numerous examples of VR animation storytelling, ranging from short films to full-length feature films. For instance, "Invasion!" by Baobab Studios tells the story of a pair of aliens who land on Earth with the intention of taking over the planet. The film uses VR technology to allow viewers to enter and explore the aliens' spaceship, interact with the characters, and witness the invasion firsthand.

VR animation storytelling is revolutionizing the way we tell stories by offering audiences a unique and immersive experience that transports them to different worlds, timelines, and realities. By creating virtual environments that audiences can enter and interact with, VR animation storytelling creates a sense of presence and engagement that is not possible with traditional storytelling methods.

3.1.4. The Challenges and Opportunities in VR Animation Production

One of the major advantages of VR animation storytelling is its ability to create a fully immersive experience for audiences. By enabling audiences to enter and interact with the virtual environment, VR animation storytelling creates a sense of presence and engagement that is not possible with traditional storytelling. This technology allows creators to create a more engaging and memorable narrative that draws audiences into the story and allows them to experience it in a more personal and emotional way.

VR animation storytelling also offers a greater degree of freedom and interactivity to audiences. Viewers can explore and manipulate objects within the animation at their own pace and direction, which allows them to interact with the story and make choices that affect the outcome. This creates a more personalized experience that can be tailored to the viewer's preferences, allowing them to take ownership of the story and become more invested in it.

In addition to entertainment, VR animation storytelling has the potential to be used for educational and training purposes. This technology can be used to create simulations that allow learners to practice real-world scenarios in a safe and controlled environment. This provides a more hands-on and interactive experience for learners, which can improve their understanding and retention of the material.

Animating for VR presents a significant challenge in designing for 360-degree environments. Unlike traditional animation, VR allows viewers to move and interact within the environment, requiring animators to consider the viewer's perspective from all angles. They must also account for different lighting conditions, viewer positions, and movements. This demands careful planning and attention to detail to create a seamless and immersive experience.[13]

Animating for VR presents the challenge of incorporating interactive elements that enable viewers to actively participate in the virtual environment. These interactive elements can

13 Hound Studio. (2023). Animating for virtual reality challenges and opportunities. Retrieved from https://hound-studio.com/blog/animating-for-virtual-reality-challenges-and-opportunities/

range from manipulable objects to doors that can be opened or levers that can be activated. To accomplish this, animators must possess programming proficiency in C# or JavaScript.

Animating for VR necessitates optimizing graphics for high-performance devices, as VR demands realistic and immersive visuals. However, this poses a challenge for low-end devices that may struggle with processing power. To address this, animators employ techniques like LOD and culling to reduce the processing requirements of the animation, ensuring smooth performance across all devices. For instance, when designing a VR experience for mobile devices, animators must optimize graphics by minimizing polygons and textures, and utilizing LOD and culling techniques to enhance performance.

3.2.Softwares

3.2.1.VR Modeling Tools: A Comparison

After determining the focus of my thesis, I conducted a brief research to identify the most suitable tool for the task. Several popular options for VR modeling and animation software were considered, including Masterpiece X, Tilt Brush, Gravity Sketch, Adobe Medium, Blocks by Google, and Quill VR. These software choices provide users with the capability to create and manipulate 3D models and animations within a virtual environment.

Masterpiece X is a paid VR modeling and animation software that offers a wide range of tools for creating intricate 3D models and animations. It is highly regarded for its advanced sculpting features, allowing users to create highly detailed models. However, its cost acted as a limitation that deterred me from selecting it.

Tilt Brush on the other hand, is a 3D painting tool designed for creating virtual reality artworks. It provides a variety of brushes and effects that enable users to produce stunning visual pieces. Nonetheless, it primarily focuses on painting and lacks some of the features present in other modeling and animation software.

Gravity Sketch stands out as a high-fidelity VR modeling and sketching tool, offering users the ability to create intricate 3D models using intuitive gestures. It particularly excels in industrial design, allowing designers to swiftly outline concepts and bring them to life within a three-dimensional space. While it is highly suited for automotive design, it has also gained popularity in fields like footwear, furniture, and entertainment art/design. However, due to its complexity, it was not the ideal choice for beginners like myself.

Adobe Medium is a sculpting tool that empowers users to create organic shapes and sculptures. It provides a diverse range of brushes and effects for crafting intricate designs. I decided against choosing Adobe Medium primarily because it is a paid sculpting tool dedicated to organic shapes and sculptures.

Blocks by Google is a straightforward 3D modeling tool that enables users to create 3D objects using simple shapes. It is particularly useful for quickly generating simple models but lacks the advanced features found in other modeling and animation software. Despite no longer being supported by Google, it remains a great option for low-fidelity, low-polygon VR modeling, especially for artists, designers, and developers working in the mobile VR realm. I did not select Blocks by Google due to its limited suitability for complex projects.

Quill VR is a comprehensive 3D painting and animation tool that allows users to create VR experiences. It is renowned for its robust toolset and user-friendly interface, enabling the creation of complex scenes and animations with ease. Compared to its competitors, Quill VR offers a unique feature set and is free to use, making it an ideal option for beginners or those with budget constraints. Quill is not just a tool; it encompasses an entire system for VR creation and consumption. As for my preferred choice, based on my past experience, I opted for Quill VR.

To summarize, the following is a breakdown of the advantages and disadvantages of the non-VR 3D creation tool (Maya), followed by the new tool explored in this research(Tilt Brush), and the Quill VR.[14]

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[14] Bandodkar, P. (2020, June 29). Comparing tools. Retrieved from https://priyaindependentstudy.wordpress.-com/2020/06/29/comparing-tools/

	Tilt Brush	Quill	Autodesk Maya (Non-VR 3D)
3D Space	Very intuitive	Very intuitive	Not intuitive
Modelling	Very useful	Very useful	Time-consuming
Texturing	Basic solid color shaders, useful for 2D cartoony aesthetics	Basic solid color shaders, useful for 2D cartoony aesthetics	Complex texture maps, material shaders, image and video textures property adjustments
Lighting	Basic lighting with shadow, fog effect, gradient sky	No lighting, for or gradience for sky	Complex lighting controls
Animation	No dedicated options for animation, some brush strokes have movement like wiggles, but very limited	Dedicated timeline for animating basic characters, useful for creating fluidic animation using animated brush strokes	Complex controls for creating high-quality animation. Not useful to create 3D animated brush strokes
Transform Tool	No tools for transforming objects	Can select objects and use the transform gizmo to move, rotate, scale objects in 3D	Can select objects and use the transform gizmo to move, rotate, scale objects in 3D
Opacity Tool	No options for adjusting mesh opacity	Has options for creating mesh by changing opacity	Mesh opacity can be changed using material properties in "Hypershade"
Blending Modes	No options for blending modes	Has the blending brushes (which work like blending modes in Photoshop)	No options for blending modes. This needs to be done manually by editing the texture file.
Rendering time	Real-time viewing and rendering, quick snapshot tools	Real-time viewing and rendering, quick tools to capture snapshots and videos	Rendering is a separate, time-consuming activity, but can create high-quality, realistic output

Comparison of 3D Softwares

3.2.2.Evaluating Quill VR Against its Competitors

The comparison between Quill and other 3D modeling software highlights some notable differences in workflow and capabilities. Quill VR surpasses its competitors in the realm of 3D modeling software. It offers more advanced animation capabilities and a larger user community than Masterpiece X. Compared to Tilt Brush, Quill VR provides precise control over object creation and animation. It also outshines Gravity Sketch with a wider range of brush options and an intuitive interface. Quill VR's simpler workflow makes it accessible to beginners, unlike Adobe Medium. Additionally, it offers more advanced animation features and a larger library of pre-made assets compared to Blocks by Google. Quill VR stands out as the superior choice in terms of workflow and capabilities.

While Quill offers rapid and intuitive modeling and animation tools, it falls short in terms of shading and shadows. In contrast, software like Maya and Cinema4D may be slower in modeling and animation of organic forms, but excels in rendering shading and shadows, allowing for dynamic lighting.These differences in software capabilities can be attributed to the underlying algorithms and programming techniques used. Quill prioritizes the use of hand gestures for modeling, allowing for more organic shapes to be created with ease. However, in order to create realistic shading and shadows, the user must have a deep understanding of painting techniques and how light interacts with objects in a scene. Conversely, Maya relies on more complex algorithms to render shading and shadows, but lacks the intuitive hand gesture modeling of Quill.

Ultimately, combining the strengths of both software could lead to a more efficient and effective workflow for 3D modeling and animation. This approach could lead to a solution that is both easy to model and animate, as well as to render with dynamic lighting. This approach would be briefly mentioned in the further chapters.

3.3.Quill VR

3.3.1.Quill VR: Functionalities

Quill VR[15] is a virtual reality painting and animation tool that was created by Oculus Story Studio, a subsidiary of Facebook's virtual reality company, Oculus. Oculus Story Studio was founded in 2014 and was responsible for creating award-winning VR content. Quill was developed in-house as a tool for creating animations for the Story Studio's own VR films.

In 2017, Facebook announced that it was shutting down Oculus Story Studio, leading to the discontinuation of their VR content and Quill being spun off into a separate entity. Quill VR was then made available to the public for free in 2018.[16]

Since its release, Quill VR has been used to create a variety of VR experiences, including short films, interactive stories, and video game cutscenes. One notable example is "Dear Angelica," a short film created entirely in Quill VR that premiered at the Sundance Film Festival in 2017. Another example is "The Remedy," a VR experience that allows users to explore a magical forest and interact with various creatures.

Quill VR is a software developed for creating 3D illustrations, animations, and virtual environments in virtual reality. Its most notable feature is its ability to create 3D animations and paintings entirely within a virtual space, using virtual "brushes" and "inks." This software offers a range of features such as painting, sculpting, and animation, enabling users to work intuitively in a 3D space. It is a valuable tool for artists, animators, and game developers who can manipulate objects in a virtual reality environment with various brushes, colors, and effects. It requires VR headsets and motion controllers for an immersive experience.[17]

Quill VR has become popular among artists, designers, and filmmakers for producing various VR content, such as music videos, short films, and immersive experiences. In addition, the

[15] Quill. (n.d.). About Quill. https://quill.fb.com/about/

[16] Facebook. (2017). An Update on Oculus Story Studio. Facebook Media. Retrieved from https://www.facebook.com/fbmedia/blog/an-update-on-oculus-story-studio

[17] Matt Schaefer, Getting Started with Quill, H2 2022.

tool has found its application in education, where it is used to create interactive 3D environments for learning. The software has also been utilized in various fields, including game development, architecture, and product design, demonstrating its versatility and potential in different industries.

Quill VR is a groundbreaking technology that leverages the potential of VR to offer new and innovative ways of creating and experiencing visual content. With its intuitive interface and advanced features, users can explore their creative potential and bring their ideas to life in a virtual environment. Its compatibility with VR headsets and motion controllers enables users to create and manipulate objects with their own hands, resulting in a more engaging and interactive experience.

Overall, Quill VR is a powerful tool that provides new opportunities for creativity and exploration in the realm of virtual reality. Its range of features and tools provide flexibility and freedom for users to experiment and create unique and engaging content. Its potential applications in education and other fields make it a valuable tool for creating interactive and engaging experiences that enhance learning and communication.

3.3.2.Quill VR: Features[18]

Quill has been specifically designed to cater to the needs of artists, prioritizing intuitive usability, expressive capabilities, and long-term comfort during usage. It is equipped to handle large-scale drawings and animations that are typically found in professional animation studios. To utilize Quill, users require a PC such as a laptop, desktop, or workstation, and a VR headset such as Oculus Rift, Rift S, or Quest 2 with Oculus Link or a compatible cable.

Some of the most important features of the Quill are explained below:

3.3.2.1.Layers

Quill offers robust support for complex layer hierarchies, enabling artists to maintain organization within their illustrations.

[18] https://quill.art/features.html

3.3.2.2.Handling Extremely Large Files

Quill is specifically engineered to efficiently handle large paintings with millions of strokes, ensuring quick and seamless loading times.

3.3.2.3.Animation Support

Quill provides diverse animation approaches, including frame-by-frame, keyframe, anim brush, and puppeteering techniques. These powerful tools and workflows empower artists to shape the look and feel of their animations without the need for traditional CG technical knowledge, such as rigging or curve manipulation.

3.3.2.4.Production Pipeline Support

In addition to flexible layer scoping and extensive data file support, Quill seamlessly integrates into production pipelines through exports to USD, Alembic, and FBX file formats. These exports can be imported into software such as Maya, Houdini, or even Photoshop. Quill also offers example materials for integration with Unity and Unreal Engine. Moreover, a standalone and highly efficient Quill viewer is provided for streamlined asset debugging.

3.3.2.5.Infinite and Precise Canvas

Quill enables the creation of vast and intricate illustrations, allowing artists to draw and construct entire production worlds or game levels without any compromise in precision. In fact, Quill allows users to draw real-scale versions of the solar system with sub-millimeter accuracy, thanks to its powerful internal layer nesting system.

3.3.2.6.Spatial Audio Support

Quill supports the import of WAV, MP3, and Ambisonic sound files, which can be utilized as stereo or spatial audio sources. The software incorporates sphere, cone, and frustum-based spatial audio emitters.

3.3.2.7.Flexible Erasers, Colorizers, and Adjustment Tools

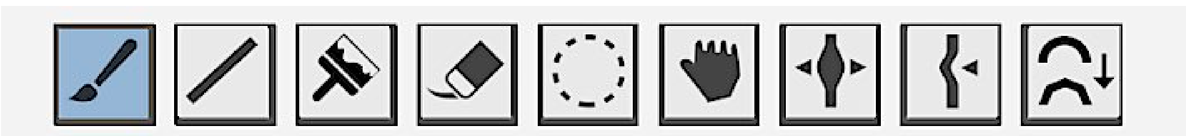
Quill offers convenient tools for modifying drawings and strokes after they have been created. These features are optimized for fast iteration and facilitate the creative process.

3.3.2.8.Maximum Image Quality

Quill places utmost emphasis on image quality, implementing cutting-edge technology to ensure the smoothest and most refined paint strokes possible. This includes advanced antialiasing techniques and precise handling of transparencies.

3.3.3.Quill VR: Interface

3.3.3.1.Tools



The available tools include Paint, Line, Colorize, Erase, Selection, Thicken/Thin, Nudge, Grab, and Optimize.

To adjust the size of the tool, we can utilize the joystick on the dominant hand, moving it up

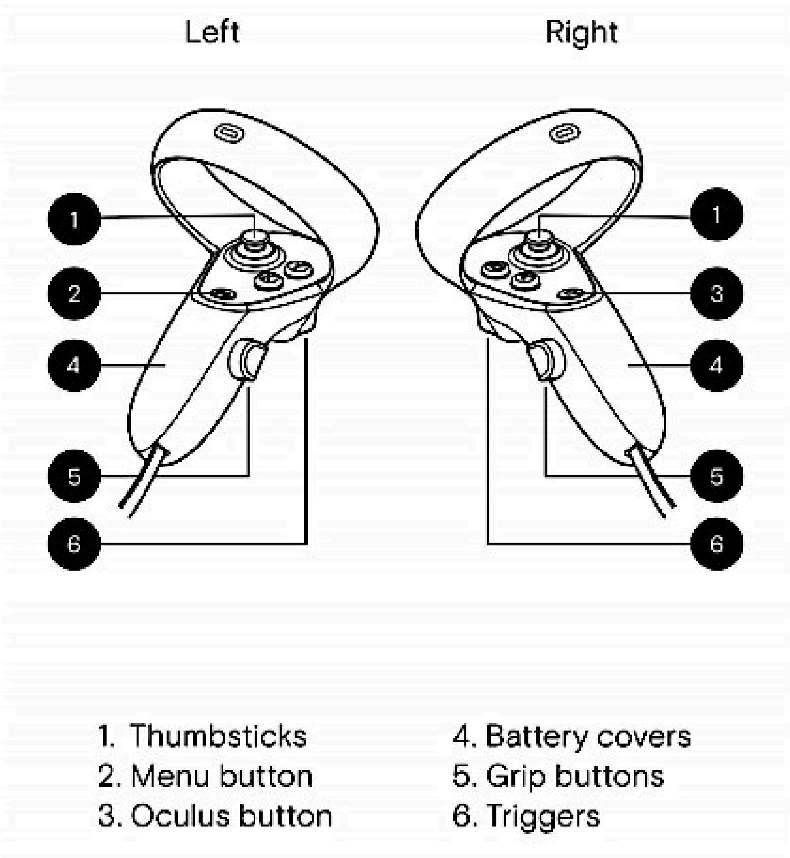


Figure 37. The Oculus Quest Controllers

or down. The joystick on our dominant hand can also be used to perform undo/redo actions by moving it left or right.

Depending on the selected tool, the tool preview on the dominant hand will dynamically change when we are not interacting with the user interface. Drawing tools will display a brush preview, while other tools will show a sphere of influence preview.

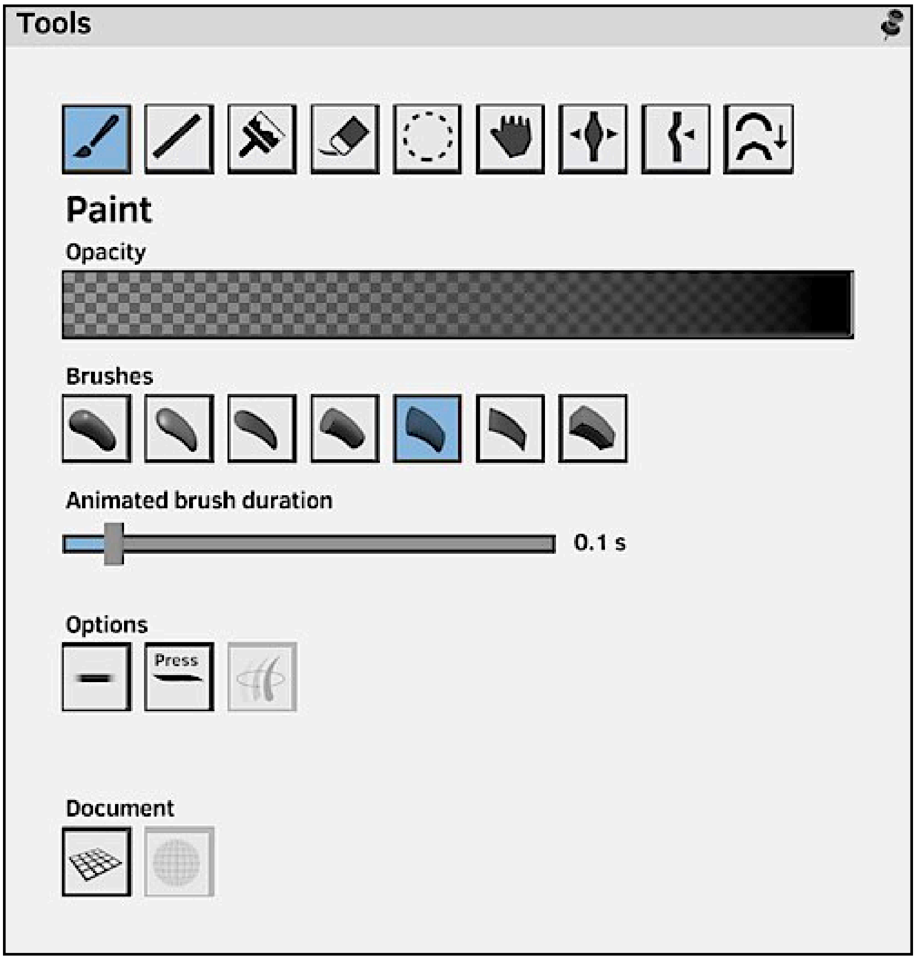
- To activate a tool, we can press and hold the index trigger on the dominant hand. We can optionally modulate the pressure as we use the tool until we completely release the index trigger.

- To quickly delete a stroke, we can position our dominant hand near it and press the lower button (A or X) on our dominant hand. If we have an active selection, pressing the same button will delete the selected area.

- To swiftly select the color of an existing stroke using the eye dropper function, we should press the upper button (B or Y) on our dominant hand. This color picking feature is also applicable to 2D image layers.

Painting Tool Panel

The Paint tool serves as the default option for creating strokes, and the Opacity bar allows us to adjust the transparency of the paint strokes.



The Brushes feature enables the selection of different brush types, including variations in shape (flat, round, square) and ends (rounded, flat).

By adjusting the Animated brush duration parameters, we can control the behavior of the animation brush while drawing during clip playback.

The Taper options grant us, control over the transparency and thickness of the stroke. The Press option allows the parameter to be regulated by the pressure applied to the index trigger, while the Auto option automatically applies tapering at both ends of the stroke. The directional visibility option fades out the stroke as the viewing angle deviates from the angle at which the stroke was drawn.

Under the Document section, there are toggles available for the floor grid guide overlay, which assists with alignment, and the brush grid helper that aids in perceiving depth by rendering a grid pattern on strokes near the tool.

