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Bridging Traditions and Technology: The Recreation of Traditional Chinese Paintings in Virtual Reality

MASTER'S THESIS

Digital Arts

submitted to

University of Kent

Supervisor

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University of Kent

School of Engineering

Canterbury, November 2024

Abstract

This master's thesis delves into the challenges and opportunities of using Virtual Reality (VR) as a medium for preserving and interacting with cultural heritage, with a particular focus on traditional Chinese paintings—a genre known for its unique artistic characteristics that pose specific challenges in VR translation. The investigation centres on the innovative application of VR technologies, using Tilt Brush to recreate three distinct artworks by Wu Guanzhong, an artist celebrated for his synthesis of traditional Chinese and modern techniques.

The project begins with an in-depth analysis of the inherent difficulties in preserving and rendering traditional Chinese paintings in VR. It examines the essential qualities of these artworks, such as brush strokes, colour gradients, and spatial compositions, and how they can be authentically represented within a three-dimensional, interactive space. The study systematically reproduces three of Wu Guanzhong's paintings to explore these challenges firsthand, offering practical insights into the process and the technology's current limitations.

Building on these reproductions, the thesis presents a series of observations and methodological recommendations aimed at improving VR's capacity to handle such complex artistic translations. These recommendations are then applied in the creation of an original VR artwork, which serves as a practical test case for the proposed techniques. This helped me test the validity of the earlier findings, while continuing to explore the potential of VR to create engaging, authentic experiences that remain true

to the cultural and aesthetic essence of traditional art forms.

In conclusion, the thesis reflects on the fidelity of VR in replicating traditional Chinese art but also contributes to broader discussions about the role of emerging technologies in cultural preservation. By documenting the challenges encountered and the solutions proposed, this research provides valuable guidelines for future projects aiming to integrate VR into the domain of art conservation and interaction, suggesting a promising, albeit complex, pathway for blending heritage with modern technology.

Contents

Acknowledgements

First and foremost, I would like to express my sincere gratitude to my supervisor Alexandra Covaci, for her continuous support, guidance, and encouragement throughout my research and the writing of this thesis. Her insightful feedback and constructive criticism were invaluable in shaping this work.

Special thanks to Engineering Department at the University of Kent for providing the necessary resources and a conducive environment for my research.

I would like to acknowledge my colleagues and friends who provided me with support, camaraderie, and stimulating discussions. Their encouragement and assistance were crucial during the challenging times of this research journey.

A heartfelt thanks to my family for their unwavering support and understanding. Their patience and belief in me have been instrumental in the completion of this work.

Finally, I would like to extend my gratitude to all those who have contributed, directly or indirectly, to the successful completion of this thesis. Your support and encouragement have been deeply appreciated.

Nana Ma

CHAPTER 1

Introduction

1.1 Context and Background

This research is situated at the intersection of technology, art, and cultural preservation, aiming to analyze the potential of VR technology not just to replicate the visual aspects of Wu Guanzhong's paintings but also to capture and convey the essence of their traditional aesthetic and philosophical dimensions. The initiative is driven by a broader goal to enhance the accessibility of traditional Chinese art, offering a novel platform for educational engagement and cultural preservation in the digital era.

By focusing on the application of VR technology to recreate Guanzhong's artworks, this thesis ventures into relatively uncharted territory within the realms of digital humanities and the integration of art and technology. This exploration is particularly pertinent given the prevalent use of VR in replicating the works of Western artists, where the emphasis often lies on the dimensional and spatial aspects that align more naturally with VR's strengths. In contrast, traditional Chinese paintings, characterised by their intricate brushwork, subtle gradations of ink, and a profound embodiment of philosophical concepts, present unique challenges for reproduction in a virtual

environment. These artworks are not just visual representations but have cultural, emotional, and philosophical significance, demanding a nuanced approach to their digital reproduction.

The predominance of VR applications in showcasing Western art has brought a technological and cultural disparity, where the distinct qualities of Eastern artworks, especially those as nuanced as Chinese paintings, risk being underrepresented in digital transformations. Traditional Chinese art, with its emphasis on harmony, balance, and the spiritual interplay between man and nature, operates on principles distinctly different from those of Western art. This divergence extends to the physical techniques employed, such as the use of rice paper, ink sticks, and the specific strokes of the brush, which are challenging to replicate with the current capabilities of VR tools like Tilt Brush. These tools are often designed with Western art methodologies in mind, emphasising volume, perspective, and a form of interaction that does not directly translate to the fluidity and subtlety required by Chinese painting techniques.

This thesis thus raises critical questions about the fidelity of artistic reproduction when transitioning from traditional Chinese painting to VR environments. It scrutinises the adaptability of traditional art techniques to new media and contemplates the broader implications of these technological advancements for the future of art preservation and appreciation. By doing so, it contributes to a more inclusive understanding of how VR can serve diverse artistic traditions, highlighting the need for technological innovations that respect and preserve the unique characteristics of non-Western art forms. In tackling these challenges, the research aims to pave the way for a more nuanced integration of art and technology, ensuring that the global cultural heritage is faithfully represented and preserved in the digital age.

1.2 Motivation

The motivation for this thesis arises from a fascination with the challenge of translating the nuanced characteristics of traditional Chinese paintings, specifically those by Wu Guanzhong, into the immersive realm of VR. This inquiry is driven by an appreciation for the delicate balance between artistic integrity and technological adaptation, exploring how the unique elements of traditional art can be faithfully represented within a digital medium. The project is rooted in a deep respect for the tangible heritage of Chinese painting and an awareness of the complexities involved in its digital recreation. Central to this research is an investigation into the specific considerations necessary to preserve the aesthetic and philosophical essence of traditional art in VR.

Despite the increasing adoption of VR technologies in artistic creation and exhibition, existing research has largely focused on technical development or immersive experience, with comparatively limited attention given to practice-based investigations of how traditional Chinese painting can be translated into immersive virtual environments. In particular, there remains a lack of systematic examination of how key pictorial qualities, such as brushwork, spatial composition, and the use of negative space, can be preserved or meaningfully reinterpreted within VR contexts.

This includes examining how VR tools, such as Tilt Brush, can be adapted to mimic traditional Chinese painting techniques and the implications of these adaptations for the artwork's integrity. By delving into these considerations, the thesis aims to contribute to a nuanced understanding of the interplay between technology and art, offering insights into the possibilities and limitations of VR as a medium for cultural expression.

This endeavour seeks not only to navigate the technical challenges of such a translation but also to reflect on the broader implications for art preservation and presentation in the digital age. Through a detailed exploration of the adaptation process, this

work aims to enrich the discourse on digital humanities, particularly in the context of integrating traditional art forms with emerging technologies. The ultimate goal is to provide a thoughtful examination of how VR technology can complement the preservation and appreciation of traditional Chinese paintings, thereby contributing to the ongoing evolution of art and its engagement with technology.

1.3 Research Questions and Contributions

This thesis investigates the innovative application of VR technology in recreating traditional Chinese paintings, with a focus on the works of Wu Guanzhong. By leveraging VR tools like Tilt Brush, this research navigates the intersection of traditional art and modern technological mediums. The following research questions are central to our exploration, addressing both the technical and artistic challenges:

RQ1: What are the artistic and technical challenge in adapting traditional Chinese paintings into VR environments?

RQ2: What modifications are necessary to adapt traditional Chinese painting techniques to VR tools like Tilt Brush, and how do these affect the artwork's integrity?

RQ3: To what extent can VR recreate the aesthetic and philosophical essence of Wu Guanzhong's artwork? What specific adaptations can enhance the VR experience to align with traditional Chinese artistic principles?

RQ4: How can a framework facilitate the adaptation of traditional art to VR, particularly on limited platforms?

This thesis makes several significant contributions to the fields of digital humanities, VR technology, and the preservation and appreciation of traditional art. One of the primary achievements is the successful recreation of selected Wu Guanzhong

paintings in VR, offering an immersive and interactive experience that opens new dimensions for art appreciation. Users are now able to engage with traditional Chinese art in unprecedented ways, bridging the gap between historical art forms and modern technology. Furthermore, the comprehensive exploration and evaluation of various VR tools shed light on their utility and limitations in replicating traditional art techniques. This reflection on the adaptation process provides valuable insights into how VR technology can be further developed or modified to better serve the preservation and presentation of traditional art forms. By navigating the challenges of integrating traditional Chinese painting techniques with cutting-edge VR technology, the thesis contributes to a deeper understanding of how these two realms can complement and enhance each other, advancing the field of digital humanities and offering a model for future endeavors in the fusion of art and technology.

1.4 Thesis Structure and Organization

Chapter 2 introduces the existing works related to this research. This part briefly introduces the background of this thesis from the perspectives of VR technology and Chinese painting art. Chapter 3 introduces the research methods used in this work. Chapter 4 introduces the VR reproduction of Wu Guanzhong's work *Water Town*. Through this work, we studied the VR construction problems of multi-element Chinese painting scenes. In Chapter 5, we took three animal paintings by Wu Guanzhong as examples to study the challenges and possible solutions of VR technology for the creation of Chinese animal paintings. In Chapter6, based on these technologies, I created a VR painting with the theme of a Chinese mountain village. Finally, Chapter 7 summarizes the entire study.

CHAPTER 2

Related Work

This literature review focuses on exploring how Virtual Reality (VR) technology is being used alongside traditional Chinese art, with a special look at Wu Guanzhong's work. I aim to cover everything from the basics of VR technology to its role in art and preserving cultural heritage. The goal is to understand how VR can help us experience and interact with traditional art forms, especially Chinese paintings, and what challenges and opportunities this combination presents.

2.1 Virtual Reality Technology: An Overview

VR is a cutting-edge technology that creates immersive digital environments, simulating physical presence in real or imagined worlds [1]. Users interact with these environments using specialised equipment, such as headsets, gloves, and controllers, which track movements and adjust the virtual space accordingly [2]. The essence of VR lies in its ability to immerse users completely in a virtual experience, making it distinct from traditional screen-based media by offering interactive, 360-degree worlds that engage multiple senses [3].

2.1.1 Historical Development of VR

The story of VR technology's development is a fascinating one, moving from early dreams to everyday reality. It started in the 1950s with Morton Heilig, an innovator who imagined creating immersive experiences that could engage all the senses. He built the Sensorama, a machine that could simulate experiences like riding a motorcycle, complete with sights, sounds, and even smells. Although it was ahead of its time, the Sensorama was too complex and expensive to become widely used [4].

In the 1980s and 1990s, as computers and graphics got better, the first VR headsets and systems were created. This was when VR began to shift from just an interesting idea to something people could actually experience. One notable creation from this time was the cave system from the University of Illinois, which let people walk around inside a virtual room, seeing and interacting with 3D spaces [5].

In recent years, the accessibility of VR technology has seen a remarkable improvement, directly impacting fields as diverse as gaming, education, and the arts [6]. The advent of standalone VR systems, which operate independently without the need for tethering to a powerful computer or external sensors, has significantly lowered the barriers to entry [7]. This development has made VR more approachable and affordable for a broader audience, enabling more individuals to explore immersive experiences. Moreover, the investment from major technology companies in VR infrastructure and content has underscored the technology's growing importance. These companies envision VR as not just a revolutionary platform for entertainment, but as a transformative tool for educational purposes and cultural engagement. This shift towards widespread adoption and integration offers exciting possibilities for art and heritage preservation.

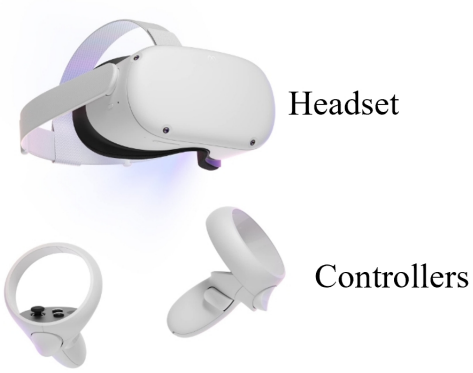


Figure 2.1: A typical VR device: Headset and controllers

2.1.2 Technical Foundations of VR

At the heart of VR technology lie several core components that work together to create immersive, interactive virtual environments. Understanding these foundational elements is essential to grasp how VR brings digital worlds to life and how it can be harnessed for applications ranging from entertainment and education to art preservation.

Hardware

Headsets: The VR headset is the primary interface between the user and the virtual world. Equipped with high-resolution displays for each eye, headsets create a stereoscopic effect, giving the illusion of depth and making digital environments appear lifelike. Modern headsets also incorporate advanced motion sensors (such as gyroscopes, accelerometers, and magnetometers) that track the user's head movements, ensuring that the virtual scene adjusts in real-time to their perspective and movements [8].

Controllers: Handheld controllers are another crucial piece of VR hardware, allowing users to interact with the virtual environment in an intuitive manner. These controllers are equipped with buttons, joysticks, and sometimes touchpads, along with motion tracking sensors. They enable users to pick up objects, navigate through spaces,

and perform actions within the VR experience, enhancing the sense of presence and immersion [9].

Motion tracking systems: Beyond headsets and controllers, motion tracking technology plays a pivotal role in VR. This can include external sensors placed around the room to track movement in a larger space or inside-out tracking systems built into the headset itself. These systems accurately capture the user's movements, translating them into the virtual environment to allow for natural, responsive interaction.