When using the Paint tool, we can temporarily switch to the Line tool by holding ALT (the index trigger on the non-dominant hand).

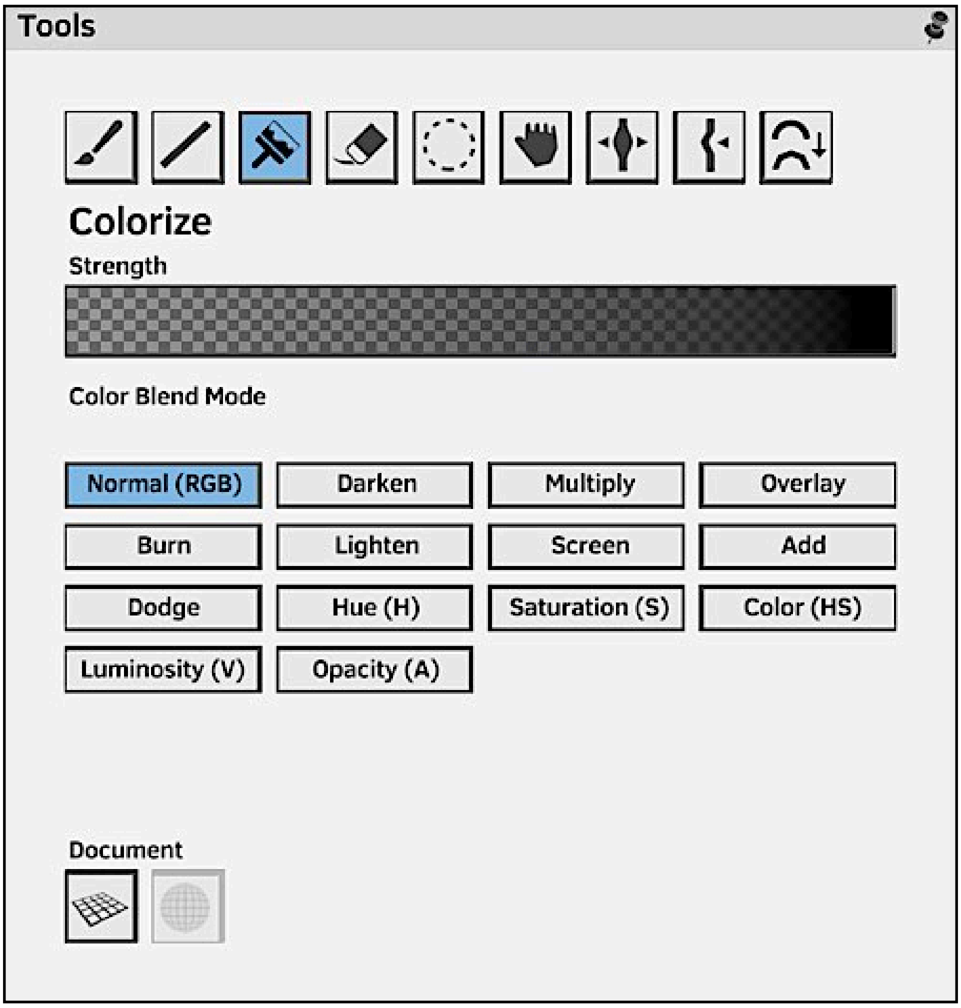
Line Tools

The Straight Line tool facilitates the creation of straight lines by allowing us to draw them between two specified points. When utilizing the Line tool, holding ALT enables the lines to snap to the grid axes, ensuring precision in alignment.

Colorize Tool Panel

The Colorize tool allows for the adjustment of stroke colors by employing different blend modes to blend the currently selected color with the existing stroke color.

Within the Colorize tool, there are two spheres of influence: an inner "hard" sphere and an outer "soft" sphere. By holding ALT and using the joystick of the dominant hand, we can modify the size of the inner sphere. When ALT is not held, both spheres can be modified simultaneously.

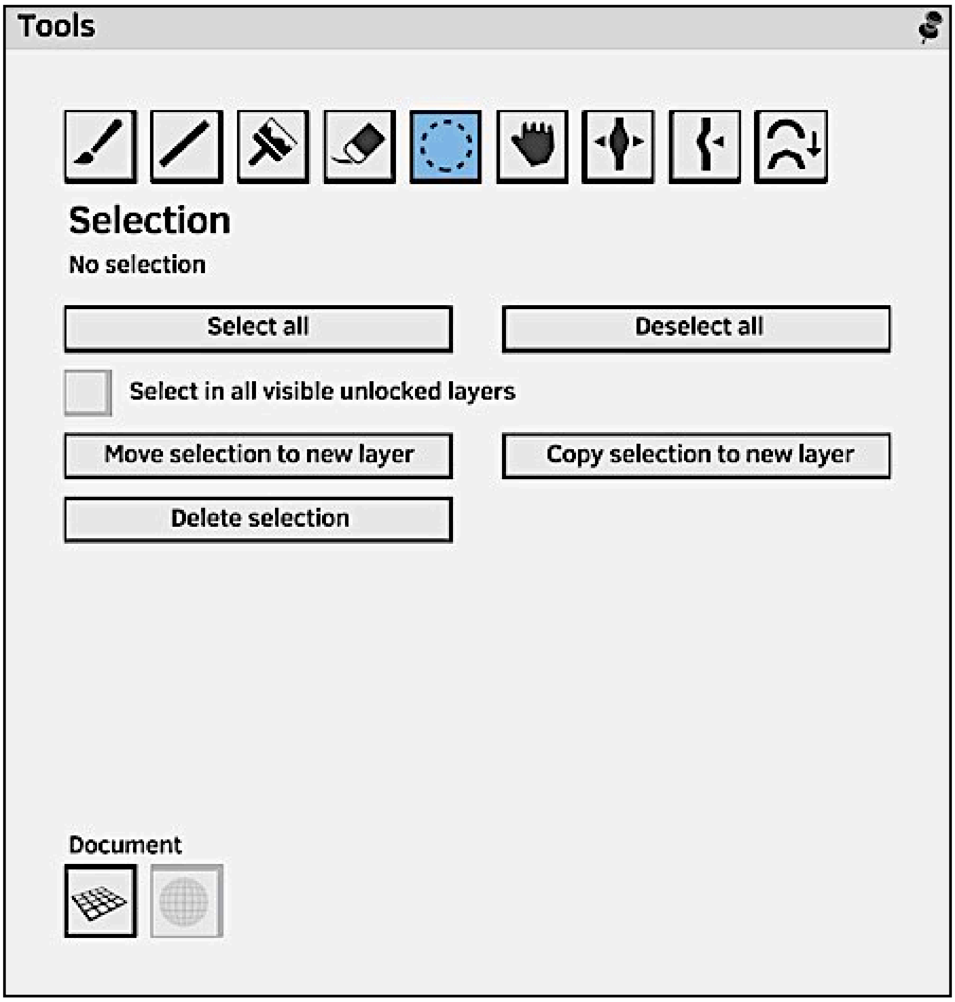


Eraser Tool

The Eraser tool is utilized to render certain portions of a stroke invisible by adjusting the opacity of stroke points. When an entire stroke has been erased, it is completely removed from the drawing. Alternatively, strokes can be restored ("un-erased") by utilizing the Colorize tool with the Opacity blend mode.

Panel for Selection Tool

The Selection tool enables users to select specific strokes for manipulation or to restrict the actions of other tools solely to the selected strokes. To quickly switch between the current tool and the selection tool, press the lower button on your non-dominant hand (X or A).



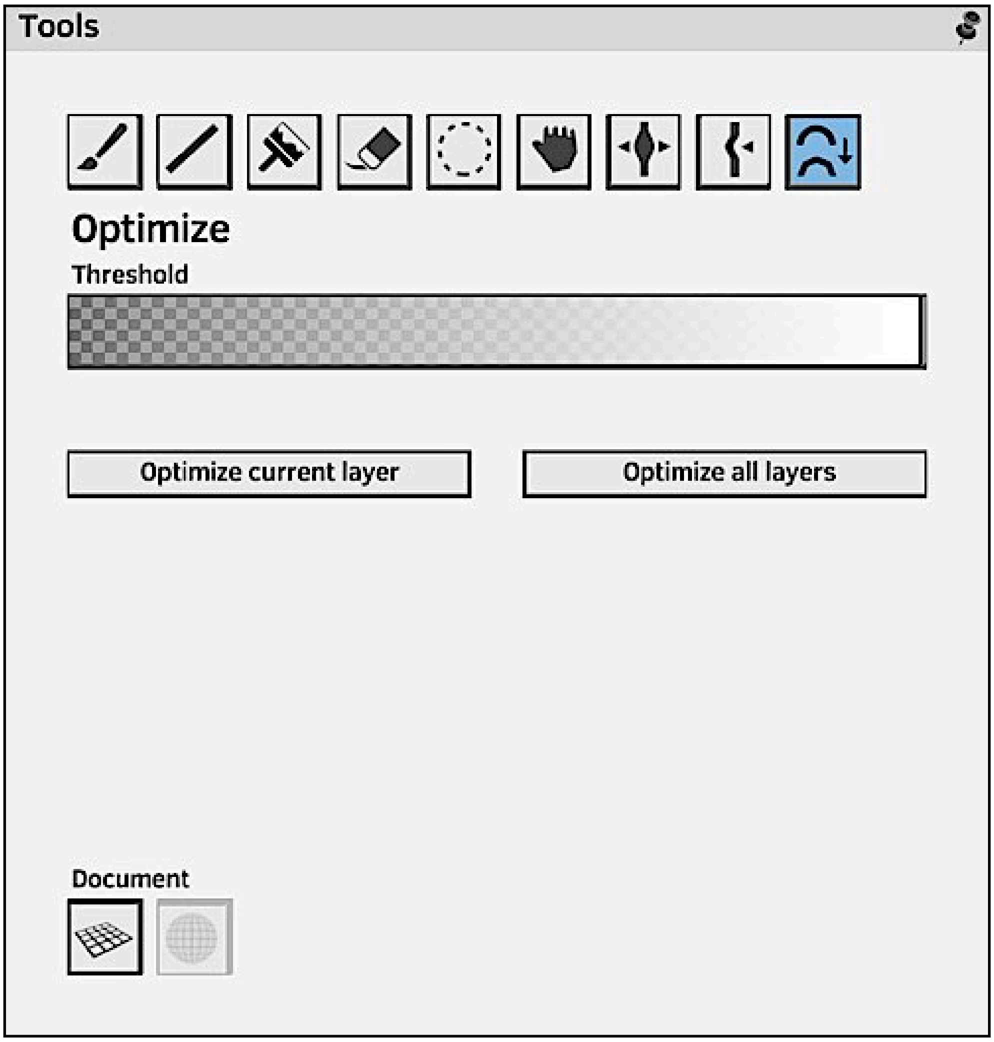
The selection is visually indicated in the drawing by a gradual fading in and out effect. The Tools panel displays the number of strokes currently selected.

- Press and hold the ALT key to remove strokes from the selection completely, or press and partially hold the ALT key to add strokes to the selection. By default, each new trigger press initiates a new selection.

- Once a selection is active, it can be directly grabbed or manipulated using the gimbal controls.

- To duplicate the transformation of the selection, hold the ALT key while performing a transform.

- Using the Redo function (dominant hand joystick right) or the "Transform Again" option in the transform toolbox will replicate the previous duplicate transform action.



The toolbox offers additional options for working with selections, such as selecting all strokes in the current layer, deselecting all strokes, moving the selection to a new layer, copying the selection to a new layer, or deleting the selection. Furthermore, the dominant hand lower button (A or X) can be used to delete the selection. The "Select in all visible unlocked layers" feature allows for selecting strokes across multiple layers simultaneously. Additionally, strokes can be selected in multiple frames by navigating through frames or playing animations while using the selection tool.

Grab Tool

The Grab tool enables direct manipulation of strokes with a softer influence that extends outward from the center, resulting in elastic deformations. This tool consists of an inner and outer sphere of influence. Within the inner sphere, the influence is at its maximum, allowing for precise manipulation. As the boundary reaches the outer sphere, the influence gradually diminishes to zero. When resizing the tool, both the inner and outer spheres are resized simultaneously. However, by holding the ALT key while resizing, we can specifically control the size of the inner sphere.

Thicken & Thin Tool

The Thicken & Thin tool provides the ability to locally increase or decrease the thickness of a stroke. By default, the tool thickens the stroke, but holding the ALT key will reverse its effect and thin the stroke instead.

Nudge Tool

The Nudge tool allows for the displacement of strokes based on the velocity of our hand movement. While it may offer slightly less precision compared to the Grab tool, it provides the opportunity to create diverse effects, particularly when used in conjunction with playing animations.

The Optimize Tool Panel

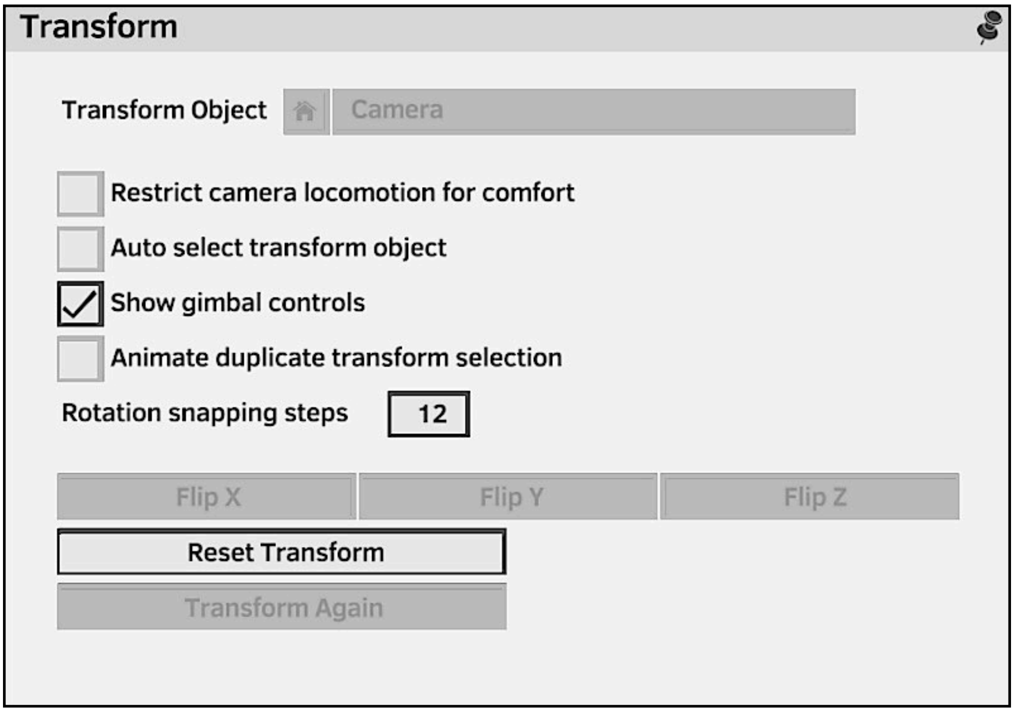
Optimize provides a means to streamline strokes by reducing the number of vertices through decimation. By adjusting the threshold parameter, users can control the extent of simplification applied. This tool offers two distinct options for optimization: direct stroke simplification within the document or utilizing the panel's buttons to optimize entire layers or the entire document.

3.3.3.2. Transform

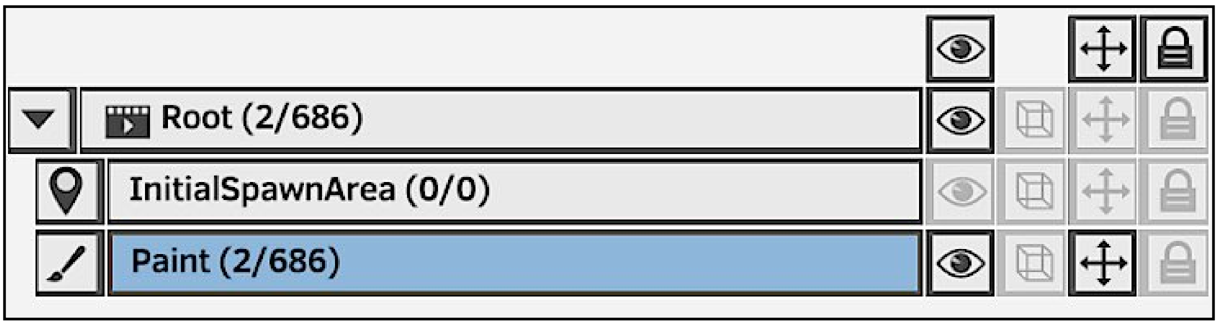
By default, when grabbing space with either or both controllers' grab buttons in Quill, the working camera is moved.

While either grab button is pressed, the joystick's up and down movement can be used to scale the transform. When both buttons are pressed, the scale is controlled by moving the hands apart or closer together. Utilizing both hands increases the precision of the transform.

If there are any comfort issues with the default transform mode, the option to activate "Restrict camera locomotion for comfort" in the Transform toolbox is available. This feature limits the rotation to the Y axis, providing a more comfortable experience.



To transform a layer instead of the camera, the user needs to select the layer for transformation by clicking on the icon with four arrows located next to the layer name.



Clicking the same icon again will disable the movement of that layer and revert back to moving the camera. In the top header row of the layers list, the transform button will be active if any layer is selected for transformation. Clicking that button will also return to transforming the working camera.

When the Auto select transform object mode is activated, it will automatically perform this action. When grabbing a layer stroke, the corresponding layer will be moved, while grabbing empty space will move the camera.

The transform object in the transform panel indicates which object is active for transformations. When a layer is selected for transformation, it can be flipped along the X, Y, or Z axis using the corresponding buttons. The camera cannot be flipped.

Reset transform will restore the transform for the layer or the camera to the default identity transform.

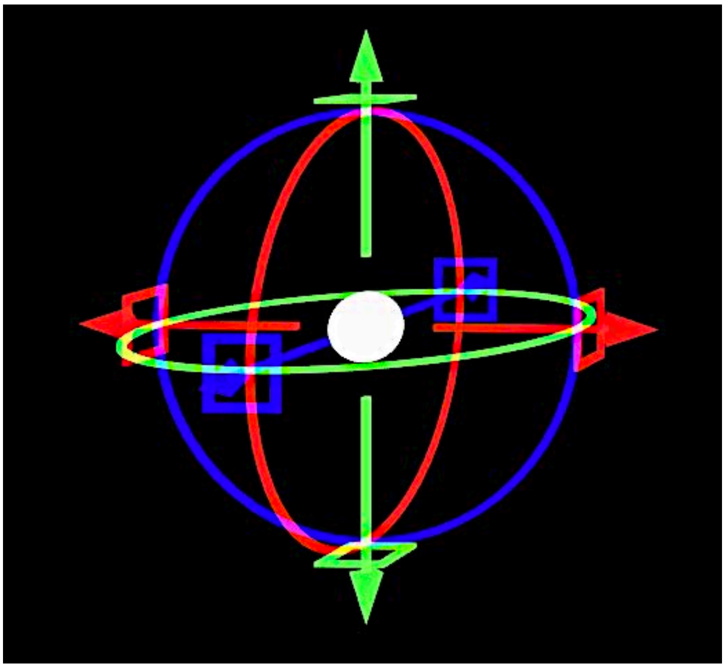


Figure 38. The Transformation Knob

When a layer is active for transformation or there is a selection, a gimbal manipulator will appear to allow transformations on a single axis. The display of the manipulator can be turned on or off with the Show gimbal controls option (shortcut: push down on the dominant hand joystick to toggle gimbal on/off).

Translation along either axis can be achieved by grabbing the corresponding axis arrow using the grab trigger. The pivot point, instead of the object, will be translated when the index trigger is used. The square handles enable translation in the corresponding planes.

Rotation on an axis can be performed by grabbing the corresponding circle using the grab trigger. If the index trigger is utilized, the rotation will be constrained to fixed steps determined by the Rotation snapping steps in the transform toolbox.

The central white sphere allows for free transform when the grab trigger is used, or free pivot transform when the index trigger is employed.

To duplicate and transform the content, hold ALT (the non-dominant hand index trigger) before and during the transformation. When transforming a layer, a new layer will be created, and when transforming the selection, new strokes will be generated. When duplicating or transforming the selection and utilizing the Transform Again/Redo feature, the Animate duplicate transform selection mode will generate a new animation frame with each repeated transform.

4. Chapter IV.

4.1.Pre-Production

4.1.1.Moodboard

By utilizing websites like Pinterest, I have been able to search for related reference photos and create several Moodboards. To organize the numerous reference photos, I utilized an application called "PureRef."

I have organized the moodboards into three main categories: the Macedonian Campaign, the Persian Campaign, and a Moodboard that depicts the confrontation between the two campaigns.

Within the Persian Campaign board, I have further divided it into three sub-moodboards: The warriors, the cavalry, and the chariots. These sub-moodboards allow me to gather specific visual references for each aspect of the Persian Campaign.