High-performance computation resources: To deliver the full potential of virtual reality experiences, VR headsets often need to be tethered to PCs equipped with high-performance graphics cards. These graphics cards are essential for rendering the complex and detailed 3D environments encountered in VR applications. They manage the intense graphical processing demands that VR imposes, such as high-resolution imagery and rapid frame rate requirements, which are crucial for creating a seamless and immersive user experience. Without a powerful GPU, VR experiences can suffer from lag, reduced visual fidelity, and frame drops, which not only diminish the quality of the simulation but can also lead to discomfort or motion sickness for users. Therefore, investing in a robust graphics card is vital for anyone looking to explore the depths of VR technology, whether for gaming, educational, or professional development purposes.

2.2 Virtual Reality and Art

Through its immersive features, VR allows users to experience physical properties such as shape, size, distance, time duration, etc. of objects and events and enables them to discover "hidden" features. According to constructivist theory, learners can construct meaning through the interpretation of their personal experience [10]. Compared to traditional 2D user interfaces, learners in virtual environments can freely explore and

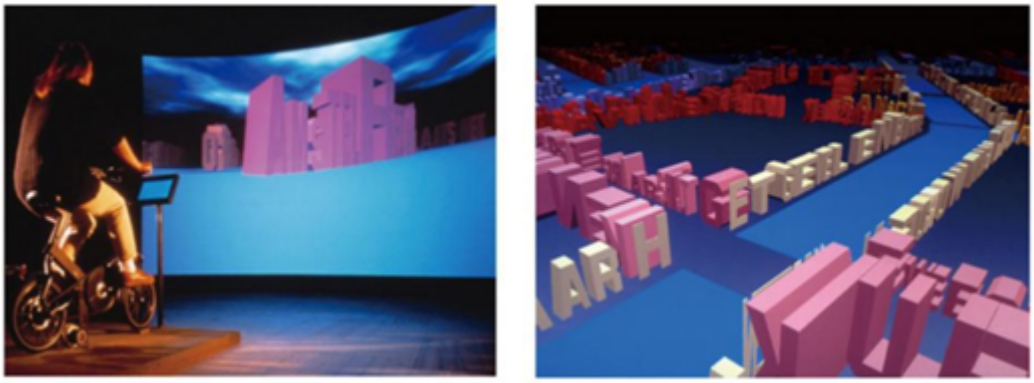


Figure 2.2: Legible City by Jerry Shaw, 1989

view 3D cultural objects from various perspectives, as well as touch or grasp virtual objects in a realistic-looking context. They can go around objects, jump inside and outside environments and access unusual perspectives or even break the law of physics. The immersive space creates a strong sense of presence, which may facilitate learners to conceptualize and assist them to construct meaning and knowledge through direct personal experience in a realistic and sensory-rich digital environment. All these have led VR to be used in a variety of application areas from training to arts. The spatial nature of VR was used in visual-spatial training [2] [3]. In the context of cultural learning, the spatial characteristics of VR technology enable learners' 3D realistic replicas [4][5] which may improve learners' spatial perception of historical places and objects [6]. Since the very beginning, the VR concept has been used by many artists to help improve the experience for audiences. In 1989, Jeffry Shaw created Legible City, a ground-breaking interactive art installation, as shown in Fig. 2.2. The experience takes place on a stationary bicycle through a simulated city of computer-generated 3D letters, which form words and sentences on the sides of the streets according to the path chosen by the person [11].

In 2017, the American production studio Oculus Story Studio created the VR animation, *Dear Angelica*, using the Quill painting tool, illustrated by Wesley Allsbrook [12],

Figure 2.3: Dear Angelica

who uses virtual reality as a narrative medium and animated by the artist entirely by hand in the VR space, as shown in Fig. 2.3. The use of a variety of brushes in Quill creates an image that is immersing the user in a subtle way.

HTC and Japanese artist Miu Komatsu created a crossover VR creation, Inori, as shown in Fig. 2.4, which transforms in 3D a flat canvas and uses the immersive nature of VR to create a virtual 'real' space that allows the author's work and worldview to be fully realized through VR interaction [13]. The new world reaches people's minds, but beyond the novelty, the experience can be different.

2.2.1 Virtual Reality Exhibitions

When exploring the use of VR technology in preserving traditional Chinese paintings, one prominent avenue of research is the creation of virtual exhibitions [14, 15, 16]. VR offers a unique opportunity to replicate the experience of visiting a physical gallery or museum, allowing viewers to immerse themselves in the beauty and detail of traditional Chinese artworks from anywhere in the world [17]. One notable example is the collaboration between cultural institutions and VR developers to digitize and showcase

Figure 2.4: Inori by Miu Komatsu

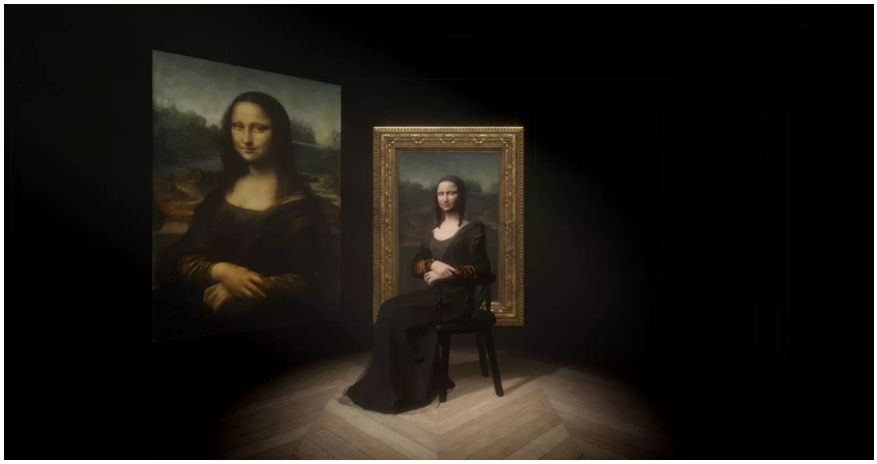


Figure 2.5: Mona Lisa: Beyond the Glass

collections of traditional paintings. These virtual exhibitions not only provide access to rare and delicate artworks that may be inaccessible to the public due to conservation concerns or geographical limitations but also offer interactive features such as zooming in on details, viewing paintings from different angles, and accessing contextual information through audio guides or textual annotations. For instance, the Louvre's Mona Lisa VR special exhibition showcases the creation and research process of the Mona Lisa through virtual reality technology, as shown in Fig. 2.5 [18].

In [19, 20], the authors highlight the potential of VR to enhance the appreciation and understanding of ancient Chinese art, with Wang emphasizing its ability to stimulate national pride and Jin discussing its potential for immersive learning experiences. Zhao [21] and Zhao [22] further explore the role of interactive technology in this context, with a focus on deepening aesthetic understanding, improving originality, and engaging users in participatory appreciation. By leveraging VR technology, these virtual exhibitions aim to preserve the cultural heritage embodied in traditional Chinese paintings while also democratizing access to these invaluable artworks. Additionally, they open up new possibilities for scholarly research, education, and public engagement, enriching our understanding and appreciation of this rich artistic tradition.

2.2.2 Digitization of Artworks

Another significant aspect of the use of VR technology in preserving traditional Chinese paintings is the digitization of these artworks. Digitization involves capturing high-resolution images of paintings and, in some cases, creating detailed 3D models to faithfully reproduce the texture, brushwork, and subtle nuances of the original artworks [22].

In the realm of traditional Chinese painting, which often features intricate details and delicate brushstrokes, digitization presents both opportunities and challenges.

Advanced imaging techniques, such as high-resolution photography and 3D scanning, are employed to capture the fine details and colors of the paintings accurately. These digitized representations not only serve as archival records for preservation purposes but also enable scholars, researchers, and art enthusiasts to study the paintings in unprecedented detail, regardless of their physical location.

Furthermore, the digitization of traditional Chinese paintings opens up possibilities for innovative forms of interpretation and analysis. For instance, digital tools and algorithms can be applied to analyze brushstrokes, identify artistic styles, or detect signs of aging or deterioration in the artworks [23]. Moreover, digital platforms and databases allow for the systematic cataloging, indexing, and retrieval of vast collections of traditional Chinese paintings, facilitating research, curation, and exhibition planning [24, 25].

Beyond preservation and scholarly research, digitization also enables new modes of engagement and interaction with traditional Chinese paintings. Virtual reality applications, for example, can offer immersive experiences that go beyond replication, allowing users to interact with the artworks in novel ways. Whether through virtual tours of museum collections, virtual restoration projects, or interactive storytelling experiences, digitization and VR technology provide powerful tools for preserving, promoting, and revitalizing traditional Chinese painting for future generations.

2.2.3 Interactive Learning

Another significant area of exploration in the realm of VR applications for preserving traditional Chinese paintings is interactive learning [26]. Traditional Chinese painting is not only an art form but also a cultural heritage that embodies centuries of history, aesthetics, and craftsmanship. VR technology offers exciting possibilities for engaging learners of all ages and backgrounds in the study and appreciation of this rich artistic

tradition, as shown in [21, 27].

One avenue of interactive learning involves the development of virtual art classes or tutorials, where users can learn about traditional Chinese painting techniques and practices in a virtual environment [28]. Through immersive simulations and interactive demonstrations, learners can explore the fundamental principles of brushwork, ink wash painting, color theory, and composition under the guidance of virtual instructors or experts. These virtual lessons can cater to learners of varying skill levels, from beginners seeking an introduction to traditional Chinese painting to experienced practitioners looking to refine their techniques [26].

Furthermore, VR applications can offer engaging experiences that bring the history and cultural context of traditional Chinese painting to life. Through virtual storytelling or historical reenactments, users can immerse themselves in the world of ancient China, exploring the lives of renowned painters, the patronage of imperial courts, and the social and philosophical influences that shaped the development of Chinese art [28]. By contextualizing traditional Chinese painting within its broader cultural and historical milieu, VR technology can deepen learners' understanding and appreciation of the art form.

Moreover, interactive learning experiences in VR can foster creativity and experimentation, empowering users to create their own virtual artworks inspired by traditional Chinese painting styles and motifs [29, 30]. Virtual painting tools and simulations allow users to practice their skills, experiment with different techniques, and express their artistic vision in a digital medium. Through collaborative projects or online communities, users can share their creations, receive feedback, and engage in dialogue with fellow enthusiasts, fostering a vibrant ecosystem of creativity and exploration.

In summary, VR technology holds immense potential for revolutionizing the way we teach, learn, and experience traditional Chinese painting. By providing immer-

sive, interactive, and accessible learning experiences, VR applications can inspire new generations of artists, scholars, and enthusiasts to connect with and contribute to the preservation of this invaluable cultural heritage.

2.2.4 Cultural Preservation

Another important aspect to consider is how VR technology contributes to the cultural preservation of traditional Chinese paintings. Traditional Chinese painting is not just an art form but also a repository of cultural values, aesthetic sensibilities, and historical narratives. As such, efforts to preserve traditional Chinese paintings extend beyond conservation of physical artifacts to encompass broader initiatives aimed at safeguarding and promoting the cultural heritage embodied in these artworks [31].

VR applications play a crucial role in this endeavor by providing innovative tools and platforms for documenting, archiving, and disseminating knowledge about traditional Chinese painting techniques, styles, and motifs. Through high-fidelity digital reproductions and immersive virtual experiences, VR technology enables us to capture and preserve the essence of traditional Chinese paintings in a dynamic and accessible format. These digital archives serve as valuable resources for researchers, scholars, and cultural institutions seeking to study, interpret, and disseminate knowledge about traditional Chinese painting to a global audience.

Moreover, VR technology facilitates cultural exchange and dialogue by transcending geographical and temporal boundaries [32]. Virtual exhibitions, collaborative projects, and online communities bring together artists, scholars, and enthusiasts from diverse backgrounds to share their expertise, exchange ideas, and collaborate on initiatives aimed at preserving and promoting traditional Chinese painting [16]. By fostering cross-cultural understanding and appreciation, VR applications contribute to the global recognition and preservation of traditional Chinese painting as a cultural heritage of

humanity.

Furthermore, VR technology has the potential to revitalize traditional Chinese painting traditions by making them more accessible and engaging to contemporary audiences [33]. Through interactive learning experiences, virtual workshops, and digital art tools, VR applications inspire new generations of artists to explore and experiment with traditional Chinese painting techniques in innovative ways. By bridging the gap between tradition and modernity, VR technology ensures the continuity and relevance of traditional Chinese painting in the digital age [34].

One of the most attractive applications of VR technology is Virtual Museum. The Dali Museum in St Petersburg, Florida, presented in 2016 the Dreams of dalí in virtual reality, which links the surrealist Dali's masterpieces and enables the first realistic exploration of his 'dreams' as shown in Fig. 2.6. This virtual reality piece is presented by creative agency Goodby Silverstein Partners (GSP). By wearing the head-mounted display, the viewer can walk around the painting and explore the environment inside at will. Dali's Dream VR has not only won critical acclaim from visitors to the Dali Museum exhibition but has also won the Lions Gold Award at Cannes, the Webby People's Voice Award and the Facebook Silver Award for Innovation, among many other awards.