For the Macedonian Campaign, I have created three sub-moodboards: the Greek troops, the Alexander Close up, and the full-figure reference. Each of these sub-moodboards focuses on different aspects of the Macedonian Campaign, enabling me to gather detailed references for the Greek troops as well as specific references for Alexander himself.

In the third category, I have included two sub-moodboards to enhance my visual references. The first sub-moodboard focuses on capturing the confrontations between the two armies, illustrating the intense clashes and interactions between them during the battles. The second sub-moodboard is dedicated to equipment and costume details, enabling me to gather visual references for weapons, armor, essential items, as well as the costumes and attire utilized by the armies involved in both the Macedonian and Persian Campaigns.

MoodBoard 1: The Persian Campaign

Figure 39. The Persian Warriors

Figure 40. The Persian's Cavalry

Figure 41. The Persian's War Chariots

MoodBoard 2: The Macedonian Campaign

Figure 42. Close-Up of Macedonian's General (Alexander)

Figure 43. Full-body Depiction of Macedonian General

Figure 44. The Greek/Macedonian Troops

MoodBoard 3: The Clash of two campaigns

Figure 45. Macedonian VS Persians: different Perspective during the battle of Issus

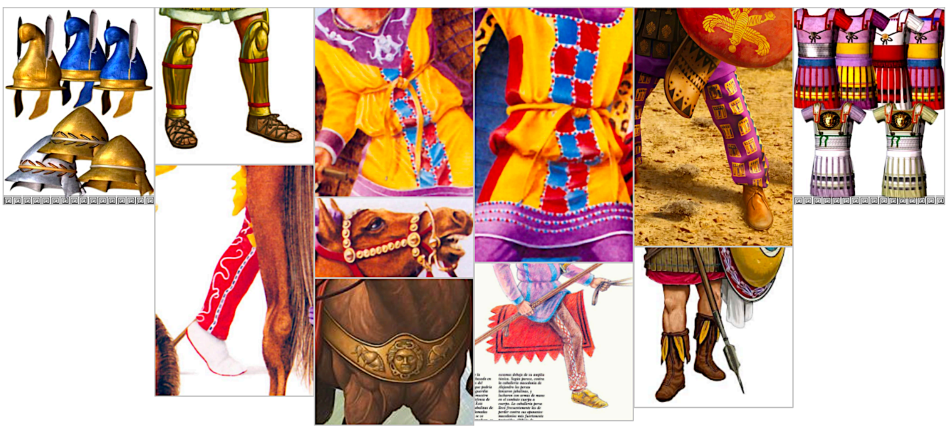


Figure 46. Equipment and Costume details

4.1.2.Concept Art

Concept art plays a crucial role in creative endeavors by visually conveying ideas, designs, and artistic intent for various elements like characters and environments. It serves as an essential tool during the pre-production phase, facilitating effective communication, decision-making, and refinement of the artistic vision before diving into extensive production efforts. By providing a visual representation of the intended aesthetics, mood, and atmosphere, concept art allows artists, designers, and stakeholders to align their visions and make informed choices regarding the project's direction.

In line with our previous discussions, I utilized the advantages of Spatial Design, as outlined in section 2.1.4.1 of this dissertation, to create my concept art within an immersive virtual reality environment. By leveraging this innovative approach, I aimed to enhance the authenticity and meticulous attention to detail in the creative process. Immersive virtual reality allows artists to step into the conceptual world they are designing, giving them a firsthand experience of the scale, proportions, and spatial relationships of the elements they are working on. This immersive experience not only fuels creativity but also enables the identification of potential design flaws or improvements that may not be apparent through traditional two-dimensional concept art methods

Figure 47. A SnapShot from the Project: Use of Spacial Design in Pre-production Phase

To breathe life into these character concepts, I embraced the immersive capabilities of Quill VR. By sketching and refining the character designs directly within the virtual reality environment, I fully immersed myself in the creative process. This innovative approach not only enhanced my ability to visualize and conceptualize the characters but also ensured a heightened level of authenticity and attention to detail.

To create the scene, I began by importing the image into Quill. From there, I proceeded to make an initial 2D full sketch based on the imported image.

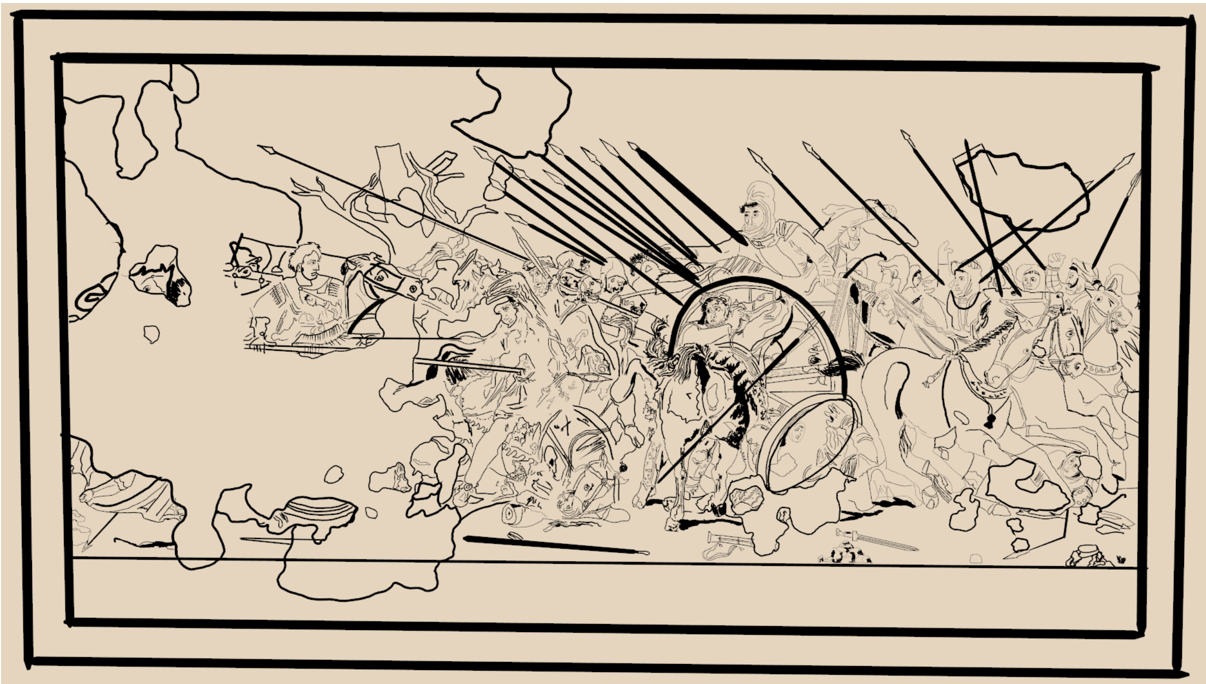


Figure 48: FullFrame Sketch Snapshot in Pre-Production Phase of Project

Drawing inspiration from the moodboards, I developed two distinct character themes: one highlighting Greek/Macedonian warriors and the other showcasing Persian warriors. These themes capture the essence of each army, incorporating visual references gathered in the sub-moodboard dedicated to equipment and costume details.

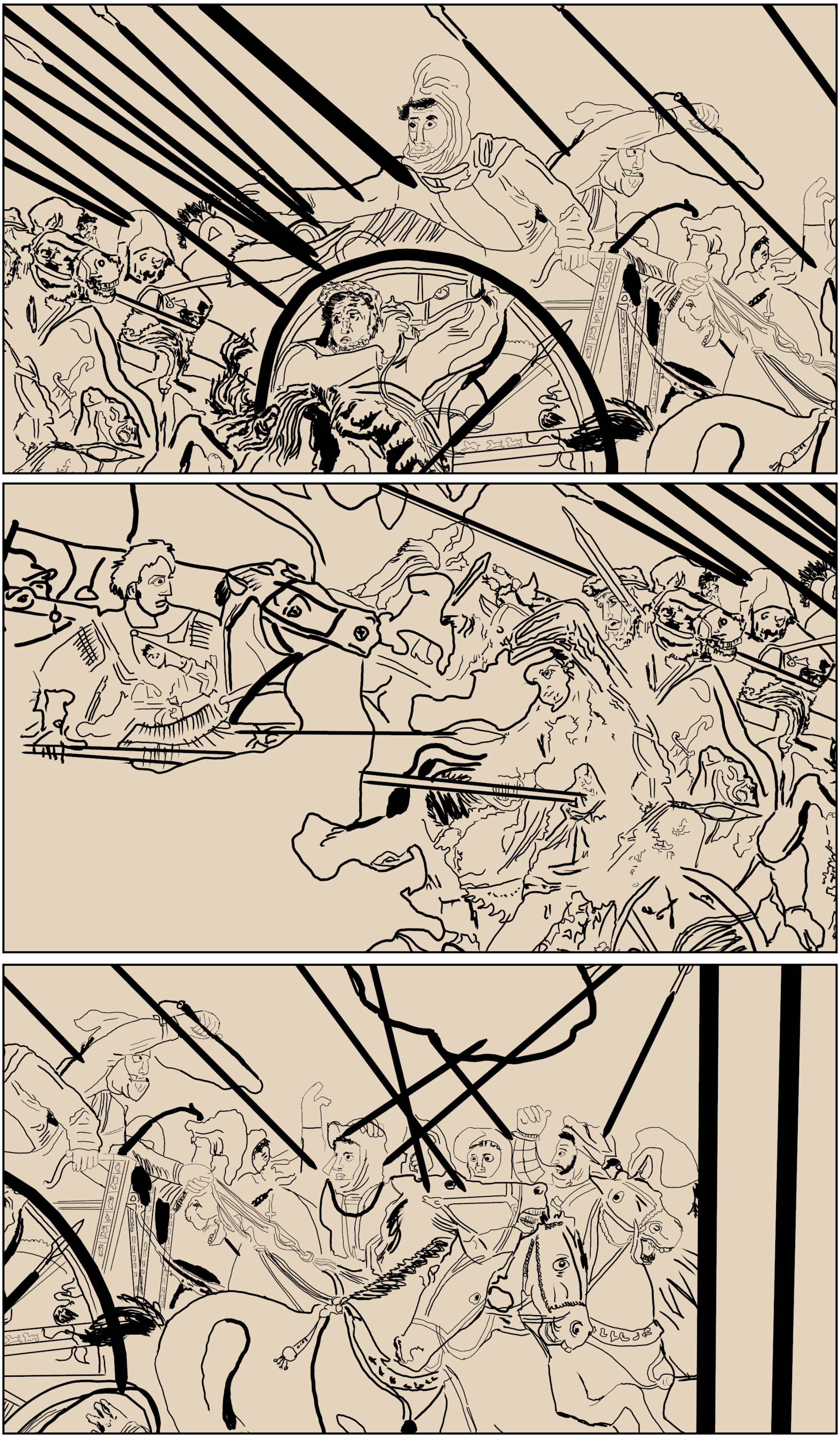


Figure 49: Three Snapshots Revealing Intricate Details: Darius, Alexander, and the Persian Troops

By utilizing Quill's layer feature, I created a new layer positioned above the sketch layer. Later on, after completing the modeling part of my project, I was able to adjust the transparency of the sketch layer, which allowed me to maintain visibility while accurately placing the 3D models and ensuring proper proportions between various objects and characters. This ingenious layering technique greatly facilitated the process of arranging elements and achieving the desired composition within the scene.

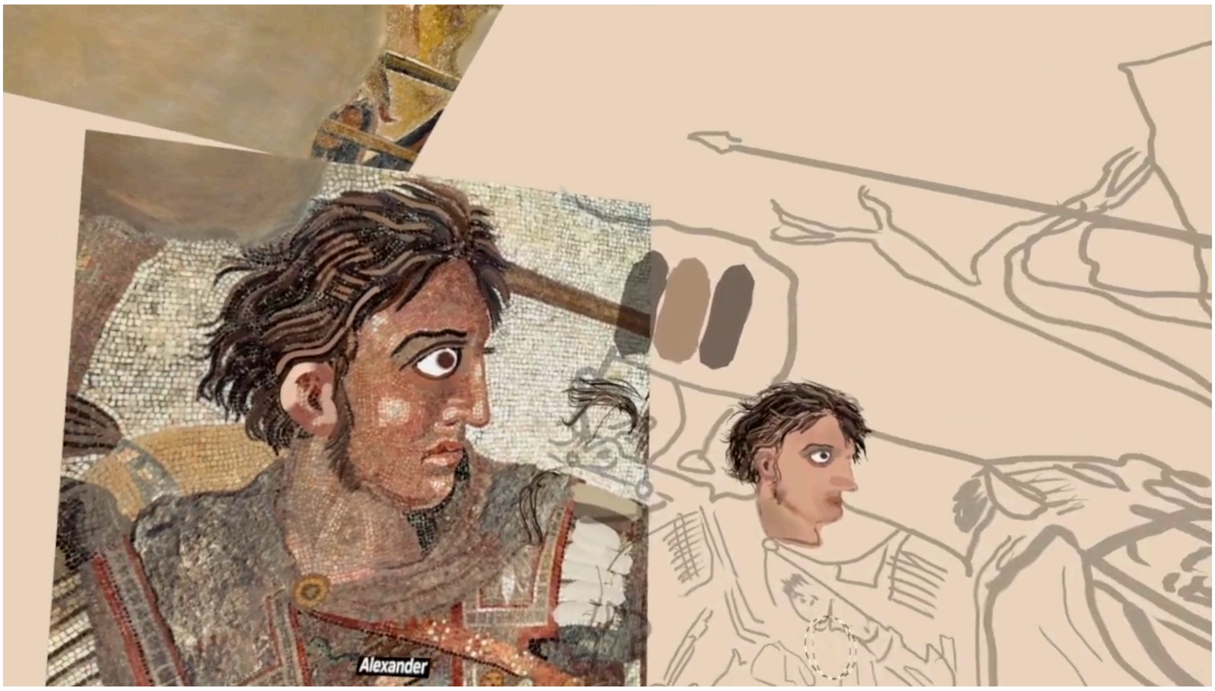


Figure 50. Imported image as reference → Sketched a 2D outline → Added a transparent layer above → Placed 3D models accurately for proportions and positioning

In the next step, I carefully analyzed the lighting in the Alexander mosaic, identifying two primary light sources. One was a large, bright light representing the sun, positioned in the top right corner behind the Persian troops. This light illuminated the troops, emphasizing their presence. The second light source was smaller and located on the left side, casting a glow on Alexander's face, accentuating his power. To ensure accuracy, I created a dedicated layer to document the light sources' positions, directions, and notable characteristics. This allowed me to understand how the lights were utilized to illuminate the mosaic faithfully.

Additionally, I selected the sky color from the painting and adjusted the world color within the Quill interface accordingly. This alignment of colors created a harmonious and cohesive atmosphere, enhancing the overall visual appeal of the artwork.

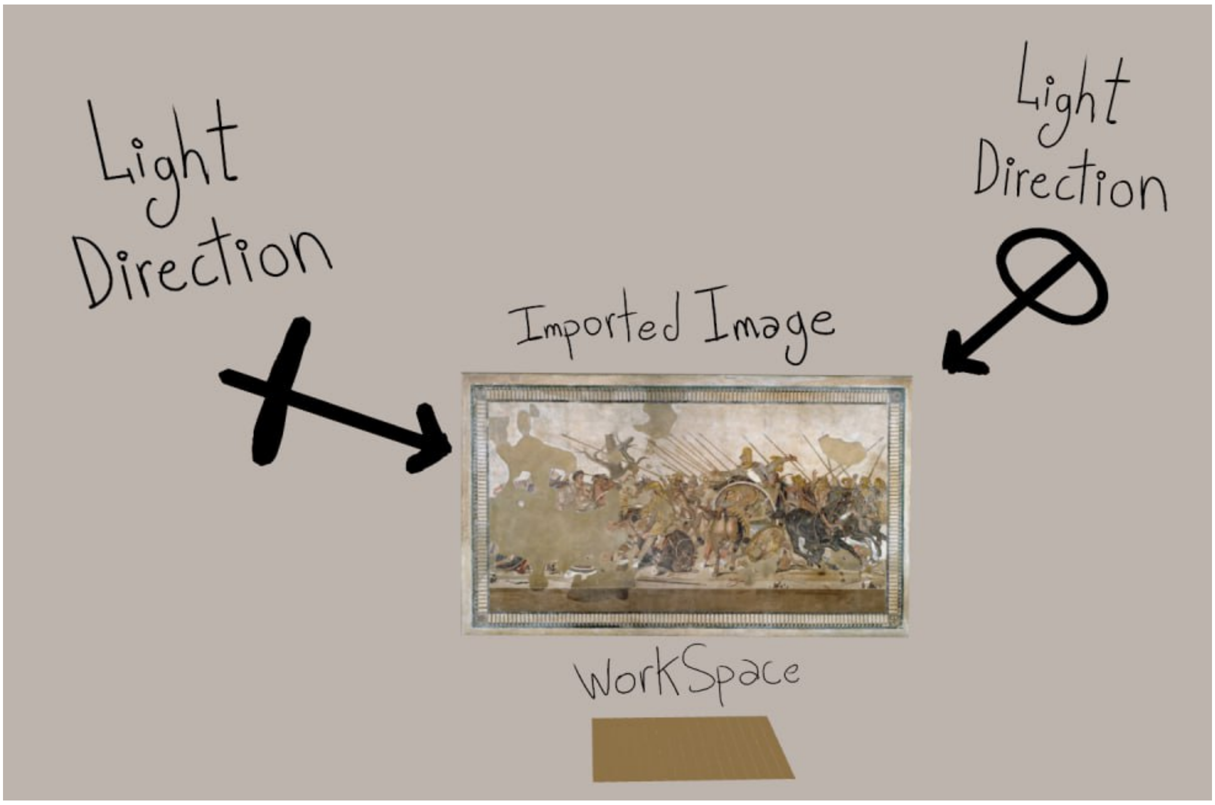


Figure 51. Examining the Light Direction

Lastly, I created a precise 2D flat surface inspired by the mosaic. This surface was designed to accurately capture the intricate color and shading details present in the artwork. The purpose was to use this 2D surface as individual pieces that could be mapped and applied onto the corresponding 3D models. Essentially, it acted as a texture, allowing me to recreate the mosaic's visual elements with accuracy and realism in the three-dimensional space.

Figure 52. Precise 2D surface for Texture Mapping

4.1.3.Analyzing the Environment

In this section of study, prior to actually creating and shaping the ambiance of the scene, I conducted an analysis that incorporated elements of history and geography to understand how battlefields appeared in reality. To achieve this, I relied on descriptions provided by historians who documented these battles, as well as geographic maps that depicted the precise locations. However, I also sought additional inspiration from artificial intelligence sources to enhance my understanding and interpretation of the subject matter. By integrating these different resources, my goal was to create a detailed and captivating representation of the battlefield that would fully engage the viewer.

4.1.3.1.Geographical Depiction

The Battle of Issus took place in 333 BC between the forces of Alexander the Great and the Persian Achaemenid Empire, led by King Darius III. The battle occurred on the Turkish-Syrian border, along the coast of the Gulf of İskenderun, with a small stream or river dividing the armies.

Figure 53. The battlefield of Issus, seen from the Pillar of Yunus Jona Lendering, Licence CC0 1.0 Universal.

The battlefield of Issus was a flat and open plain, divided by a small river called the Pinarus. This river originated from the nearby mountains and flowed towards the sea. The plain was roughly three kilometers wide and seven kilometers long, providing ample room for the two armies to maneuver. The nearest city to this location is Dörtyol, which is in modern-day Turkey.[19]

Figure 54. The iver Pinarus, now known as Payas, Jona Lendering, License CC0 1.0 Universal.

I used GPS coordinates of the Battle of Issus and height-map generator tools such as SkyDark[20] and maps3d.io[21] website to create custom 3D maps of the actual battlefield. These resources enabled me to accurately depict the terrain and layout of the historical site, resulting in a visually engaging and realistic setting. By combining geographical data and advanced mapping technology, I was able to recreate the battlefield with great accuracy.