In addition to western arts, VR technology has also found many promising perspectives in the Chinese market. National Palace Museum of China developed a project named V-Museum as shown in Fig. 2.7. The buildings and inside furniture and decorations are remodelled in VR space according to their real counterparts. The project was initiated when the Palace's most popular and storied hall, the Yang Xin Hall, was temporarily closed in 2015 for a five-year conservation and restoration project. By recreating the Yang Xin Hall in VR, people can visit this beautiful ancient building online. Annotation functions are available for some art pieces. By simply clicking the note box next to the object, the details of this object can be shown in front of

Figure 2.6: Dreams of Dalí in virtual reality

the audience. Buildings, furniture, and other 3D structures are well-recreated in this project. However, for some 2D ancient Chinese paintings, scanned pictures are used in VR. These can be contributed to the fact that duplication of ancient Chinese paintings is very difficult in VR, due to the difference between western art and Chinese art, which will be mentioned and discussed in the next sections. If these 2D paintings can be recreated in VR, they will be very meaningful for the preservation of ancient Chinese paintings and can also bring new life to traditional paintings.

VR was shown to make museums more accessible to people all over the world. With VR technology, these valuable artistic pieces can be accessed by people anywhere as long as they are accessible to the internet. It promotes the spread of civilization, and heritage preservation, and lowers the threshold for the viewing of art [35]. There is no doubt that the recreation and protection of cultural heritage is an important application direction of VR technology [36].

In conclusion, VR technology offers exciting opportunities for preserving, promoting, and revitalizing traditional Chinese paintings as a cultural heritage of humanity.

Figure 2.7: V-Museum of National Palace Museum of China: https://v.dpm.org.cn/

By harnessing the power of immersive experiences, digital archives, and collaborative platforms, VR applications contribute to the safeguarding and transmission of the rich artistic legacy embodied in traditional Chinese paintings for future generations to cherish and enjoy.

2.3 Basic Painting Concepts

The material medium of visual art is based on the way the eyes perceive, utilizing viewing as the mode of appreciation for two-dimensional art pieces [37]. Painting, as one form of visual art, possesses a unique artistic language and structural principles [38]. Through the formal language of elements such as points, lines, shapes, light and shadow, colors, imagery, perspective, and composition, painting shapes visual representations on surfaces such as textiles, paper, wood panels, and walls. In doing so, it achieves the purpose of reflecting the artist's real-life experiences and expressing their thoughts and emotions.

Originating from the realm of fine arts, painting is among the earliest categories of fine arts, which also encompassed sculpture and murals. Examining the cave paintings and primitive sculptures left behind by early humans, it becomes evident that the

initial purpose of painting was to document life, express reverence for nature and reproduction, and convey information. As human societies gradually fulfilled their material needs, the purpose of painting shifted towards subjective expression, serving to fulfill spiritual needs.

Different traditional Chinese painting types have their own characteristic painting mediums. According to the varied mediums used for creation, traditional painting encompasses paper-based painting, canvas painting, mural painting, silk painting, printmaking, etc. The painting technique that utilizes papers such as rice paper, watercolor paper, and sketch paper is collectively referred to as paper-based painting. The distinctive feature of paper-based painting is the ability of pigments to blend with water, resulting in high transparency of colors and the capability to display the texture and grain of the paper. Examples include watercolor paintings, sketches, and quick drawings. Paper-based paintings typically have relatively small dimensions, making them convenient for binding or transportation. This category of traditional painting is the most widely spread and has the largest user base.

Canvas painting involves using linen or blended canvas for painting, also known as oil painting canvas when used in oil painting, requiring the use of oil paints and other creative tools. The characteristic feature of canvas painting is the vibrant colors that can be applied and preserved for a long time.

Mural painting traces back to primitive societies, where abstract patterns carved on cave walls showcased the primitive aesthetic sense of painting. The representative form of mural painting is fresco, which involves painting on dry or semi-dry walls, tightly integrating with architectural structures and the surrounding environment. Mural paintings typically have large dimensions, are difficult to move, and are highly susceptible to natural environmental influences, leading to color fading or detachment from the wall, making long-term preservation challenging.

Silk painting involves painting on fabrics such as silk or satin and finds extensive

application in the field of fashion design.

Printmaking is also an ancient painting technique, involving carving images onto woodblocks, stone blocks, or metal plates, which are then used for printing. Printmaking allows for reproduction of artworks, with a unique artistic style in line and color representation.

2.3.1 Formal Language Analysis of Painting

The most crucial aspect that constitutes a painting is its form, which refers to the manner in which the content of the painting exists. It encompasses the organizational structure of the painting content and the external manifestation of the material materials and artistic language. The key to creating a sense of form lies in the use of painting language, which includes the constituent elements of expressive forms, composition, material textures, visual psychological perceptions, aesthetic principles, grayscale layers, and color relationships. Painting is a visual art characterized by the depiction of intuitive images and the artist's sensory perceptions. Therefore, whether it is representational, figurative, or abstract, the formal language of painting serves as the foundation for visual art and is the ultimate means of realizing visual effects.

Throughout the process of creating painting art, people have developed the principles of formal beauty based on their understanding and summarization of aesthetic formalities. These principles primarily include proportion and scale, contrast and harmony, symmetry and balance, rhythm and cadence, variation and unity. The principles of formal beauty serve as the measuring scale for creating aesthetic sensations in this experiment, and they should be reflected in various elements of painting.

Composition in Painting

"Composition" refers to the layout and organizational structure of painting content, including the arrangement of various parts and the connections between elements. Common composition techniques include triangular composition, S-shaped composition, diagonal composition, and others. Composition creates a rhythm and flow among the elements in the painting, such as density, harmony, stability, resonance, and impact. Through composition, the various elements in the painting form a harmonious unity while also presenting contrasts and variations, thereby showcasing the aesthetic beauty of the artwork.

Painting Form

Form encompasses shape, size, solidity, length, and curvature. Through the manipulation of form, alterations and adjustments can be made to the size, thickness, length, curvature, and solidity of objects.

Painting Lines

In painting, lines are one of the constituent elements of artistic style and an essential component of the subject matter of artworks. Lines can vary in length, thickness, regularity, irregularity, continuity, and discontinuity. Artists subjectively employ different types of lines to reflect their own concepts, aesthetics, and emotions.

Painting Brushstrokes

Brushstrokes refer to the techniques used in the process of painting. By varying the thickness of paint, the pressure applied while brushing, the rhythm of brushstrokes, and the use of dots and strokes, artists can depict the texture, volume, form, and changes in light and shadow of objects.

In Chinese painting, brushstrokes are characterized by the "bone method," which first manifests as different shades of ink on rice paper, ranging from dense to light, dry to wet. Secondly, the manner of brushstroke execution varies, resulting in techniques such as outlining and dotting, which are specific to Chinese flower-and-bird paintings and landscape paintings.

Color

Color in painting is a crucial component of creative expression, primarily conveyed through hue, value, temperature, and saturation. Warm tones from the red-yellow spectrum, cool tones from the blue-purple spectrum, and green tones can evoke distinct atmospheres and stylistic characteristics in a painting. The degree of brightness and darkness can depict the intensity of light, while highly saturated colors appear more vibrant. By skillfully manipulating color relationships, artists can imbue their paintings with a sense of visual harmony and aesthetic pleasure.

2.3.2 Characteristics of Chinese Painting

Traditional Chinese painting, with its deep cultural roots and unique aesthetic principles, is distinguished by several defining features that reflect its rich artistic heritage:

- **Ink and Brush:** Central to Chinese painting is the use of ink and brush on paper or silk, which enables a diverse range of expressions[39]. The brushstrokes are highly varied, capable of conveying delicate details and bold dynamism within the same piece, thereby communicating a broad spectrum of textures and emotional states.
- **Emphasis on Nature:** Nature is not merely a backdrop in Chinese painting but the heart of its thematic exploration [40]. Landscapes are particularly revered,

with artists often portraying the ethereal and sometimes mystical qualities of mountains, rivers, and forests. The objective is to capture the 'spirit' (qi) of nature, which is seen as a reflection of the universe's harmonious natural order.

- **Symbolism and Philosophy:** Symbolic content is prolific in Chinese paintings, with elements often carrying meanings from Taoist, Confucian, and Buddhist traditions[41]. These symbols might include specific birds, plants, or natural features, each representing different virtues, ideas, or cosmic principles, thereby imbuing the artwork with layered meanings.

- **Negative Space:** The strategic use of negative space, or 'leaving white', is a hallmark of Chinese painting[42]. This technique is about more than just balance and composition; it invites the viewer into the artwork, encouraging a personal engagement that completes the scene imaginatively, which is considered an integral part of the artwork's aesthetic and spiritual experience.

- **Subtle Colors:** While early Chinese painting primarily used shades of black ink, the traditional palette expanded to include subtle, natural pigments[43]. These colors were applied not for their realistic portrayal but to evoke specific feelings and atmospheres, enhancing the painting's poetic and evocative power.

- **Variety of Styles:** The diversity in Chinese painting styles is vast, ranging from the highly detailed Gongbi technique, known for its precise brushwork and meticulous detail, to the more free-form and expressive Shui-mo (water ink) style, which prioritizes broad strokes and an impressionistic approach to form[44]. Each style offers a different path to understanding natural and spiritual elements, demonstrating the adaptability and depth of Chinese artistic traditions.

- **Integration of Poetry and Calligraphy:** Often, Chinese paintings are accompanied by poetry and inscribed with calligraphy, reflecting the deep intercon-

nections among the arts in Chinese culture[45]. This integration enhances the narrative and philosophical depth of the artwork, making each piece a multidimensional tapestry of artistic expression.

These distinctive features of Chinese painting not only highlight its artistic and philosophical depth but also underscore its profound connection to the broader East Asian cultural and aesthetic landscape. Traditional Chinese painting is thus not just an art form but a philosophical exploration that captures the transient beauty of the physical world and the enduring truths of the spiritual realm.

2.4 Why Wu Guanzhong

There are many renowned Chinese artists, such as Gu Kaizhi, Ma Yuan and Li Cheng. However, for this thesis, we selected Wu Guanzhong's paintings as they are considered the foundation of modern Chinese paintings. Wu Guanzhong is again recognized as a central figure in 20th-century painters due to the infusion of oriental and western artistic traditions in his landscape paintings.

2.4.1 Wu's Styles

Wu Guanzhong's paintings, particularly his use of white space, have been the subject of recent studies. Fan [46] found that the white space in his work is not just a background, but a deliberate design element that influences viewers' aesthetic experience. This is in line with the broader tradition of Chinese painting, which often conveys meaning through the use of space [47]. Wu's work also reflects the tension in contemporary Chinese art, as artists navigate between Western and traditional Chinese styles [48]. Harrist [49] provides a historical context for this, exploring the use of landscape in Chinese painting and its connection to private life.

In his paintings, Wu Guanzhong led the development of imagery painting in modern Chinese art. After studying in France, he brought French modernism and integrated it with Chinese traditional art concepts [50]. In the 20th century, Brettell [51] explained that European painters explored lines, faces, and color, contrasting with realism's previous impressionism and color. In most Chinese traditional paintings, the concept of imaging, originating from the South Qi Dynasty, is still very distinct. However, with the integration of French modernism, Wu Guanzhong inducted the appearance of imagery combination in his paintings [52]. This helped him achieve a distinct combination of western painting and traditional Chinese art. In turn, this contributed to breaking modelling and solid painting expression methods and breaking the use of single ink materials during painting.

Fan et al. [53] highlight that space is emphasized in traditional Chinese paintings, which helps render the art's beauty conception. In addition, space,entails the absence of ink, hence creating an environment for life to flow and change. Wu Guanzhong's paintings incline on the Chinese expression methods achieved through transformation and selection. This means that the paintings are issued an intriguing charisma style expressed through the rhythm of brush and ink. The 'space' characteristic in Wu Guanzhong's paintings is depicted by the movement of dots and lines that marginally appear suitable [42]. Guanzhong incorporated shapes and color subtractions in his paintings, especially in creating the Southern China landscape. Guanzhong used pure color blocks while painting the landscape, including the meaning of Chinese ink painting. In the long run, this helped him focus on appearance instead of shape, making the painting have a more profound implication.

In Taoism, a strong emphasis is returning to nature, which links most Chinese natural landscape paintings. Similarly, most imagery painters have an equal focus on landscape subjects, which helps their work be closely knit with the natural phenomena [54]. In light of this, Guanzhong's landscape paintings are depicted in a way a kite

navigates not too far from the ground. He uses wash and ink to reveal his solid grounding, which aligns with the traditional Chinese ink landscape painting [55]. In Guanzhong's paintings, colossal mountains show a majestic mountain peaks presence, as used in the Early Spring painting by Guo Xi (1000-1090).

In addition, some of Guanzhong's paintings are influenced by some Song dynasty painters (969-1279) and the Qing dynasty (1644-1911). In this context, the nature of the brushstrokes he used when adding texture variation and atmospheric effect. Nonetheless, despite the influences, Joung [56] notes that Guanzhong used bright colors, radical compositions, and liberal wash use, all of which were based on formalism interests. For example, in his painting, A Big Manor as shwon in Fig. 2.8, Guanzhong depicted grand rural towns and homes, showing a man-made environment. This contrasted with traditional Chinese images focusing on the natural environment's majesty. Guanzhong from the architecture removed the traditional structural rhythm and geometric beauty in the painting. Instead, he used liberal wash and radical composition in showing the house roofs.