[19] Allempires.com. (n.d.). The Battle of Issus. http://www.allempires.com/allempires.com-redirect/article/index.php?q=battle_issus

[20] https://heightmap.skydark.pl/

[21] https://maps3d.io/

Figure 55. Satellite Map of the city of Dörtyol that includes the battlefield of Issus

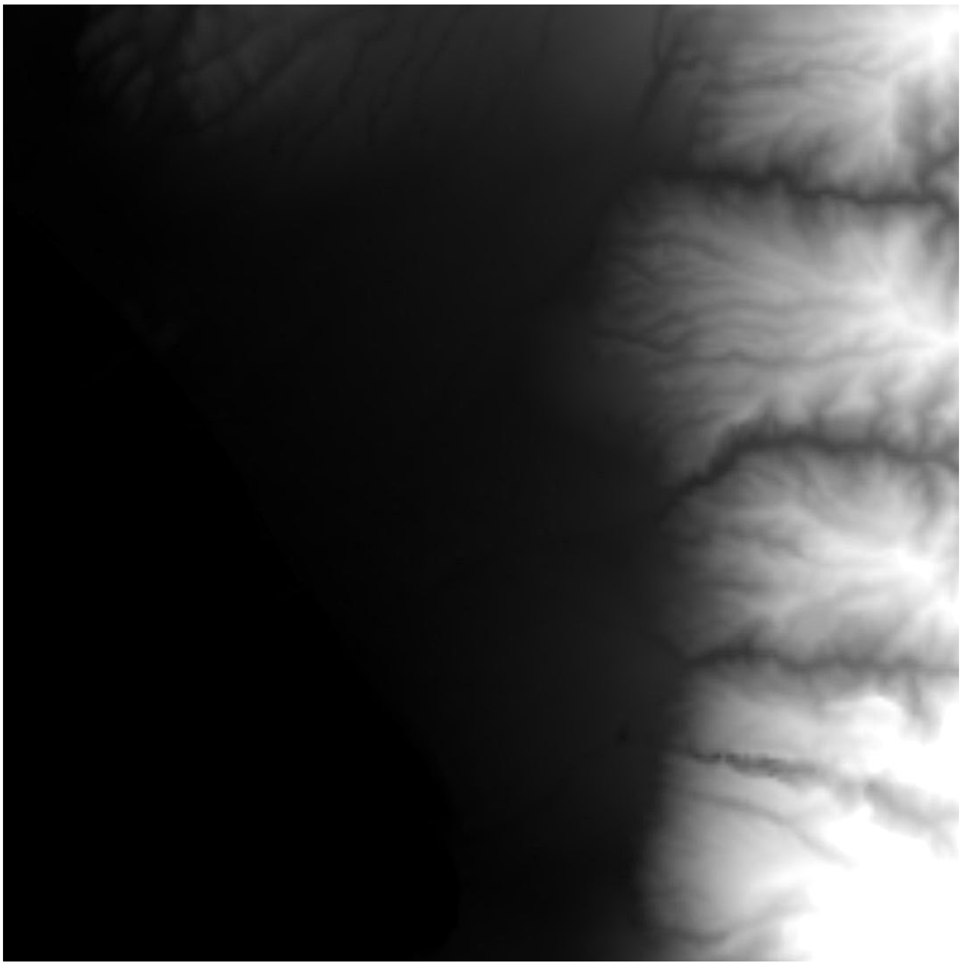


Figure 56. hight-map of the battlefield generated by api.mapbox.com website

The GPS coordinates for the Battle of Issus in Turkey are as follows:

DD Coordinates: 36.837894 36.211109

DMS Coordinates: Latitude: 36° 50' 16.42" N Longitude: 36° 12' 39.99" E

UTM Coordinates: 37S 251301.81169152 4080520.2547501

GEOHASH Coordinates:[22] sy9c840h7cpv

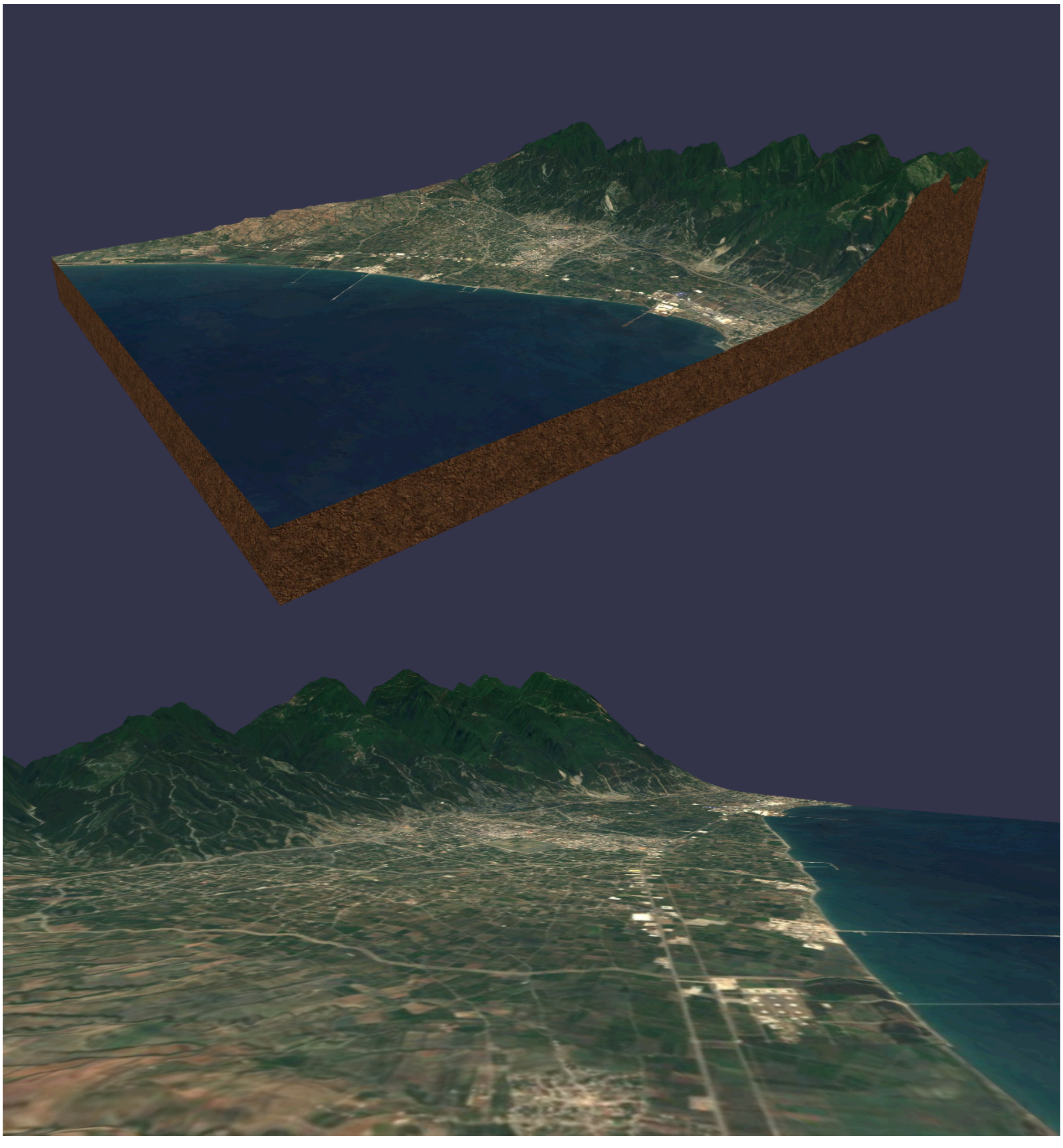


Figure 57. 3D models of battlefield zone generated by maps3d.io website

4.1.3.2.Historical Depiction[23]

Historians[24] recount that during the Battle of Issus, the Persian Achaemenid army occupied a position on the Issus plain near the Pinarus River. Meanwhile, Alexander and his army were located about a dozen miles south, preparing for the upcoming march. As they assessed the road ahead, Alexander led his entire army to the high ground at the Pillar of Jonah, from where they could see the Achaemenid campfires in the distance across the plain. *(Figure 59-A)*

Upon reaching the stream, Alexander's infantry regiments formed a line, with the sea to their left and foothills to their right. The majority of Alexander's cavalry concentrated on the right flank, setting the stage for the imminent showdown. *(Figure 59-B)*

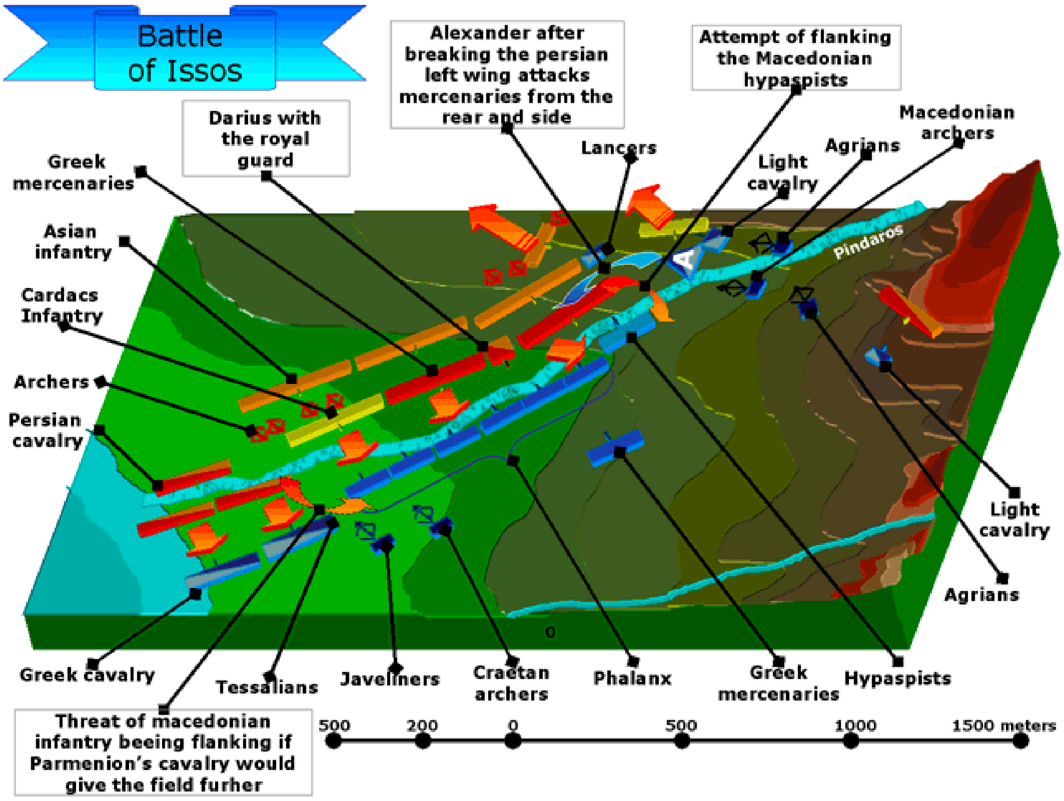


Figure 58. Battle of Issus, Source: Kevin Herbert Papers, Washington University Libraries, Department of Special Collections

[23] Quintus Curtius Rufus. (AD 60–70). Historiae Alexandri Magni.

[24] Hollis, M., & Voller, P. (2021, Dec,26). Battle of Issus 333 BC - Alexander the Great DOCUMENTARY. Retrieved from YouTube channel Kings and Generals. https://www.youtube.com/watch?v=pEsyRHLmBGw

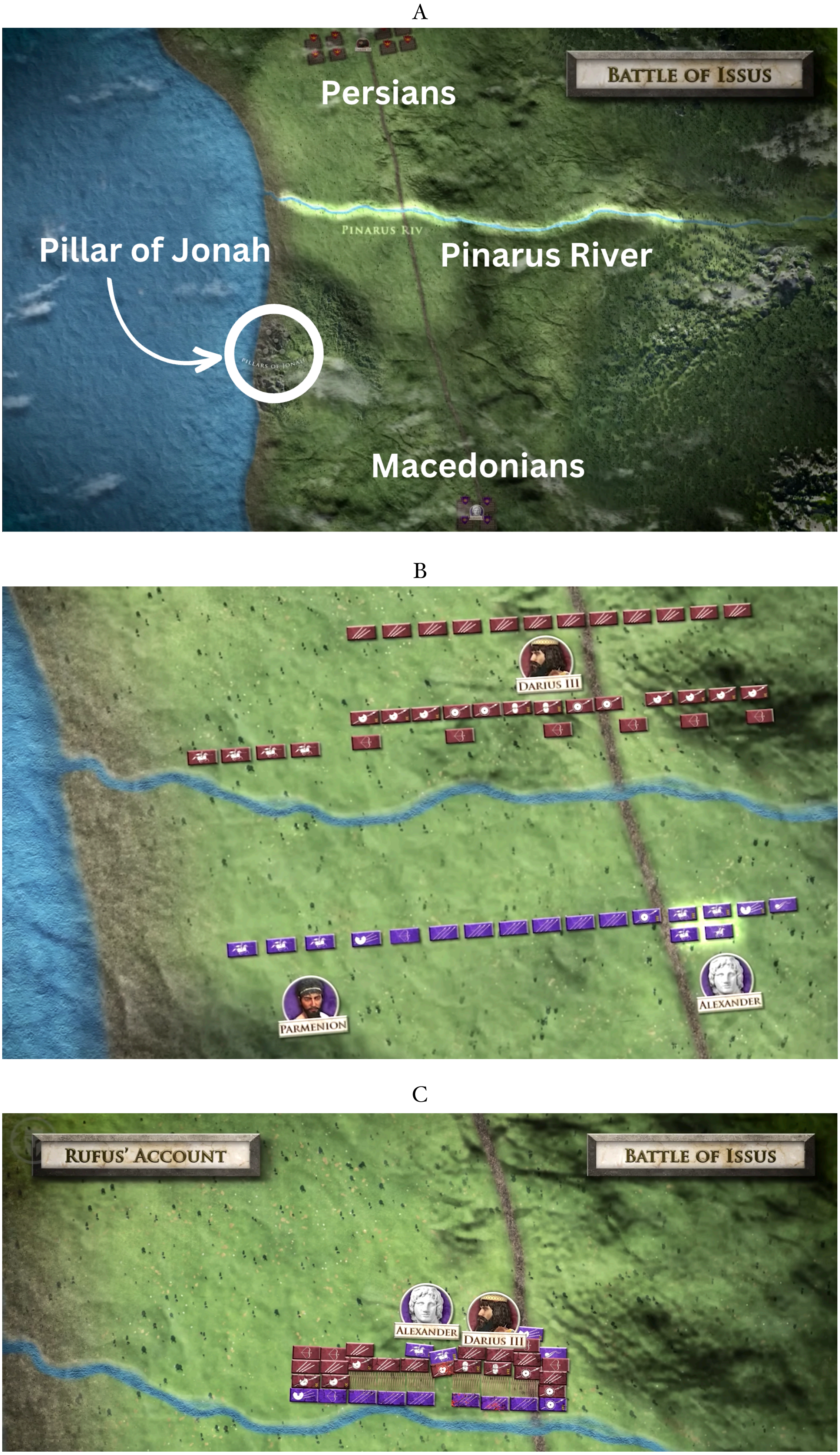


Figure 59. Military arrangement of two armies in battle: a) The river Pinarus divides the armies b) The initial position c) the secondary position that has been captured in the Alexander mosaic

Initially, the Macedonian troops were positioned in the southern part of the battlefield, respecting the river, while the Persians were in the northern part. However, during the battle, Alexander's forces crossed the river and approached King Darius of Persia. This particular moment was captured in the famous painting known as the Alexander mosaic, created by an artist from Pompeii. In this painting, *(Figure 59-C)*

To faithfully recreate the captivating mosaic scene, Alexander is depicted on the left, and Darius is shown on the right. Behind Alexander is the sea, while behind Darius are mountains. The river is situated to the south, and the hills are located to the north. The camera's perspective would be somewhere between the river and the two armies, with a tree positioned between the armies and the hills to the north.

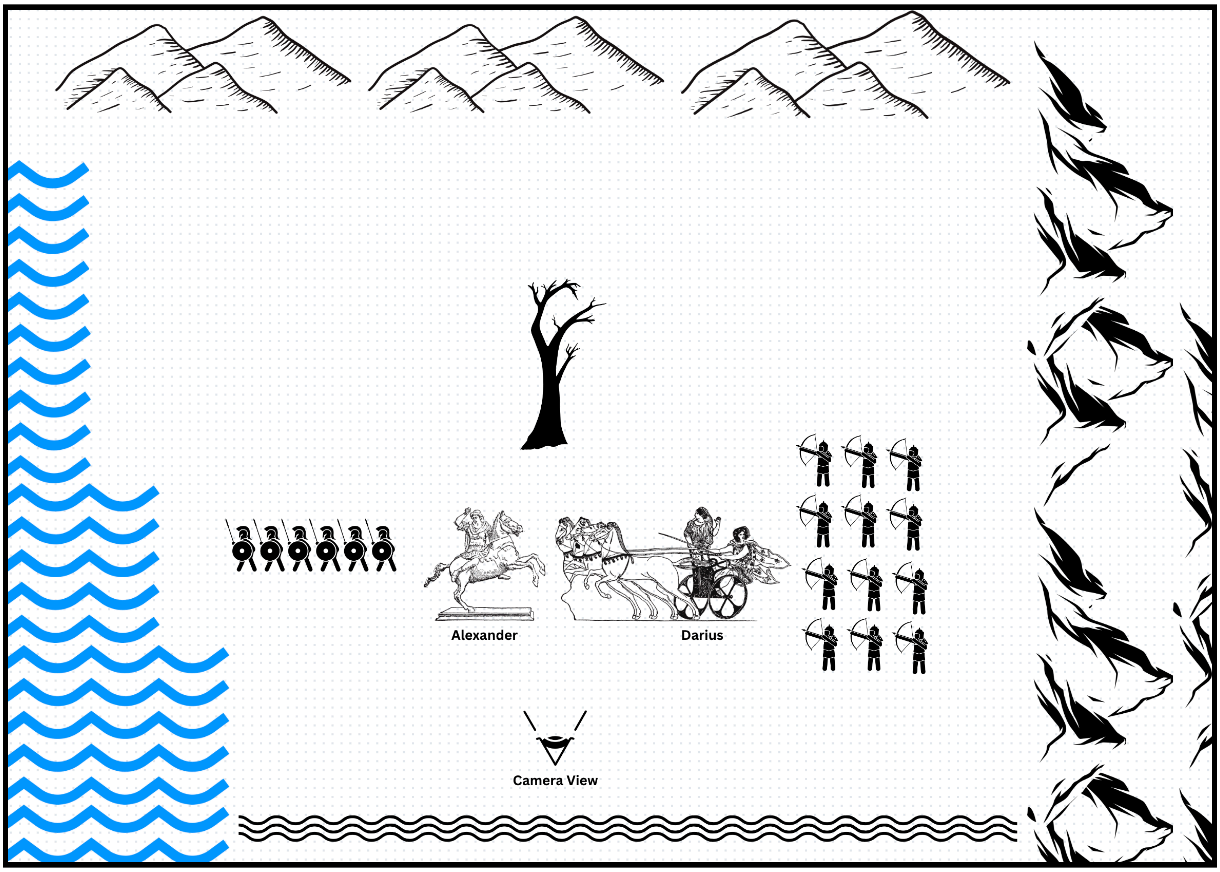


Figure 60. Battle of Issus and the position of Camera to recreate the perspective Alexander mosaic

The narrowness of the plain played a significant role in the battle, as it allowed Alexander to concentrate his forces and prevent the Persians from encircling him with their larger army. After several hours of intense fighting, Alexander managed to break through the Persian center and forcing Darius to flee. The Persian army was left in disarray and suffered heavy losses, while Alexander's forces experienced relatively few casualties.

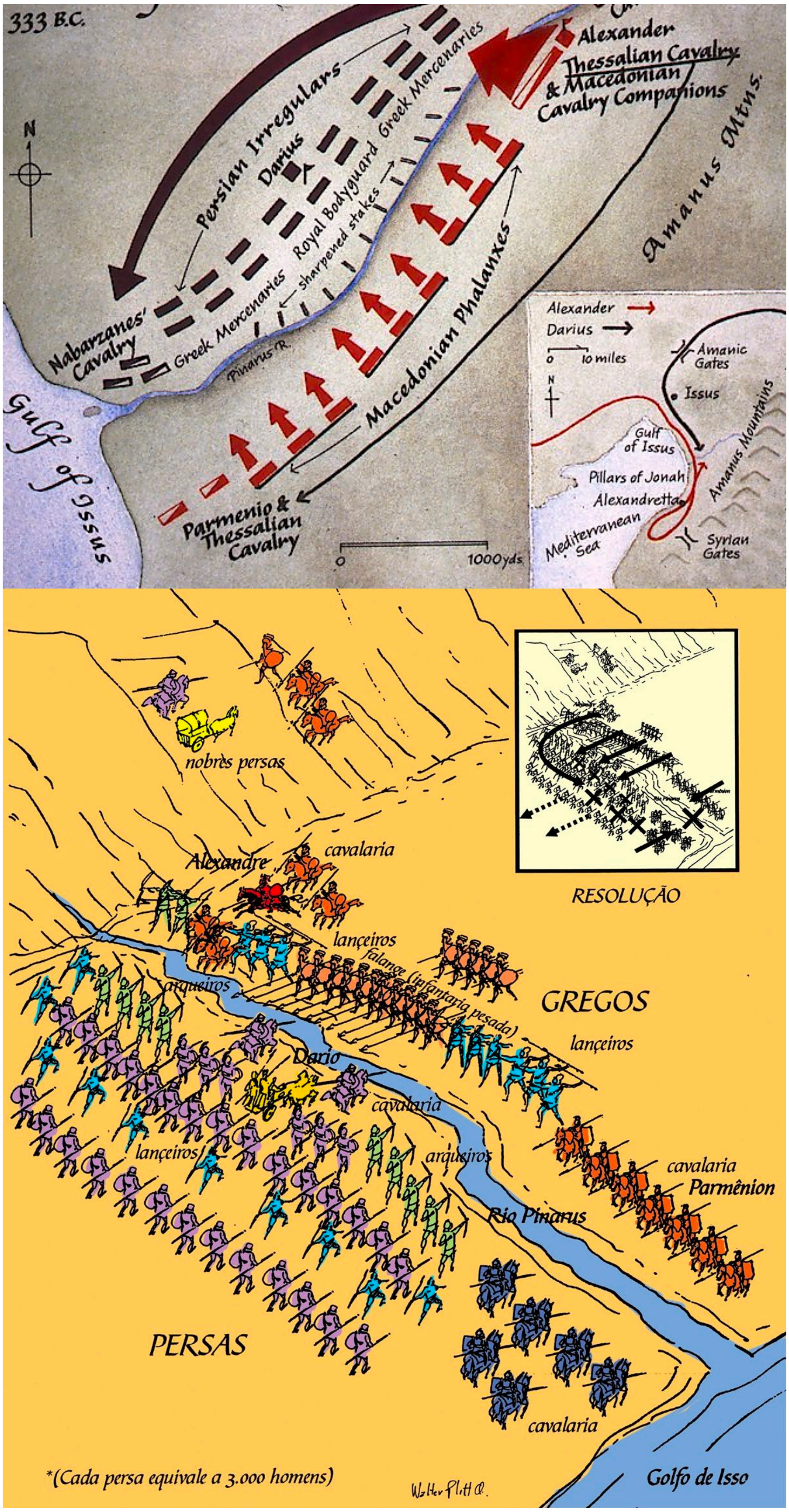


Figure 61. The positioning of two armies at varying levels of deployment.

4.1.4. Supplementary Sources of Inspirations

4.1.4.1. AI Generated Images

AI-generated images prove to be an invaluable asset for animators in environmental design for animation production. They offer a wide range of options promptly, fostering creativity, aiding in world-building, facilitating style exploration, and saving time.

I have utilized **Midjourney**[25] to gain inspiration from 2D image references. Midjourney is an AI tool that generates concept art images by interpreting textual instructions. It produces high-quality images with complementary colors, detailed elements, and artistic use of light and shadow. The entire image generation process typically takes around 50 seconds.

In Midjourney, a prompt is a short text phrase that the AI analyzes to generate an image. An example of a simple prompt, resulted in the generation of an innovative image depicting Alexander of Macedon:

[Alexander mosaic, war scene, battlefield, ultra detail, sea, river, field, meadow, mountain]

Figure 62. AI generated photo of Alexander during the battle

[25] Midjourney Discord: https://discord.gg/midjourney

By adding additional keywords such as "extreme long-shot" and "wider frame" to the prompt, we can generate a more immersive 3D image that showcases Alexander prominently in the center of a detailed and expansive scene. The new Promet was:

[landscape scene, recreation 3d, alexander mosaic, 8k, ultra detail, battle with Darius of Persia, issuss, battlefield,war scene, extreme longshot, river and medeow, world, field --q 2]

Figure 63. AI generated photos showing the Alexander campaigns passing thorough the Pinarus river

Through trial and error, I reached a satisfying result by using a more complex prompt. The prompt aimed to depict a vast perspective of a battle, showcasing a panoramic view from the hilltops overlooking the sea. The complex prompt and it resulting are below:

[nadershah vs alexander, landscape scene, recreation 3d, alexander mosaic, 8k, ultra detail, battle with Darius of Persia, persian army, persian art, nature, quill vr, vr animation, issuss, battlefield,war scene, extreme longshot, river and medeow, and see, world , field, horses, soldiers, darius iii, dario, persia, persian, soldiers, incredible, war, battle, scene, panoramic, landscape, alexander mosaic, restored, recreation, real life, full scene, war, pinarus river]

Figure 64. AI generated photo depicting an wide view of the Issus battle

I also explored the **Skybox**[26] AI platform, which utilizes AI to generate complete 360-degree panoramic images. Since my aim was to work within a 3D environment, I decided to give this platform a try as well. I have set the prompt to **[Persian,Greek,Sea,Mountain,River,Battlefield, Landscape]** and set the theme to **Fantasy**, the result is as follows:

Figure 65. A 360 AI generated photo

[26] https://skybox.blockadelabs.com/

4.1.4.2.Surrounding Terrain of the Battleground

Given that the battle took place in a coastal Mediterranean setting, it is important to consider the entire battlefield when visualizing it. When an observer watches the animation and turns their head, they should be able to see mountains in the background and a flowing river. To enhance my creative process and find inspiration for designing the surrounding elements, I sought additional photos. Among them, I came across a captivating image captured in Milford Sound, located within Fiordland National Park in New Zealand. This particular photo caught my attention due to its aesthetic beauty, with lush green moss-covered rocks in the foreground, which could potentially evoke the desired atmosphere I was seeking.

Figure 66. Reference photo for surrounding of battleground, Milford Sound, in New Zealand

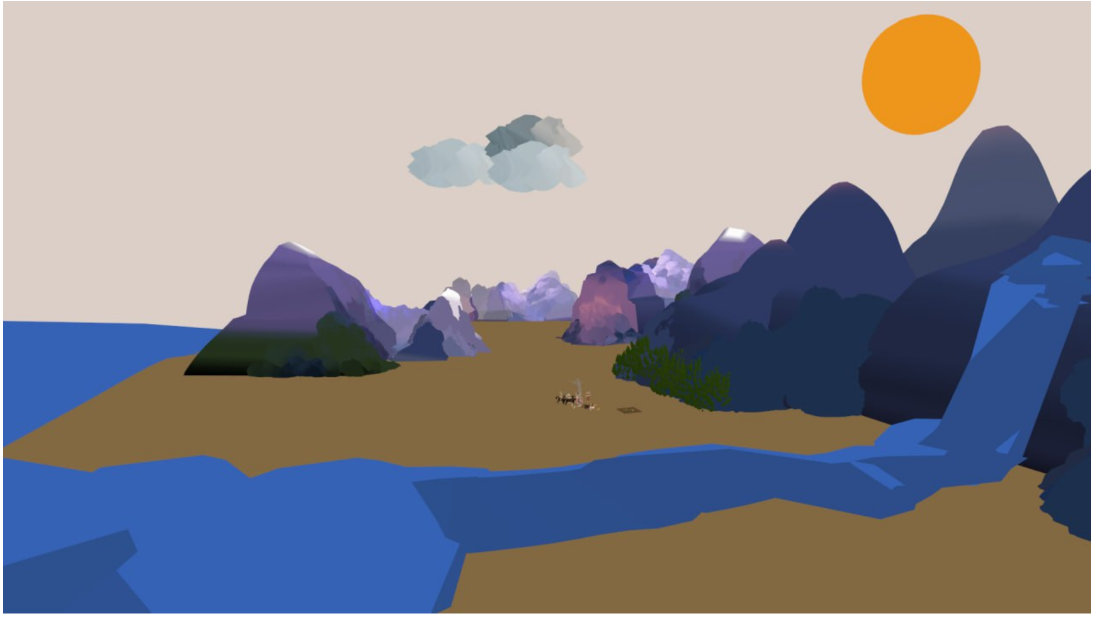


Figure 67. World created in the Quill VR

4.1.5.Unpreserved Segments

The original mosaic, attributed to the artist Philoxenus of Eretria from the 3rd century BC, endured approximately one-third damage over time. To restore these missing portions, I employed a combination of artistic imagination and works from various artists. Notably, the left side of the frame, where the Macedonian army is situated, bears the brunt of the damages.

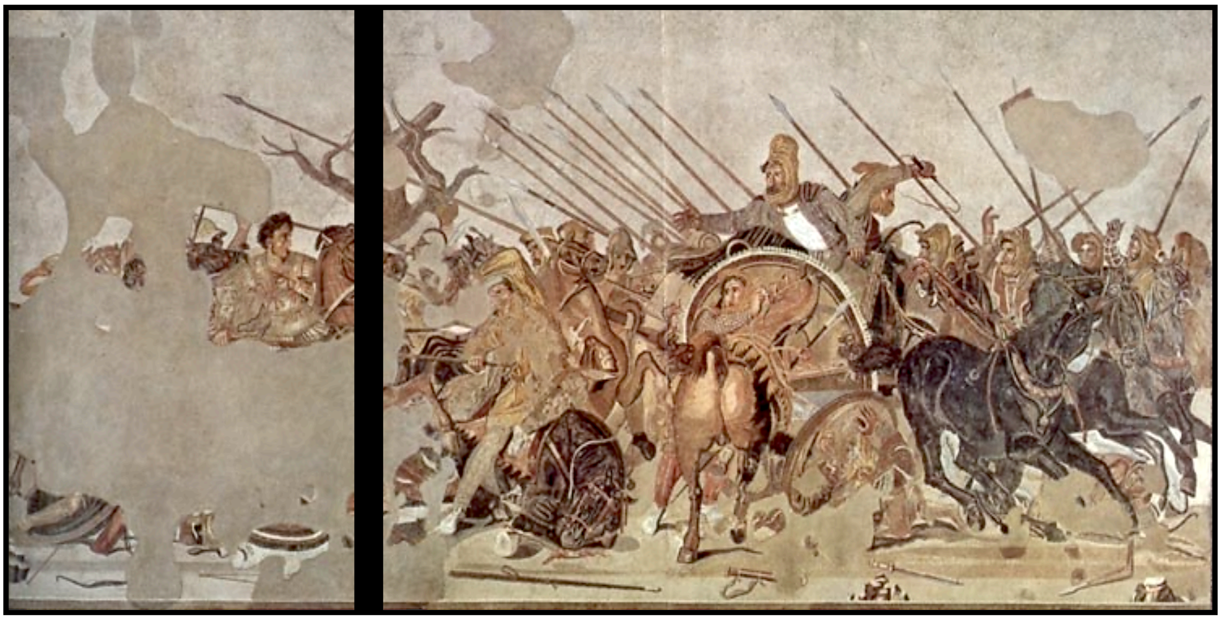


Figure 68. One-third of the Alexander mosaic painting has vanished, with the left side bearing the brunt of the loss.

I have specially incorporated into my work another reconstructed version of the Battle of Alexander the Great mosaic, painted on old soon after the discovery of the mosaic in 1831which housed in the Museum of Naples.

In this version, not only are the troops of Alexander depicted on the left side, but also intricate details such as the flag held by the Persians have been imagined and meticulously restored.

Figure 69. The old Painted old reconstruction on the left and the original mosaic on the right

Figure 70. Another reconstructed version of the painting bears a striking resemblance to the oil version

Figure 71. Issus battle. Flats from Christian Carl Cortum Figurinen. Painting Jean-Francois Pierre 2018

This image below depicts a reconstruction based on a painting published in 1893. Which was a source to many other restored versions.

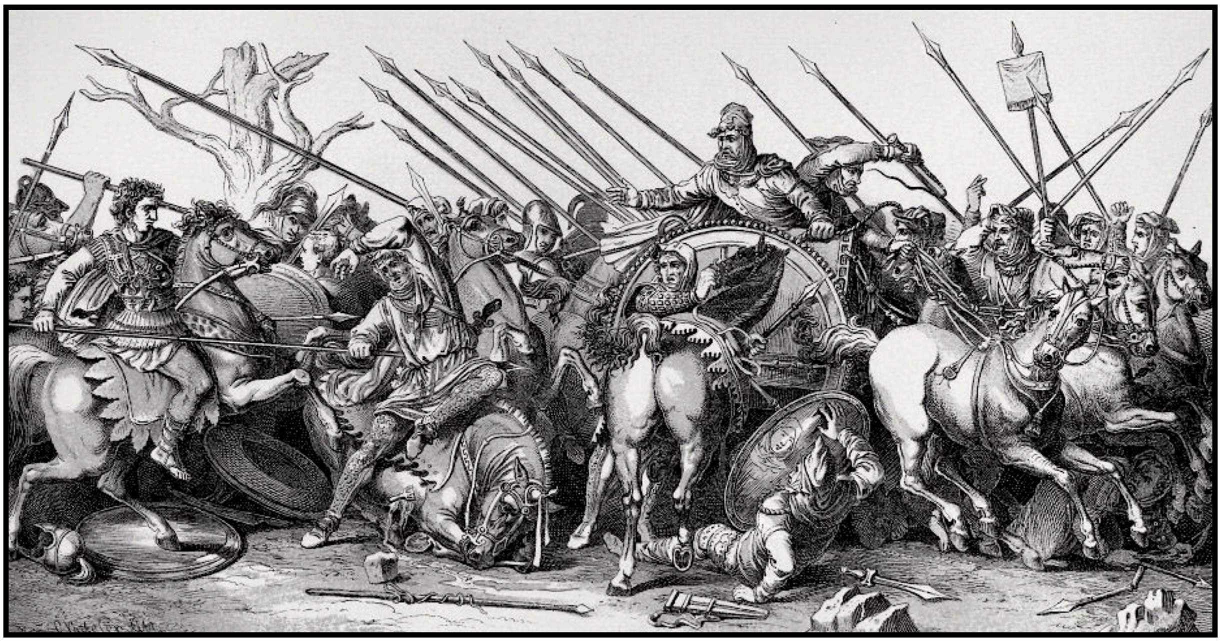


Figure 72. A depiction of the Alexander mosaic reconstructed in 1893.

It is worth mentioning other notable attempts, such as a 17th-century painting by Italian artist Robertus de Mol, created between 1674 and 1682, and a contemporary digitally remastered version by the artist known as EthicallyChallenged publish in deviantart.com website.

Figure 73. Battle between Alexander the Great and Darius III, Robertus de Mol, Pietro da Cortona, 1674 - 1682

Figure 74. Digital Reconstruction of Alexander the Great mosaic, @EthicallyChallenged

4.1.6.Characters

In traditional animated productions, model sheets play a crucial role in providing visual consistency and guidance to artists and animators. These reference documents or sets of drawings offer detailed information about characters or objects, including multiple views and key details. They serve as an essential tool throughout the design and production stages.

However, in the unique workflow of my production, things took a slightly different approach. Instead of creating specific character model sheets, we found inspiration and reference in the Alexander Mosaic itself. This ancient artwork served as a visual foundation and guide for our characters. Characters were painted in a way that joints and limbs were easy to select and movable for posing and animation. Limbs and Foots are simple brush for this matter.

Figure 75. visual representations of a selection of the Characters

4.2.Production

4.2.1.VR Modeling: Building the Scene

Building the virtual reality (VR) environment with Quill was a time-consuming but enjoyable process. My main goal was to fully explore and utilize Quill's capabilities in adding intricate details to the scene. While I had prior experience in creating complex artwork, my focus this time was on enhancing the soldiers and their customs.

By designing the entire experience within VR using Quill, I had the advantage of making important decisions early on, knowing that they would seamlessly translate into the final version. I treated the environment like a theater stage, carefully arranging props and set elements for each shot to enhance the narrative.

To aid in this process, I created two libraries. One contained simple shapes like spheres and cubes, while the other focused on more detailed but repetitive props like swords and textiles and Organic tissues.

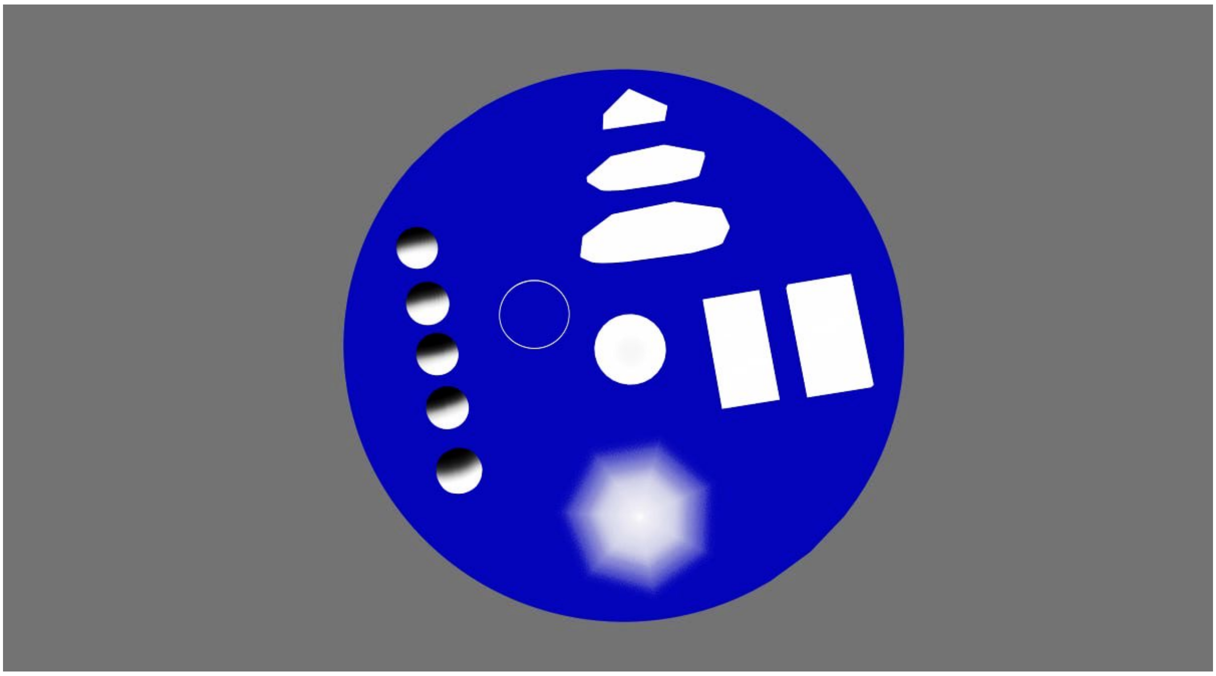


Figure 76. Basic Shapes Library

Figure 77. Libraries for the accessories and the organic materials

4.2.2.Coloring and Shading

After modeling is complete, the next step is coloring. Since Quilt lacks a lighting system, we need to simulate light by painting it. In this section, I discuss color adjustments in Quilt and techniques for achieving realistic lighting effects.

One method for color adjustment in Quilt is using the Palette. It allows easy color changes with just a click. The hue can be adjusted using a slider or by tapping on the color box for precise selection. Color adjustments can also be made using the analog stick. Selected colors can be saved to the swatches and used as a background by pressing the B button on the right controller.

Another technique is Recoloring, which involves picking colors from images or existing strokes and applying them to the entire stroke or specific parts. It's important to note that strokes can only be recolored in the direction they were drawn, similar to spaghetti noodles. The Recolor tool offers different effects by holding the left trigger and moving the analog stick up and down. Adjusting the focus area inside the circle produces sharper or softer edges.

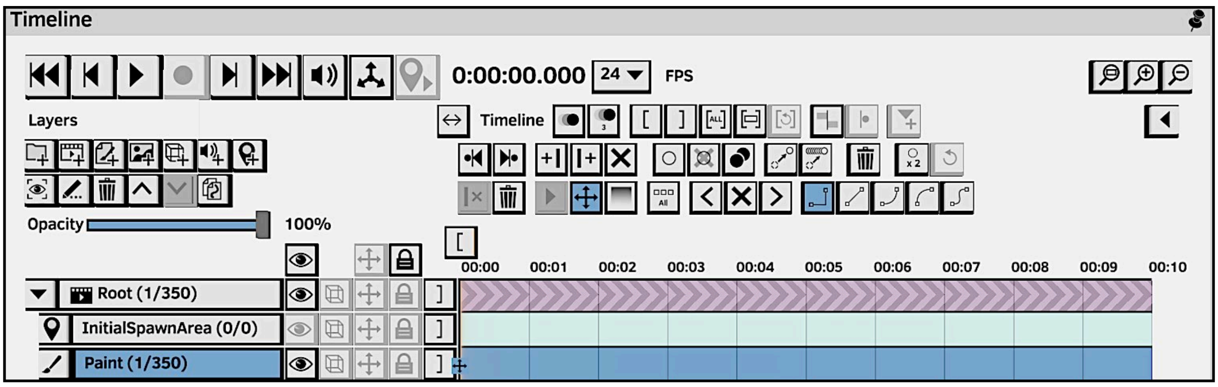
To create gradients that go against the stroke direction, vertical strokes can be created and duplicated along a straight line. This allows for recoloring and achieving gradients from bottom to top, although it works best with flat lines.

Quilt also provides various Blending Modes, which affect strokes without blending between layers like in Photoshop. For example, Multiply darkens the color, Overlay usually brightens it, and Dodge can add highlights. Opacity adjustments can make parts of the stroke transparent. The Colorize blending mode changes the overall color of the stroke. Experimenting with blending modes and colors will help find the best effects for artwork.