Over time, Guanzhong's landscapes become increasingly abstracted, aiming to show intentions of representing emotions and concepts rather than depicting realistic representations. For instance, in his Alienation painting as shwon in Fig. 2.9, instead of showing long-view perspectives in his paintings, Guanzhong provided a closer view, in a sense that incorporated the viewer in the image.

From the following four aspects we chose Wu's works as the objects in this research.

1. *Cultural Significance:* Wu Guanzhong's works hold a unique place in both modern and traditional Chinese art. His ability to bridge the gap between Western artistic influences and traditional Chinese techniques makes his art particularly suitable for studying the application of VR in preserving and recreating cultural heritage.

2. *Fusion of Styles:* Wu's paintings are known for their distinctive fusion of Western

Figure 2.8: A big Manor:https://asiasociety.org/files/6$_{AB}ig_{M}anor.jpg$

Figure 2.9: Alienation painting, Wu Guanzhong, 1992: https://asiasociety.org/files/7$_{A}lienation.jpg$

modernism and Chinese artistic traditions. This blend of styles offers an ideal platform to explore the strengths and limitations of VR technology in rendering both abstract and representational elements.

3. *Diversity of Subjects:* Wu's works cover a wide range of subjects, from landscapes and architecture to animals and figures. This diversity provides a comprehensive basis for evaluating the ability of VR technology to capture various forms of artistic expression.

4. *Challenges in Technical Reproduction:* The expressive brushwork, subtle use of color, and intentional use of negative space in Wu's paintings present significant technical challenges when translated into a 3D virtual environment. These challenges are crucial to exploring the potential improvements and future developments in VR art creation.

Technical Challenges

Wu Guanzhong's paintings often feature intricate brushwork and layered compositions, presenting technical challenges that would be exciting to tackle in a VR recreation. This challenge is further complicated by the need to support design without restricting the artist's creative process [57]. However, recent advancements in VR painting, such as 3D volumetric painting, can provide a solution by allowing artists to draw detailed scenes with full control of spatial color fields [58]. These advancements, combined with the use of VR to convert complex 2D artwork into immersive environments, could potentially be leveraged to recreate Wu Guanzhong's paintings in a way that captures their intricate details and layered compositions. However, with currently-available technologies, capturing the nuances of his style in a three-dimensional space would require innovative approaches to digital painting and modeling. Moreover, as VR technology originated in Western countries, many

features and characteristics of VR painting software are specifically designed according to Western artistic conventions. However, the art forms of traditional Chinese painting differ significantly from Western painting. This disparity can make it challenging to replicate certain painting techniques and expressive methods of Chinese painting using current VR tools. Additionally, painting in a 3D space presents a considerable challenge for most artists, as humans have traditionally painted on supported platforms for hundreds, if not thousands, of years. Painting in an unsupported virtual space poses significant challenges.

2.5 Conclusion

In this chapter, we briefly introduce the history and development of VR technology. We then discuss its applications and prospects in the field of artistic creation. VR technology has been widely used in the arts, including virtual exhibitions, virtual museums, and virtual education, among others. Next, we introduce some basic concepts and techniques of painting from the perspective of artistic creation, thus providing readers with a foundational understanding of artistic creation. We summarize the basic elements of artistic creation, including brushes, colors, views, lines, etc. Understanding these basic elements and concepts is crucial for VR artistic creation of Chinese paintings. One of the main tasks of this work will be how to implement these elements and techniques of Chinese painting in VR. Finally, combining VR technology with Chinese painting art, we introduce the Chinese painter Wu Guanzhong and explain why his works were chosen as the subject of study for this project. This is because Wu Guanzhong's modern paintings, which combine features of Western painting with traditional Chinese painting techniques, make his works more adaptable to modern VR technology, which was developed based on Western art.

CHAPTER 3

Methodology

3.1 Overview

The advent of new painting forms has propelled the integration of painting with technology, with digital painting being a prominent example. Digital painting, commonly referred to as computer painting, digital painting, or CG painting, involves using specialized computer software and digital drawing tools to create images or graphics digitally. The tools used in digital painting include graphics tablets, pressure-sensitive pens, and digitizing tablets.

The tools for digital painting are divided into hardware and software. Hardware encompasses computers, image input devices, and image output devices, such as drawing tablets, digitizing tablets, and pressure-sensitive pens. Software refers to digital imaging tools, such as Photoshop (PS) and Illustrator (AI). Although digital painting has only existed for a little over sixty years, which is considerably shorter than the history of traditional painting, its development has been rapid in the modern era. One of the main reasons for this rapid development is the continuous advancement of digital painting tools.

Today, digital painting has become an integral part of the art industry and design fields, serving as a practical art form and finding widespread application in various design areas, including architectural design, industrial product design, fashion design, UI design, visual communication design, as well as film special effects, animation, and multimedia design.

This research begins by studying the selected Chinese paintings closely, understanding the techniques, brushstrokes, and artistic styles employed by the original artists. I pay attention to the composition, use of negative space, symbolism, and thematic elements. This work primarily investigates through the reproduction of Wu Guanzhong's works in VR space, exploring the limitations and challenges of VR technology for the creation of Chinese paintings and other types of artwork. Throughout this process of reproduction, we will continuously explore different ways to achieve this translation. Based on the characteristics of Wu Guanzhong's works, our research is divided into three parts. In the first part, we use Wu Guanzhong's work 'Water Town' as a medium to demonstrate the expressiveness of VR technology for large-scene paintings with traditional Chinese characteristics. Moreover, we will introduce the challenges traditional Chinese painting techniques bring to VR painting. For these challenges, we will attempt different techniques and solutions to optimize and provide references for the readers. The second part will showcase the problems encountered in depicting Chinese animal paintings with VR technology, using three of Wu Guanzhong's animal paintings as examples. Animal painting is an important component of traditional Chinese art, most of which are also categorized as fine brushwork paintings. A characteristic of these paintings is their emphasis on lines, focusing on depicting the animal subject while lightly rendering the background, and the scenes they display are often small. How to handle the lines, backgrounds, colors, and other elements of traditional Chinese animal paintings in VR poses significant challenges to artists and VR technology researchers.