In my opinion, the best approach is to utilize third-party software like Blender or Cinema 4D, which possess powerful rendering engines and advanced lighting capabilities. These tools can create visually striking effects. In the next chapter, I will briefly explain how Blender can be employed to achieve impressive lighting effects.

4.2.3.Timeline and Keyframing

The timeline provides an effective method for arranging content and animations as well as organizing complex storylines.



The Quill animation timeline[27] resembles a simplified version of timelines found in Adobe After Effects or Premiere. It encompasses familiar features such as layers, layer groups, layer sequences, and keyframe interpolation, making the transition to Quill relatively effortless for those accustomed to working with these functionalities in other software. In the case of static scenes without any animation, the timeline can be condensed to show only the layers, minimizing visual clutter.

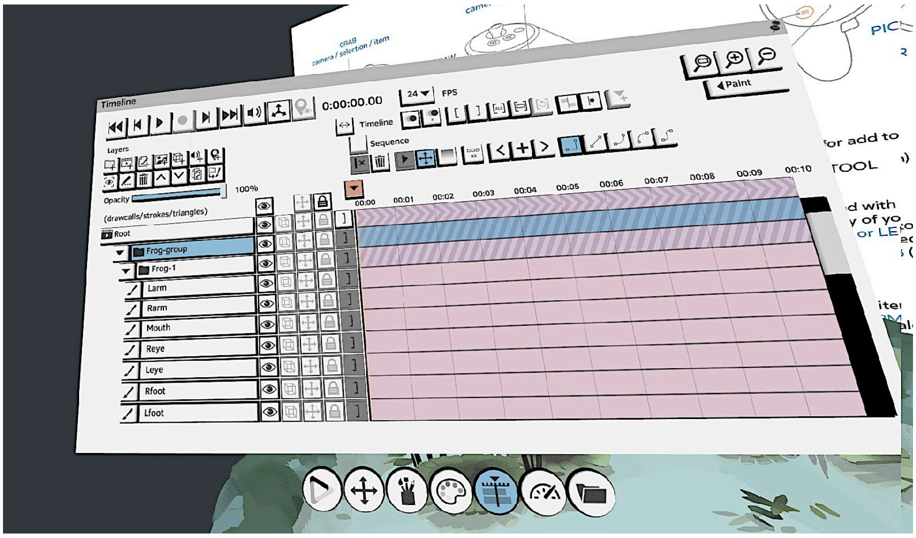
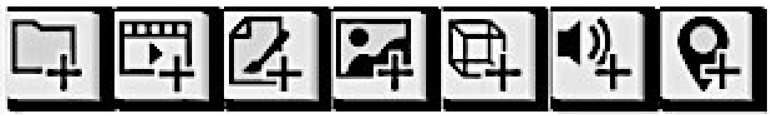


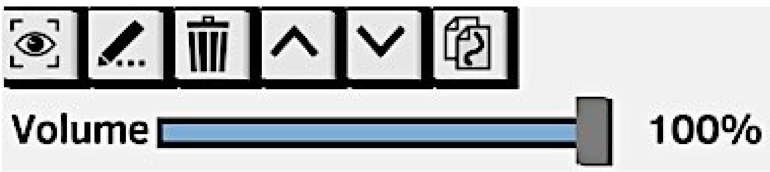
Figure 78. The Quill Timeline and it's layers

4.2.3.1.Layers

In Quill, a scene is organized into layers, allowing the creation of new layers of various types using these buttons.

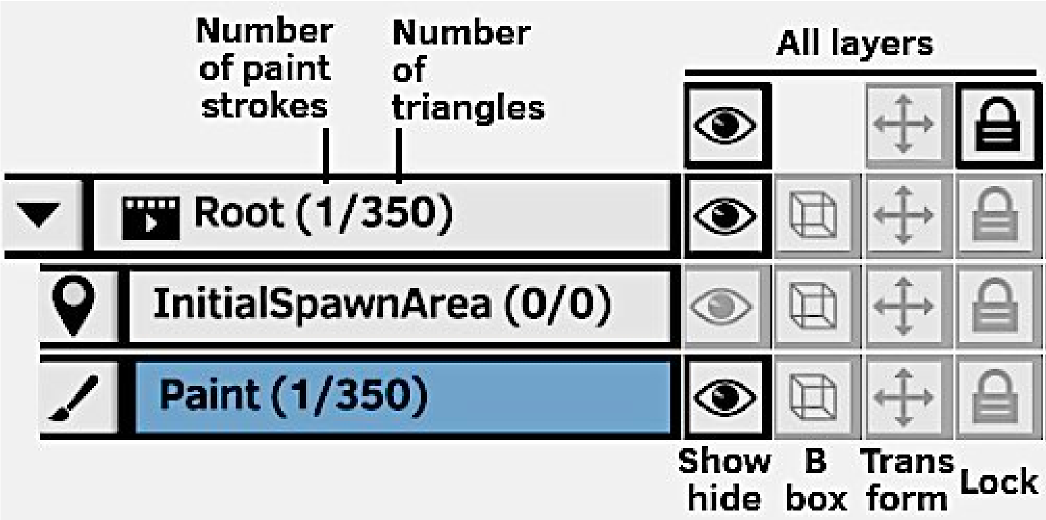


The highlighted layer appears in blue, allowing us to perform various actions such as re-entering the view, renaming, deleting, moving within the hierarchy, or duplicating the selected layer. Moreover, paint layers can be merged with the layer below, and groups consisting solely of visible paint layers or other groups can be flattened.



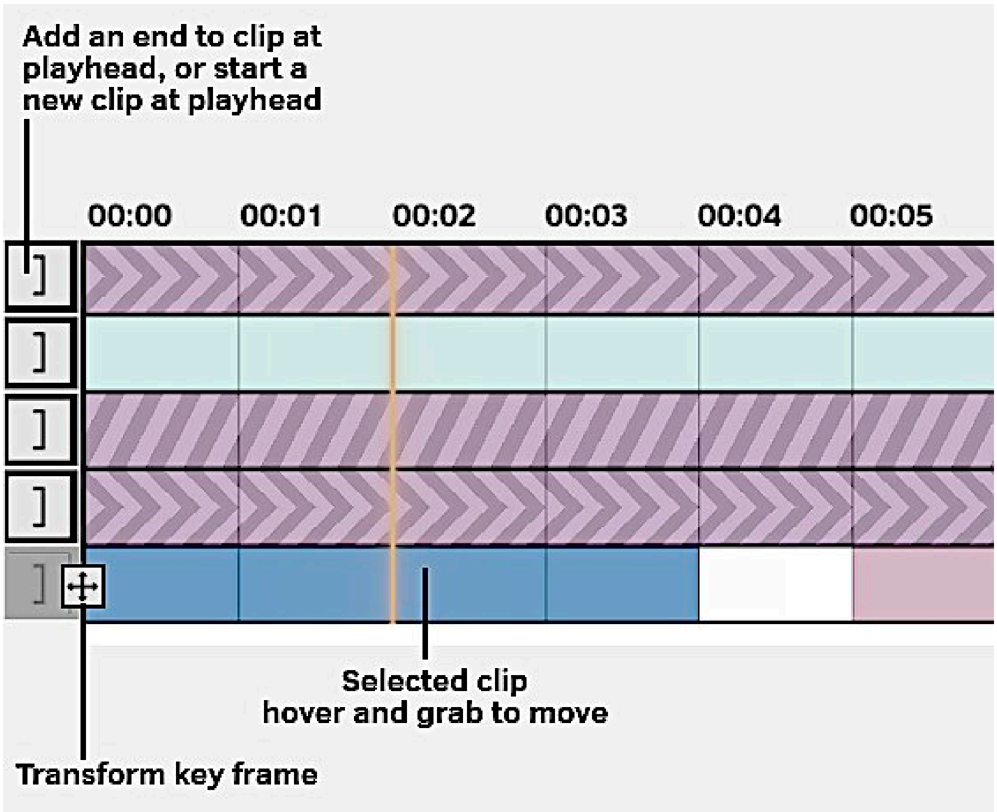
[27] https://quill.art/tutorials_timeline.html

Layers have the ability to be hidden or shown, and their bounding box can be optionally displayed. They can also be selected for transformation or locked to prevent further modifications. Statistics, represented as the number of strokes and triangles, are displayed to assist in optimizing content for various platforms.



4.2.3.2.Clips

On the timeline, layers are represented as clips, with each layer having a default clip that begins at time 0 and continues indefinitely.



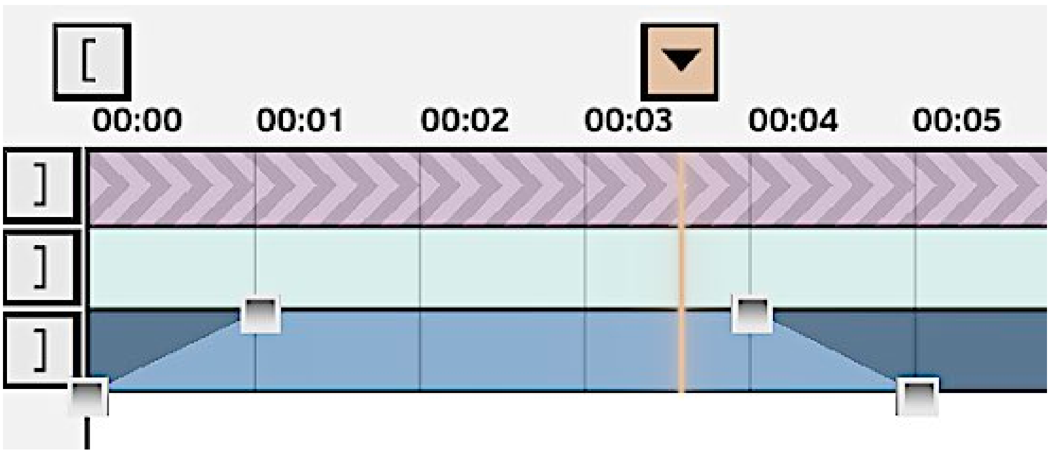
Clips can be given an end point, allowing for multiple clips of the same layer to exist at different times with unique properties, enabling asset reuse.

When a clip is selected, it can be manipulated directly by hovering over it and using the grab button. The left and right edges can be grabbed to trim the clip, while the center part can be moved.

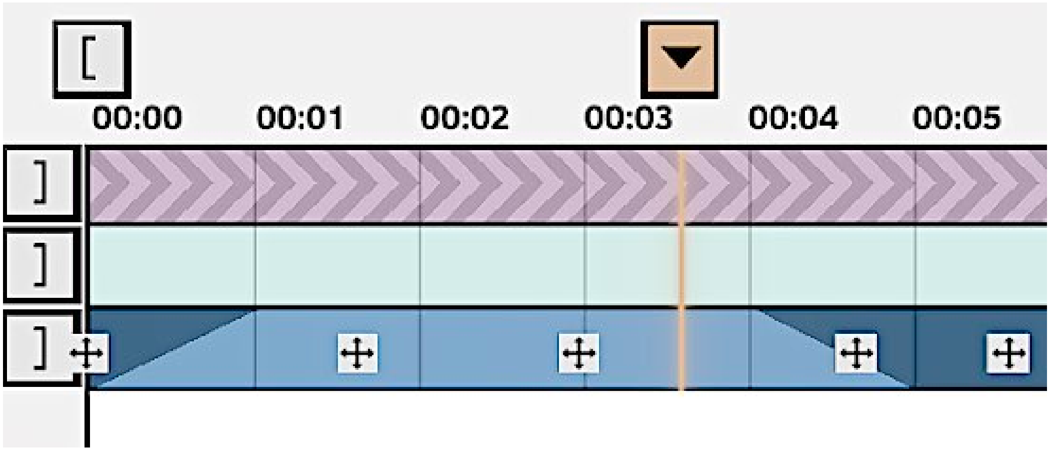
Depending on the selected mode, the keyframes of the selected clip will also be displayed. Clips are color-coded based on their layer type, and groups are further distinguished by a hatched pattern, while sequences are marked with an arrow pattern.

4.2.3.3.Key Frames

The ability to set keys for transformation and opacity values is available for clips, enabling interpolation between them. Keyframes can be set for any layer type, facilitating the creation of intricate nested animations without sacrificing flexibility in post-animation editing.



As an example, one could animate a pilot within a plane by utilizing a layer group and applying transform keyframes to the group. This approach allows for adjustments to be made to individual layers within the group while maintaining the overall animation. Similarly, it is possible to animate a car on a highway by using a few transform keyframes, thus avoiding the need for frame-by-frame animation. Notably, keyframes store only property values, resulting in significantly reduced file sizes compared to frame-by-frame animation.



In the timeline toolbox, it is possible to navigate between created and deleted keyframes.

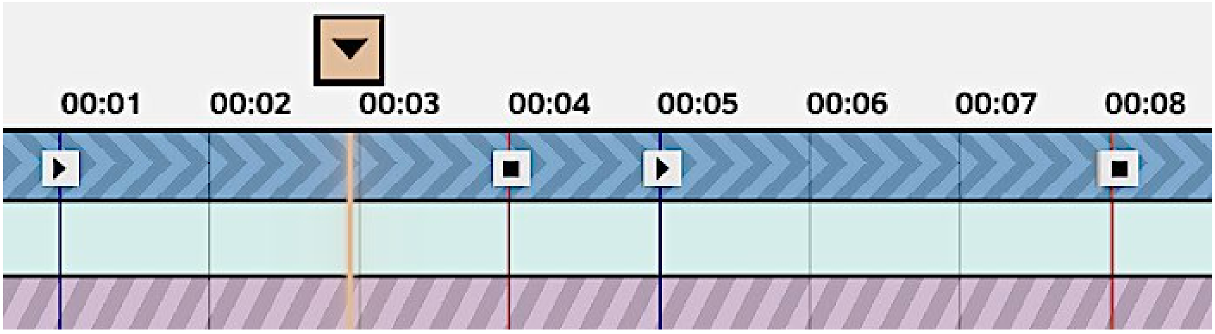
Keyframes can be selected by touching them (ALT for multiple selection) and moved by hovering and using the grab button (ALT to duplicate).

Different styles of interpolation are available for keyframes, ranging from stepped (no interpolation) to linear at a constant speed, as well as linear with various easing options (ease in, ease out, ease in & out).

4.2.3.4.Stops/Plays

Stops introduce a unique concept in VR storytelling, enabling the story to pause while keeping the scene active. Unlike traditional film, VR allows for infinite paths and camera angles, and Stops give viewers the freedom to explore the scene at their own pace, examining details and fully experiencing the environment. By granting viewers the power to choose when to proceed with the story, creators offer an interactive narrative experience.

As for Plays, they represent the location where the play head jumps to when rewinding a scene.



In a scene, Stops and Plays are exclusively defined within the Root layer. They are visually represented as red and blue lines in the timeline and can be manipulated just like any other type of key frame within the Root layer.

4.2.3.5.Sequence Layers

Sequence layers function similarly to Group Layers with a key distinction: they serve as nested timelines within the main timeline. They are utilized to keep animated layers active during a "Stop" or to create loops of animated layers or groups.

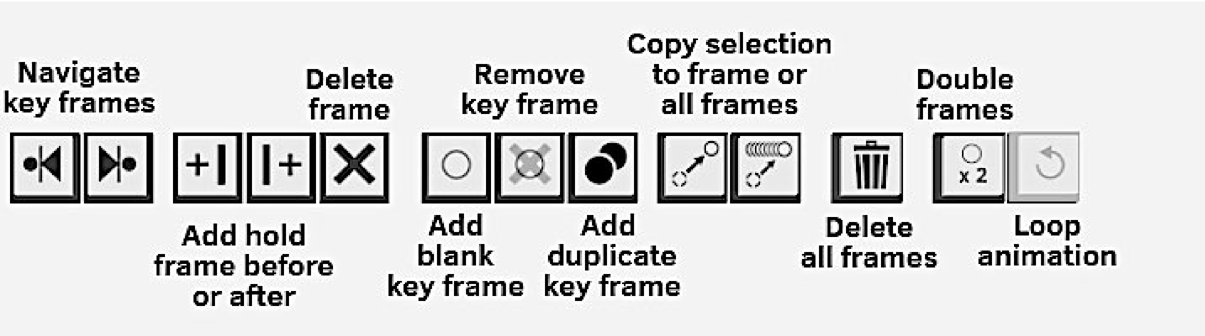
It is possible to convert any Sequence Layer back into a Group Layer and vice versa.

To enable looping within a sequence, utilize the looping icon and the play head to designate the loop point.

4.2.3.6.Paint Layers

Paint layers encompass independent key frames that can be individually modified and hold frames that maintain the same drawing for a specific duration. The frame-by-frame animation can be looped and is presented on the timeline in the following manner: [Image: timeline rendering example

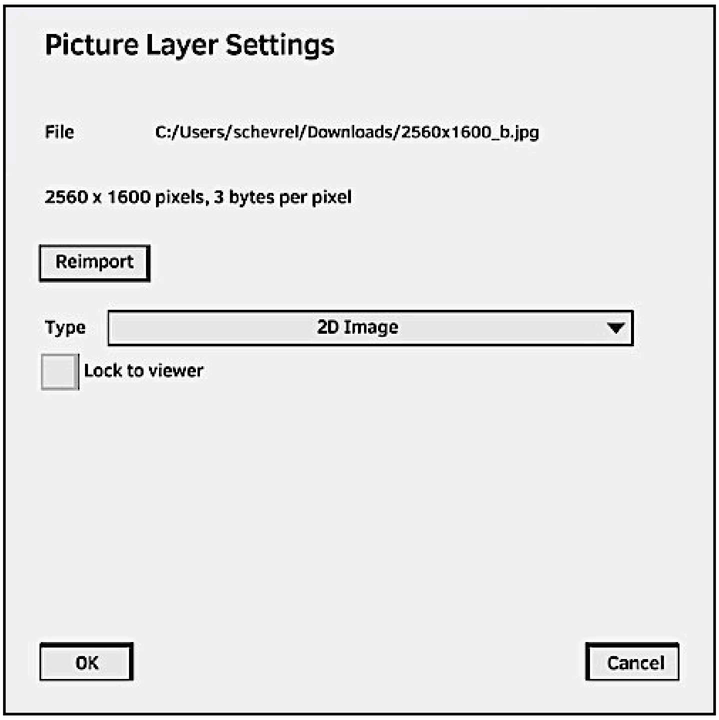
When working with paint layers, we have access to the following commands to manipulate key frames and hold frames.



In frame-by-frame animations, the presence of key frames can significantly increase file size. Therefore, it is crucial to minimize the number of key frames and utilize holds for static poses that are held for an extended period. Whenever possible, opt for layer transform key frames to handle linear motion or other types of animation instead.

4.2.3.7.Picture Layers

Images in PNG and JPEG formats can be imported into Quill for display as either flat 2D planes or immersive 360 spheres or cube-maps.



To access the settings for picture layers, simply touch the image icon located before the layer name.

By locking images to the viewer, they remain unaffected by the camera's movements.

Utilizing 360 images and cube-maps is an effective means of incorporating global environments or backgrounds into our scene

4.2.3.8. Model Layers

3D models can be imported into a Quill scene for reference purposes.

Quill's tools do not allow direct editing of the models, but their properties can be animated with key frames just like any other layer.

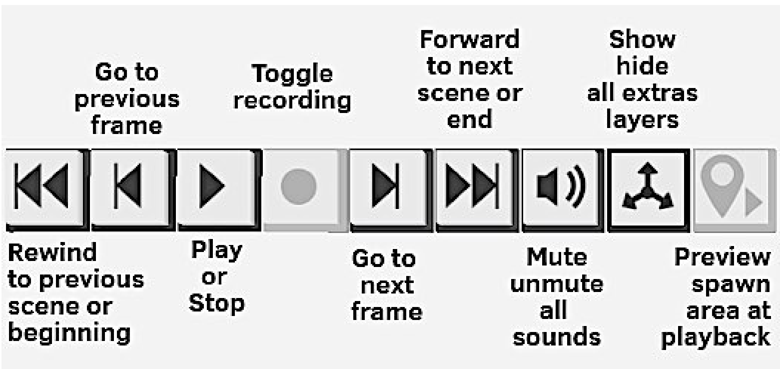
To access the settings for model layers, click on the cube icon located before the layer name.

4.2.3.9. Spawn Areas

Spawn areas determine the viewer's position within the scene for viewing purposes.

4.2.3.10. Playback Controls

The playback controls enable the initiation, cessation, and navigation of timeline content. During recording mode, any real-time transformation or opacity adjustment made to a layer is automatically recorded in the timeline at the current play head position.



Moreover, there exist global mute options for sounds and additional layers, along with a preview mode that synchronizes the working camera with the default viewpoint.

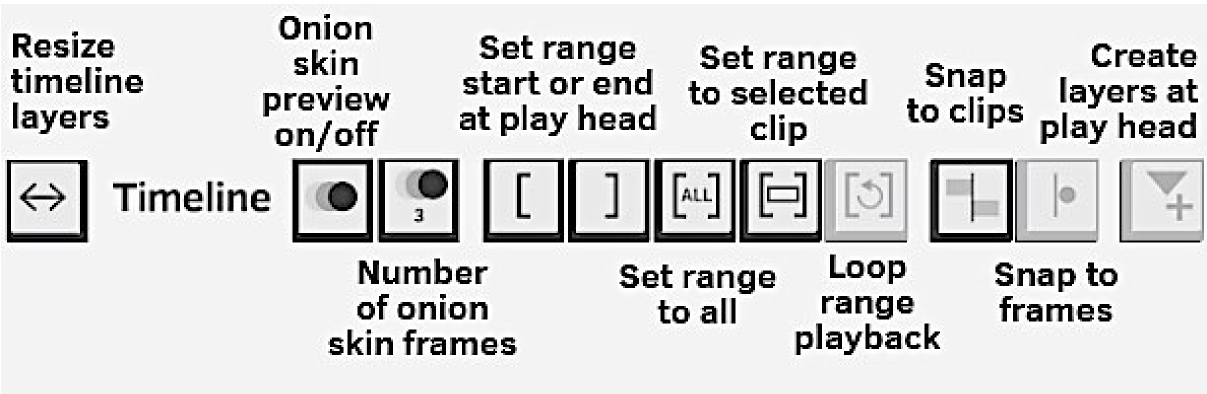
4.2.3.11. Timeline Options

The size of the timeline section can be adjusted by selecting the arrows button.

Onion skin settings enable the preview of animations when the playback is paused.

Range controls allow the selection of a specific working range, facilitating easy looping and rewinding within a smaller section of the scene.

Additionally, there are options for snapping and determining whether new layer clips should be created at the play head or at the beginning.



4.2.4. Animating and Recording

The animation process shares similarities with 2D animation. The animator begins by establishing key poses, followed by setting breakdowns, and finally manually creating in-betweens once the approved poses and breakdowns are in place.

Onion Skinning Quill VR features an functionality that aids in aligning frames. The previous frame is displayed in red, while the upcoming frame is shown in blue. Adjusting the onion skin settings allows users to view multiple frames simultaneously, facilitating better alignment of in-between frames.

Figure 79. The Onion Skin feature while animating in Quill

My main goal is to create a story that can be enjoyed by as many people as possible. To make it accessible, I want to ensure that it's comfortable to watch. The animation will be designed to be viewed from a seated position without needing to turn around completely. At the same time, I aim to minimize any discomfort that may come from virtual reality.

Based on Scientific research[28] that showed that seeing movement in the corners of our vision can make us feel sick. I decided to fade out the surroundings when there is fast movement in the animation. This will reduce the amount of moving things we see in our peripheral vision and keep the focus on the most important parts of the story. I'm intend in using this limitation as a way to enhance the storytelling.

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[28]N. Tian, P. Lopes, and R. Boulic, "A review of cybersickness in head-mounted displays: raising attention to individual susceptibility," Virtual Reality, vol. 26, no. 4,pp.1409-1441, 2022. DOI: 10.1007/s10055-022-00638-2.

Figure 80. The impact of peripheral movement on motion sickness

4.2.4.1. Techniques and Recommendations

Tips and Tactics:

Due to the frame-by-frame animation approach utilized by Quill, rectifying mistakes in the animation process can prove challenging, as it may involve difficulties in reverting back to the original state, as it may involve difficulties in reverting back to the original state.

Techniques:

During the animation process in Quill, various animation techniques were utilized to bring the characters and world to life. These included a rig-like workflow for the characters, as well as frame-by-frame animation for additional effects.

✤ To maximize efficiency, I discovered that it's best to focus on animating one element at a time. This allows me to give my full attention to the timing and spacing of each movement without being distracted by other elements. For instance, I worked on animating the Alexander first before adding the Spear. To keep the two animations synchronized, I created a separate layer for the Spear and made sure it had the same number of frames as the Alexander layer. This technique was also used in the last scene.

✤ In Quill, the order of animating models is crucial for achieving the desired results. It is widely known among experienced Quill users that the smallest object within a model should always be moved first. Moving the entire model should only be done at the very end of the animation process.By adhering to this order, we can achieve smooth and realistic animations within our models. The following example will illustrate this point: Let's imagine we have a model composed of various objects, and we aim to animate it. The initial step involves focusing on the smallest object within the model, such as an antenna. Once the smallest object has been animated, we can proceed to animate the other objects within the model. Finally, we can animate the entire model once all the individual objects have been appropriately animated. It is of utmost importance to follow this order when animating models in Quill, as neglecting it could lead to unexpected movements of the smallest object.

4.2.5.FX and Particles Simulation[29]

Particle animations are vital in creating visually captivating scenes in computer graphics and animation. In this exploration, the focus is on hand-animated techniques that provide artists with more artistic control and flexibility. The methods presented here utilizes transform keyframes and nested groups to achieve desired particle movements.

Creating Transform Keyframe Animations:

The first step involves using transform keyframes to animate particle groups. By applying keyframes to groups rather than individual layers, animations can be easily reused, eliminating the need for redoing animations for specific layers. This technique proves advantageous for future projects that require similar particle animations or the utilization of specific groups for baking.

[29] Retrieved from Tutorial by Animbrush, Goro Fujita: www.youtube.com/watch?v=4mTxgEx-wU4&t=694s

Achieving Varying Trajectories:

To introduce dynamic and natural-looking particle movements, multiple rotation pivots are employed. By nesting groups and applying rotation keyframes to each pivot, particle trajectories can be modified. Adjusting the angles and timings of the keyframes enables the creation of a diverse range of trajectories, simulating the randomness observed in real-world particle behavior. It is important to maintain linearity in the animations to emulate the constant velocity of particles in fluids.

Controlling Opacity and Fading Effects:

Opacity keyframes are utilized to control the visibility of particles over time, allowing for smooth fading effects. By setting keyframes at desired intervals and adjusting transparency values, particles can gradually fade in and out, enhancing the overall visual appeal. Aligning opacity changes with animation loop points ensures a seamless transition.

Creating a Loop and Baking Particle Animation:

To create a looped animation sequence, the particle animation is duplicated and aligned to start at the desired point in the timeline. By adjusting the loop start time, a small gap can be introduced between subsequent animation cycles, adding further variation to the particle simulation. Once the desired loop is achieved, the animation can be baked into a frame-by-frame sequence ready for further manipulation.

Offset Animations and Merging:

To add diversity and avoid uniformity in particle behavior, offsetting animations is recommended. By trimming and offsetting individual animations, each particle group exhibits distinct behaviors. The process involves trimming the desired amount from the start of each animation, ensuring consistent length across the complete animation sequence. When merging offset animations, continuity is maintained without any noticeable jumps or disruptions.

Reusability and Scene Integration:

The advantages of the presented technique extend beyond initial animation creation. Frame-by-frame particle animations can be saved and reused in other scenes by importing them into new projects. By removing unnecessary elements and retaining the particle animations, artists can effortlessly incorporate these dynamic particles into future projects, saving valuable time and effort.

4.2.6.Camera Setting

In this section, I discuss the camera features in detail. There is a feature called camera layers, which allows for the creation of multiple cameras. Each camera creates a field of view and has a monitor panel to display its output. Scaling the camera is important to avoid clipping. If the camera is too large, it may start clipping, so it is advisable to make it smaller to get closer to objects without clipping.

To change the field of view, one needs to adjust the camera options. The lens setting determines the field of view, and it's important to note that it is not keyable. Each camera has a predefined field of view, similar to a real camera. The monitor panel is a powerful tool that allows for switching between cameras, adjusting composition, and framing shots. The resolution can also be changed in the monitor panel to visualize the final output.

Rendering Cameras:

The yellow bar in the timeline represents the range slider for rendering. The start and end points of the range we want to render can be defined. The export panel provides options for sharing with media studios, capturing 2D thumbnails, or rendering. The desired camera can be selected for rendering and its output can be previewed within the defined range. Different codecs are available for rendering, and if the resolution exceeds 4K, the vpx codec is required. The quality can be adjusted, and the rendered file will be saved in the designated folder.

Figure 81. Camera setup in Quill VR

Animating Cameras:

To animate cameras, it is recommended to use a single camera for convenience. A new camera group can be created, and the camera can be positioned within it. Keyframing the group's position and rotation allows for creating camera movements. Scaling the group enables bringing the camera closer without losing the ability to rotate around the pivot. To achieve smooth camera movements, the step interpolation option between keyframes can be utilized.

By animating the camera in this manner, complex and dynamic shots can be created. The monitor panel aids in visualizing camera movements, and switching between animated cameras is straightforward. Setting the range and previewing the animation ensures a clear understanding of the intended rendering. Spatial audio can also be integrated, enhancing the immersive experience.

4.2.7. Export and Sharing

The process of exporting a Quill file involves saving the file within the Quill application and then selecting the "3D Model" option in the export menu. One of the commonly used export settings is the "inm" option. This setting ensures that the Quill file is converted into an Interactive Media Markup (IMM) format suitable for uploading to platforms like Oculus Media Studio.

To create an Oculus Media Studio account, users should visit the creator.oculus.com website, log in with their Facebook or Oculus account, and complete the registration process as an individual or organization.

During registration, it is necessary to mention past artwork and express the intention to upload Quill work. After approval, users can access their library to manage and upload content, including providing relevant details such as titles, descriptions, and thumbnail banners. It is important to note that approval is required before publishing, and saved drafts will only be visible to the creator on the Oculus Quest platform. Direct links can be obtained for published or published unlisted pieces to share the work with others.

4.3.Post-Production

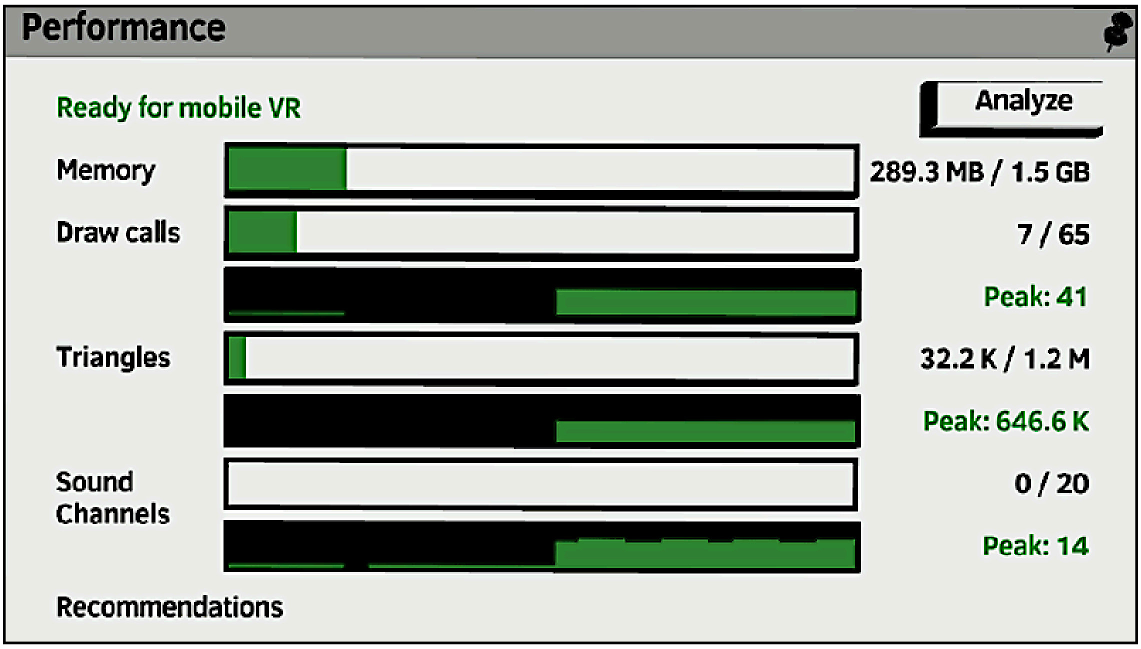
4.3.1.Optimization

The Oculus Quest 2 headset has been proven to offer a self-contained platform for gaming and media consumption, eliminating the need for additional computing hardware. However, due to its integration of a mobile phone chip, the headset's processing power is limited. This limitation becomes particularly relevant when using Quill. Thus, it is crucial to maintain consistent performance within the optimal range, in order to ensure an optimal experience.

When working on a project intended for publication, certain restrictions need to be considered. To enable the experience to be enjoyed anywhere on the standalone headset without relying on a high-performance computer, creators must adhere to these restrictions. These limitations encompass the total number of visible triangles and the maximum number of draw calls allowed within a project simultaneously.

The Oculus TV's VR Animation Player (VRAP) is specifically designed for Quest 2 headsets, which utilize a mobile chipset. Consequently, the rendering power available to viewers experiencing our film or piece is relatively lower compared to the capabilities of Quill, which was created on a PC. However, this disparity should not be cause for alarm, as it is to be expected. Quill handles a greater level of algorithmic complexity due to its extensive editing capabilities, whereas the VRAP playback engine operates on a pre-determined and non-editable geometry within the IMM format, resulting in faster and easier rendering.

Nevertheless, it is crucial to maintain a lightweight composition since the VRAP relies on a low-power chip for rendering. In fact, when uploading our piece to the Oculus Media Studio (OMS), the platform will assess its suitability for playback on a Quest 2 headset. If the piece surpasses certain thresholds in terms of complexity or weight, it may be rejected. To assist in optimizing the weight of our piece, Quill provides the Optimization Toolbox panel.



The OMS evaluates four specific metrics to determine the compatibility of a piece for Quest 2 playback: (1) Memory usage, (2) number of Draw Calls[30], (3) number of Triangles, and (4) number of Sound Channels.

Triangles per frame	Maximum 1.2 million
Memory usage at any time during playback	Maximum 1.5GB
Draw calls at any time during playback	Maximum 65
Sound Channels at any time during playback	Maximum 20

Each of these metrics has a predefined threshold that must not be exceeded in order for the piece to be accepted for publishing. Quill incorporates these thresholds into its Performance panel, allowing us to assess and address any potential issues that may arise. By utilizing this tool, we can make informed artistic decisions and identify areas where simplification may be necessary.[31]

[30] A Draw Call in the context of Oculus TV's VR Animation Player is equivalent to 65536 triangles.

[31] For the official and most up-to-date values of these metrics, please refer to the OMS website at the following link: https://creator.oculus.com/media-studio/documentation/quill

4.3.2.Audio

4.3.2.1.Spatial Sounds

Quill has a user-friendly interface for creators to synchronize animations and sound effortlessly by displaying audio waveforms in the timeline. To enhance the immersive experience, sound layers can be spatialized and positioned in 3D space, allowing for a realistic audio placement. Creators have the flexibility to modify and animate sound sources over time by applying transforms. These transforms can be applied individually or as part of groups and sequences. To access the sound settings, users can simply touch the speaker icon located before the sound layer name. The following options are available:

1. **Reimport:** This option allows users to choose an updated version of the referenced audio file or even select a completely different file. When the document is reopened, the audio waveforms on the timeline are redrawn accordingly.

2. **Test:** Users can preview the audio file referenced by the selected sound layer when the timeline is stopped.

3. **Loop:** Enabling this option allows for sample-accurate, end-to-end looping of the sound layer audio file.

4. **Spatialize:** This option enables spatialization for monophonic sounds. Non-spatialized mono sounds play in a head-locked manner.

5. **Gain:** Users can adjust the volume of the sound layer, ranging from 0.0 (silence) to 1.0 (no attenuation).

6. **Mute & Solo:** These options allow users to mute or solo the selected sound layer, respectively.

7. **Transform:** Enabling this option enables users to move the emitter's transform while the sound layer pane is open. It replicates the functionality described in the Transform tutorial.

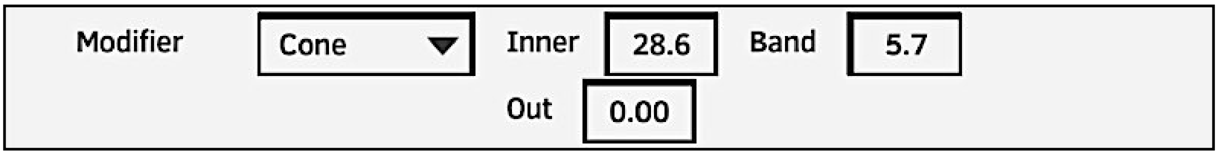
8. **Attenuation:** Attenuation controls the fading of sound based on the distance from the source. It is visualized as a green sphere within which the sound volume is maximum, and a red sphere beyond which the sound becomes inaudible.

    - **None:** The sound is spatialized, but no attenuation over distance is applied.
    - **Linear:** Linear curves gradually fade out sounds over distance.
    - **Logarithm:** Logarithmic curves fall off more quickly over distance and closely mimic human hearing behavior.

4.3.2.2.Sound Modifiers

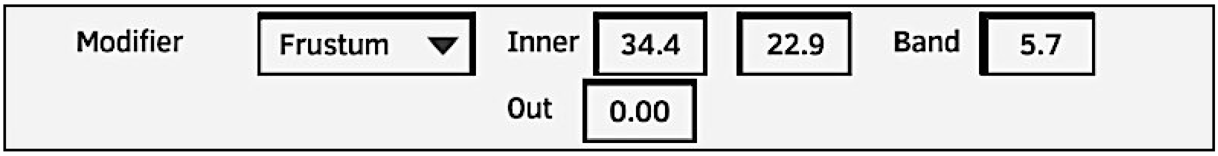
Modifiers can be applied to achieve directional sound emission in a cone or frustum (pyramid) pattern. These modifiers are previewed as nested cones or frustums, with the green zone representing the maximum volume and the red zone indicating the specified volume by the layer's Out values.

For cone emitters:



- **Inner Angle:** The green shape represents the inner angle within which volumes are multiplied by 1.0 and play at full volume.
- **Band:** The transition zone where the volume fades from the Inner value/full volume to the volume specified by the Out value. Visually, the Inner + Band represents the angle of the red cone.
- **Out:** This determines the volume of the sound layer when the listener is outside the range of the layer's Band. Sound layers with an Out value of 0.0 will be silent outside the red-colored cone shape.

For frustum emitters:



- **Inner 1:** Represents the horizontal inner angle or width. Within this angle, volumes are multiplied by 1.0 and play at full volume.
- **Inner 2:** Represents the vertical inner angle or height. Within this angle, volumes are multiplied by 1.0 and play at full volume.
- **Band:** The transition zone where the volume fades from the Inner values/full volume to the volume specified by the Out value.
- **Out:** Determines the volume of the sound layer when the listener is outside the range of the layer's Band. Sound layers with an Out value of 0.0 will be silent outside the red-colored frustum shape.

Quill supports audio source file formats such as WAV, OGG, and MP3. Both stereo and mono files

4.3.2.3. Voice Over and Narration

In the realm of virtual reality, the viewer will have the freedom to look around, but this will also mean that framing a shot perfectly will not be possible. Consequently, techniques will be employed to lead the eye of the viewer and ensure that no essential aspects of the story are missed. Various methods will be tried, ranging from simple composition to techniques commonly used in cinema. However, it will be found that the combination of movement and audio proves to be the most effective way of guiding the viewer's eye.

To this end, a flying arrow will be utilized in the future, with the arrow flying in front of the viewer's face. The sound of his humming will be spatialized, meaning it will give the impression that the sound is coming from left to right or vice versa, and it will feel as though arrow is now in front of the viewer. Quill will be instrumental in creating such techniques, as it will make working with spatialized audio easy. These techniques will prove essential in directing the viewer's attention and guiding them through the story in the future. To ensure precise timing and pacing, it is intended that text-to-speech sound clips in the Persian language will be utilized as temporary narration placeholders. Subsequently, these clips will be imported into Quill to ascertain the pacing, rhythm, and flow of the animation.

During the production phase, I had this remarkable opportunity to visit the recording room of Robin Studio. This visit will grant the privilege of engaging professional voiceover artists for the purpose of narration. The seamless integration of the freshly recorded voices into the experience will be a straightforward process, involving the replacement of the existing text-to-speech clips with the newly acquired audio clips. In parallel, close collaboration will be maintained with a skilled sound team to meticulously craft an immersive auditory landscape, incorporating impactful sound effects, atmospheric tones, and captivating music. Witnessing the harmonious convergence of all these elements within the very Quill file that was initiated will undoubtedly be a profoundly inspiring moment.

4.4. Improvements:

4.4.1. Quill to Blender

4.4.1.1. Stylized Texture

Upon importing the quill geometry into Blender, the layers from Quill are automatically separated within Blender. This separation proves advantageous when applying materials to specific sections of the character. Therefore It is advised to utilize a new layer during this process, as it simplifies subsequent tasks when importing the model into Blender and applying distinct materials to different components of the characters. It is important to note that the color data can be accessed in Blender through the utilization of the vertex color node.

Before commencing with the material application, it is necessary to remove the default materials added by Quill and initiate the process anew. To begin, a vertex color node is added, and upon connecting it to the base color, the colors previously assigned in Quill become visible within Blender.

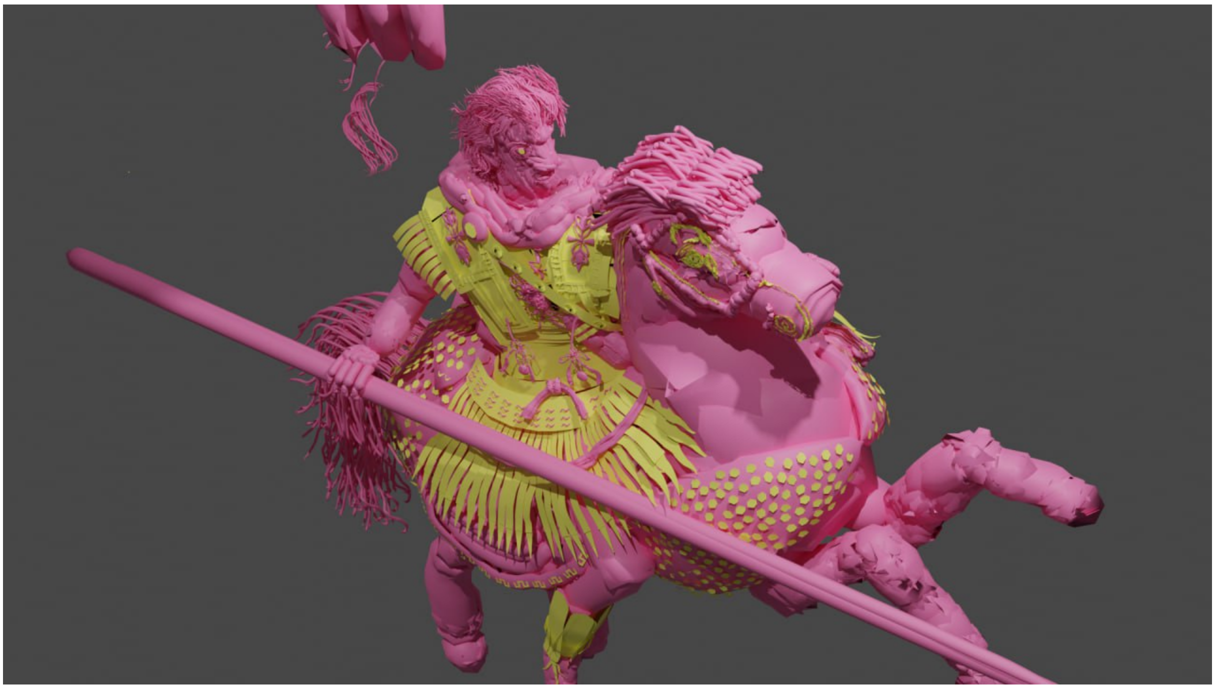


Figure 82. Assigning different materials to the imported model

Subsequently, an image texture is introduced, functioning as an alpha map. This particular map consists of black and white imagery featuring various random brush strokes, thereby imparting a painterly aesthetic. Adjusting the material's blend mode to Alpha Hashed is essential, and it is also imperative to perform UV unwrapping using the Smart UV Project.

Figure 83. The Alpha map made with several random black and with brush strokes

The current appearance may not be entirely accurate, thus requiring the inclusion of an invert node to rectify the issue. The resulting setup encompasses an alpha texture alongside a color texture or vertex color.

Figure 84. Snapshot from the models imported in Blender viewport

The UV map features scattered polygonal islands within the UV space, aligning perfectly with the texture map. The newly created material is then applied to the remaining sections of the character. The unwrapping process and vertex painting are repeated for all objects, with color additions made as necessary. Due to the chaotic nature of the UV map utilized for the alpha texture, a new UV map is created and projected from the view.

It should be noted that the vertex color applied in Quill's VR environment may appear darker or exhibit slight hue deviations when imported into Blender. While the exact cause of this discrepancy remains unknown, adjustments can be made using hue saturation nodes or by repainting the affected areas.

To animate the alpha map texture, keyframes are inserted for the mapping coordinates. The graph editor is then utilized to adjust the movement accordingly, with the interpolation set to linear to avoid any easing effects. Playback speed is adjusted to 12 frames per second to facilitate better texture evaluation.

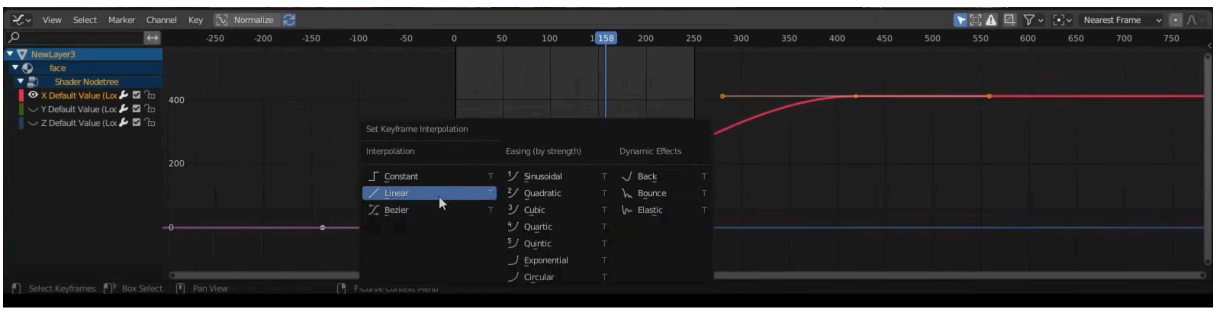


Figure 85. Graph Editor for animating the texture

4.4.1.2.Rigging and Animation

Next I will be focusing on rigging and animating a character using the Auto Rig Pro add-on in Blender. My aim will be to harness the advanced features of Auto Rig Pro, which will allow me to achieve precise rigging and seamless retargeting of motion capture data to my custom rig. This add-on will prove to be an invaluable tool, particularly in the context of Blender where comparable functionalities are scarce.

To enhance my future animations, I will incorporate a pre-existing animation cycle sourced from Mixamo[32], which is an online platform that provides a reliable collection of pre-made

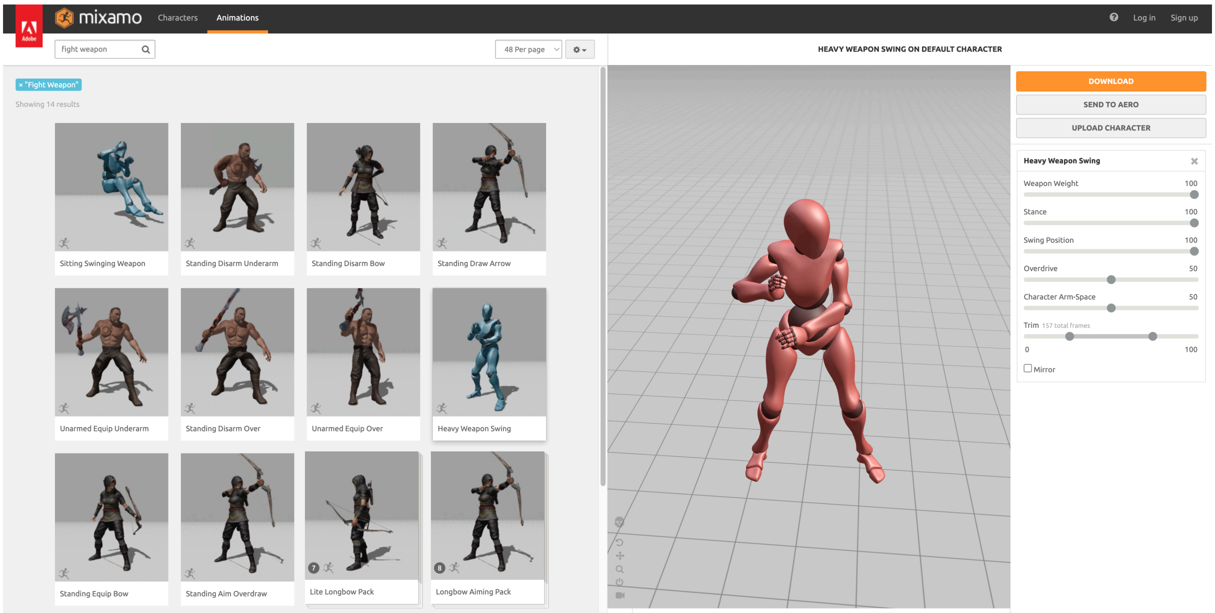


Figure 86: Screenshot from Mixamo.com, an online animation sequence resources website.

3D character models, animations to simplify the process of creating realistic animations.

4.4.1.3.Lightening and Rendering

For the lighting, the first step will be to add a sun lamp, which will serve as the primary light source in the scene. I will make some key adjustments, such as turning on contact shadows

[32] https://www.mixamo.com/

and reducing the bias of the light. These changes will allow the light to affect even the smallest details in the geometry, emphasizing the quilt geometry that I have painted.

Additionally, in the render settings, I will enable ambient occlusion, set the desired value for it, and turn on Bloom and SSR. To ensure high-quality shadows, I will maximize the shadow resolution.

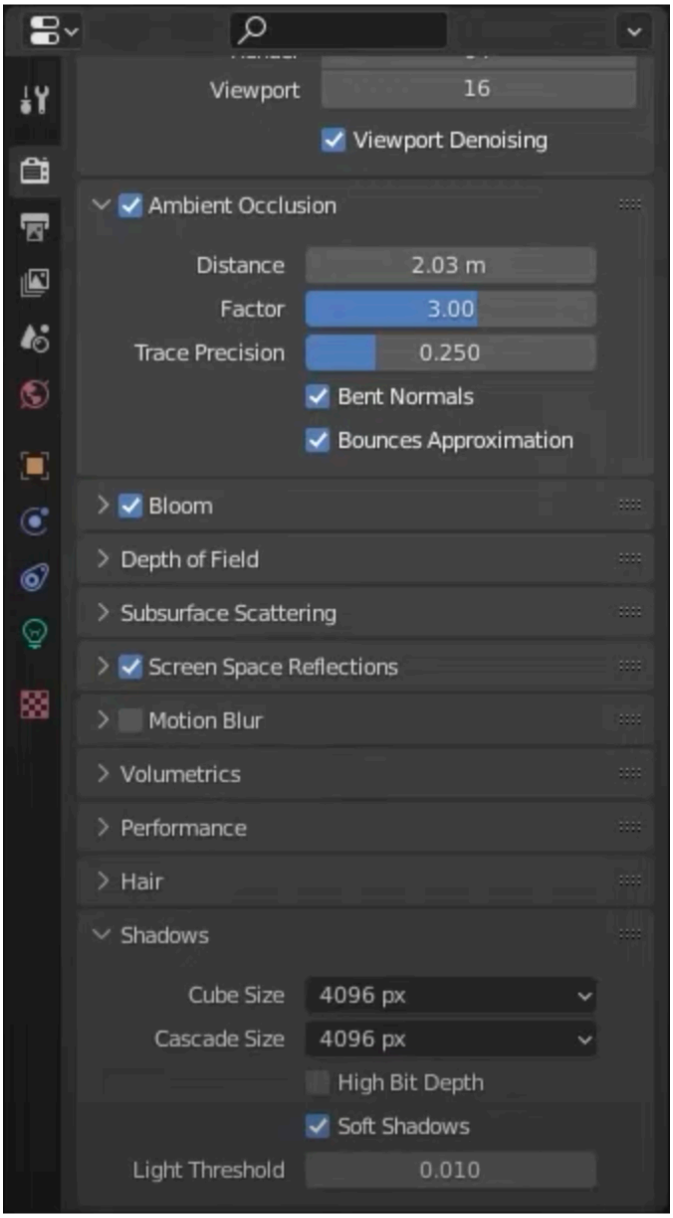


Figure 87. Render settings on Blender

Eevee is recommended for its speed and real-time feedback. World settings will be adjusted to fill shadows with color, creating a global illumination effect. Material adjustments will be made, and additional lights added for reflection. Furthermore, I will configure the time remapping settings to render every second frame as a PNG sequence with an alpha channel

I'll use an emissive shader for the background plane, render a quick preview, and create a shadow catcher. Further adjustments will be made based on feedback, such as tweaking colors and replacing the head with a 3D scanned one.

For the final render, settings will be optimized, and transparency enabled. Background plane will be removed, keeping shadows intact. In post-processing, I'll add a color layer to enhance the final result. This completes the lighting and rendering phase.

Figure 88. The 3D models created in Quill and lighted using Blender

4.4.2.Claymation Appearance

The animation can be significantly enhanced and imbued with a claymation aesthetic through the utilization of Blender nodes and the implementation of a realistic clay shader.

After setting up the character and the ground plane, adjustments will be made to accurately visualize colors in Quill. The shader editor will be used to activate contact and height shadows for better effects. Unwanted artifacts from the previous tutorial will be addressed using an attribute node. The shader will be exported without alpha and the color format will be adjusted accordingly. Lighting intensity will be adjusted, and materials will be applied to the character and ground plane. The head will be duplicated for future use, and studio mode will be preferred over render mode. To achieve a clay-like appearance, a subdivision surface node and a displace node will be added, and smooth shading will be enabled. Data transfer techniques, including face corner data and face projection, will be utilized to enhance the results. Normals will be smoothed for improved visual quality.

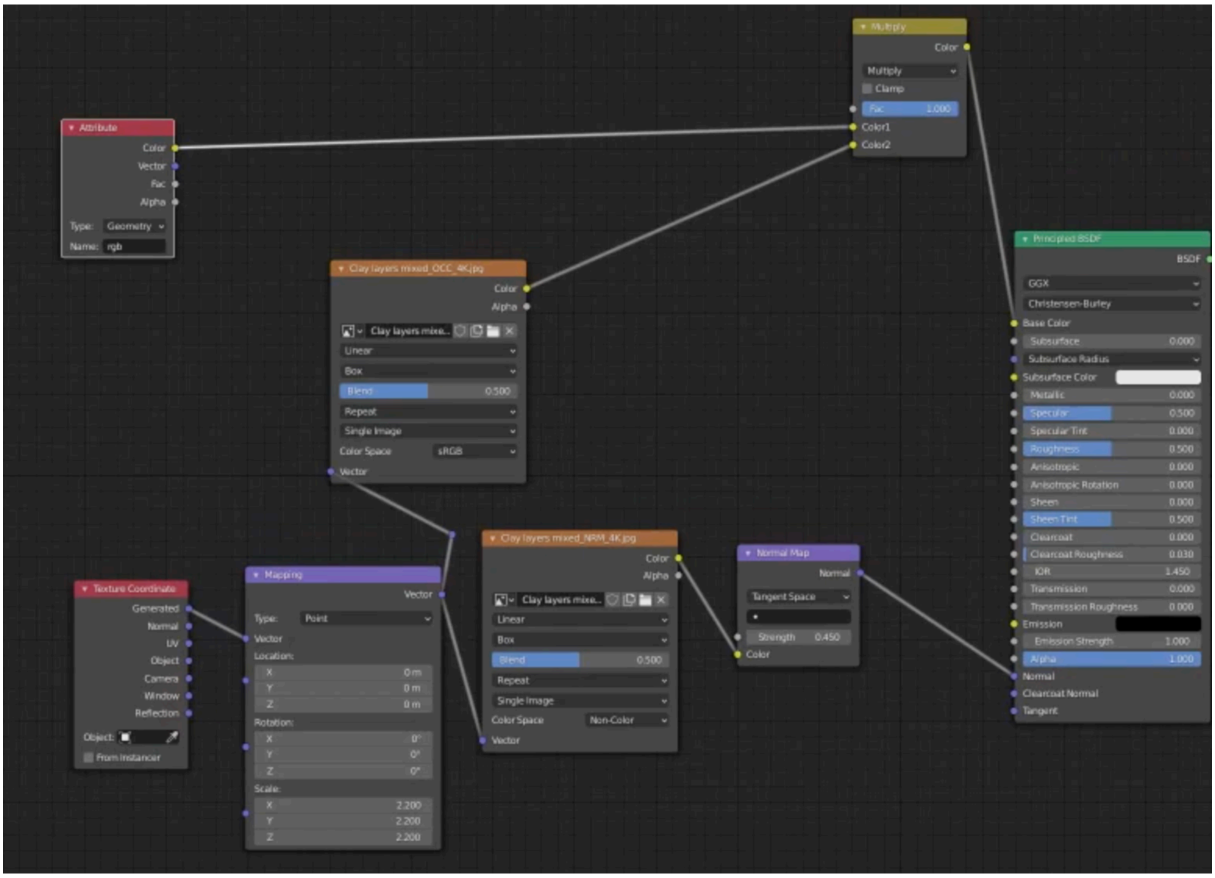


Figure 89. Blender Procedural Nodes used for adding Clay look to the models

The clay-like appearance will be refined by adjusting the strength and scale parameters. Additional enhancements will be made by adding normal and occlusion maps. The diffusion component will be derived from vertex colors, and a roughness map will be created by blending shaders. The roughness map will then be connected and fine-tuned to achieve the desired outcome. The previous adjustments to normals will play a role in determining the optimal range of roughness.

5. Chapter V.

5.1.Conclusion

5.1.1.Overcoming Limitations and Enhancing Efficiency

My thesis explores the potential of virtual reality tools, specifically Quill, for animation and storytelling. Through the process of creating a project, I have discovered that these tools offer unique opportunities to push the boundaries of storytelling. The immersive experiences enabled by virtual reality can establish deeper emotional connections between viewers and the narrative. It has the potential to revolutionize storytelling in the future.

Virtual Reality reignited my passion for animation, allowing me to focus on the artistry of each frame without the burden of technical complexities like rigging. Unlike traditional tween animation and 3D software, VR animation preserves the joy of crafting frames by hand, reviving the freedom and satisfaction of frame-by-frame animation. Unlike stop-motion animation, I was able to make adjustments to specific frames, such as adding a blink to a character.

The decision to use Quill was motivated by the limitations I encountered while working in 2D animation. As I often visualize scenes in a 3D format, but the 2D concepts I created didn't always capture the vision I had in mind. I realized the abstract nature of creating 3D art on a 2D screen and recognized the crucial role VR creation will play in shaping future 3D productions. Quill allowed me to effortlessly paint and animate within the same scene, translating my physical movements into animated actions and bridging the gap between my 2D imagination and 3D realization.

Creating 3D illustration and animating in VR involved significant trial and error due to limited learning resources.A major obstacle was character design, as making significant changes became challenging. To address this, I minimized paint strokes for soldiers while preserving essential details, resulting in faster processing times. Animating one element at a time and syncing them together achieved a smooth and cohesive animation.Working with Quill required acknowledging its limitations, particularly with brushes and animation layout. The absence of a keyframe copying option in the Quill animation timeline necessitated careful planning for looping and maintaining positions.

In conclusion, my thesis demonstrates a glimpse into the immense potential of virtual reality storytelling, and I eagerly anticipate its future development.

5.1.2.A Reflection on the Future of Animation

The animation industry has undergone significant transformations since its inception, moving from traditional hand-drawn animation techniques to computer-generated imagery and virtual reality. With the emergence of advanced technologies, it is predicted that the future of animation will be characterized by an even more profound transformation.

In the coming years, the animation industry is expected to experience a shift towards more immersive and interactive experiences. Advances in motion capture technology and virtual reality are likely to play a significant role in this transformation. The development of powerful and accessible tools for creating VR content has already begun, enabling artists to create immersive animated worlds that viewers can experience from a first-person perspective.

One exciting aspect of VR animation is the collaboration it offers to artists. By connecting and working together in a shared virtual space, artists from different locations can come together and simultaneously contribute to a project. This opens up new possibilities for teamwork, creative exchange, and real-time feedback.

Another significant development in animation is the rise of real-time rendering techniques. This technology will change the way animated content is produced and consumed. It also allows for the creation of interactive animated content that can be experienced in real-time, providing viewers with a new level of engagement and interactivity.

Furthermore, machine learning and artificial intelligence are poised to play a significant role in the future of animation. These technologies can be used to automate the animation process, reducing the time and effort required to create complex animations. They can also be used to create more realistic and lifelike animations, enabling artists to focus on the creative aspects of their work.

In terms of display, the future of animation is likely to be characterized by increased use of virtual and augmented reality technologies. The development of the Metaverse is also expected to play a significant role in the future of animation, as it offers a platform for creating and experiencing interactive and immersive animated content.

Overall, the future of animation is bright and exciting, with advances in technology and new methods of production and display offering new possibilities for artists and viewers alike. The industry is set to become more immersive, interactive, and accessible, offering a whole new level of engagement and creativity

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