Lastly, based on this study, we have attempted to create an original work. The purpose of this creation is to demonstrate the practical application of the techniques and insights gained from the reproduction of Wu Guanzhong's paintings in a VR environment. This new work serves as a proof of concept, illustrating how traditional Chinese painting techniques can be adapted and transformed within a virtual space. The original work showcases the unique potential of VR as a medium for traditional artistic expression while addressing the technical and artistic challenges encountered throughout the study. By incorporating elements such as brushwork, spatial composition, and the use of negative space—key aspects of Chinese painting—this work allows us to evaluate the efficacy of VR technology in capturing the essence of traditional art forms. Additionally, the creation highlights how VR can offer new perspectives and interactive experiences for viewers, enhancing their engagement with the artwork. Ultimately, this original piece is not only a culmination of the research findings but also a step towards exploring the future potential of VR as a tool for both preserving and evolving traditional art practices

Based on the characteristics of Wu Guanzhong's works, this research is structured into three interconnected parts, each focusing on a different aspect of VR-based pictorial reproduction.

Before introducing the technical tools and workflow, it is necessary to clarify the criteria and rationale underlying the selection of the specific artworks used in this study, as this choice directly informs both the methodological approach and the scope of analysis.

3.1.1 Case Selection Criteria

In this study, a case-study approach is adopted to examine the translation of traditional Chinese painting into a VR environment. The selection of Water Town and animals

(Water Buffalo, Panda and Swan) was guided by a combination of methodological and cultural considerations, rather than by an attempt to represent the full scope of Wu Guanzhong's artistic practice. These works were chosen as focused case studies that enable a systematic examination of how traditional Chinese pictorial elements are translated into an immersive VR environment.

From a methodological perspective, the selected works exhibit visual characteristics that are particularly relevant to VR-based reproduction. These include strong linear structures, simplified spatial organisation, and a clear separation between subject and background. Such features allow the study to investigate how line, depth, scale, and spatial composition behave when transferred from a two-dimensional painted surface into a three-dimensional virtual space. In particular, Water Town provides an effective case for examining large-scale spatial composition and architectural rhythm, while the animal-themed works enable a closer analysis of fine line work, controlled brushstrokes, and compact pictorial scenes within VR.

In addition to their formal suitability, these motifs also carry significant cultural recognisability within the tradition of Chinese painting. Water towns, water buffaloes, and animal subjects such as pandas and swans have long functioned as familiar visual elements in Chinese art, often associated with rural life, natural harmony, and symbolic meaning. Their recognisable nature allows viewers to draw upon prior visual and cultural memory when encountering the VR reproductions, thereby supporting a more meaningful assessment of how traditional imagery is perceived and reinterpreted in an immersive digital context.

The selection of these works therefore serves a dual purpose. Methodologically, it enables a structured exploration of different compositional and technical challenges in VR painting. Culturally, it provides a grounded framework for examining how VR reproduction mediates between traditional Chinese visual language and contemporary modes of artistic experience. This study does not claim to offer a comprehensive

survey of Chinese traditional painting or Wu Guanzhong's oeuvre; instead, it employs these selected works as culturally and formally informed case studies to support an exploratory investigation into VR-based pictorial transformation.

3.2 Tools

This project focuses on reproducing traditional Chinese paintings by Wu Guanzhong within a VR environment. The primary goal is to translate the aesthetic and philosophical dimensions of his works into the digital space while preserving their unique artistic essence.

As illustrated in Fig.. 3.1, the VR painting setup comprises two main components: a high-performance computer and a VR headset. The computer, equipped with a high-end GPU, is essential for processing the complex image data required to render detailed and immersive 3D environments in real-time. The VR headset, which serves as the primary interface for the artist, is connected to the computer either through cables or wirelessly, depending on the system configuration. This setup ensures a seamless flow of data, allowing for precise rendering and fluid interactions within the virtual space.

The VR headset not only provides a stereoscopic view of the digital canvas but also tracks the artist's movements, enabling intuitive navigation and control. Integrated hand controllers or pressure-sensitive styluses allow the artist to simulate traditional brush techniques, such as smooth ink gradients and fine line work, within the VR environment. The combination of hardware ensures that the artist can replicate the expressive qualities of traditional Chinese painting while exploring the additional dimensionality offered by VR.

The software used for this project plays an equally crucial role in enabling artistic expression in VR. Tilt Brush, a widely accessible VR painting tool, was selected for its robust functionality and intuitive interface. This software allows artists to paint

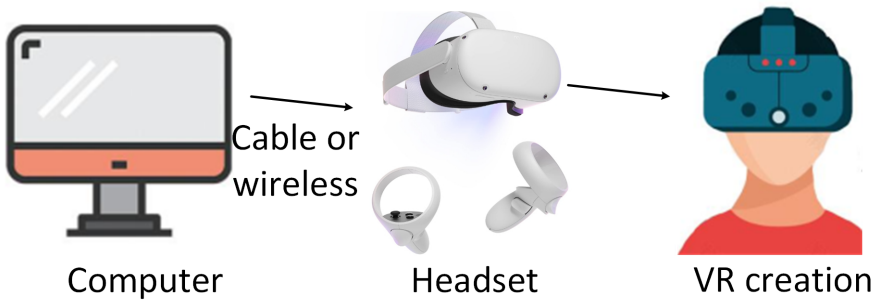


Figure 3.1: Basic architecture for VR painting

directly within a three-dimensional space, offering an extensive array of brushes, textures, and effects that mimic traditional media. Features such as the color picker, eraser, and symmetry tool provide the precision needed for intricate compositions, while specialized brushes simulate traditional ink and watercolor effects.

The process began with an initial phase of familiarization, during which I created a simple VR painting to understand the core functionality of the tools and hardware used in the project. This allowed me to explore key features such as brush selection, stroke control, and spatial movement within a three-dimensional environment, laying the foundation for more complex recreations later in the process.

Following this familiarization phase, I turned my attention to recreating three selected works by Wu Guanzhong in VR. The focus was on adapting traditional Chinese painting techniques, such as the use of brushstrokes and ink gradations, to the capabilities of the VR environment. Particular care was taken to translate the aesthetic qualities of Guanzhong's works, including his use of space, texture, and symbolism, into a new, immersive context. The challenge was to preserve the essence of these traditional techniques while embracing the additional dimensionality offered by VR.

The final phase of the project involved the creation of an original painting based on the theme of a Chinese mountain village. By this stage, the insights gained from recreating Guanzhong's works informed the development of new techniques, pushing

the boundaries of traditional Chinese painting by utilizing VR's unique features. This phase emphasized not just the reproduction of existing works but the exploration of how traditional art forms can evolve in virtual spaces.

The primary software used for this project was Tilt Brush, a VR painting tool that is widely accessible through the Steam and Oculus libraries. Tilt Brush allows artists to paint within a three-dimensional space and offers a wide array of brush types and effects that simulate traditional media. Key features of Tilt Brush, such as the eraser, dropper, and mirror functions, were integral to the workflow. These tools made it possible to refine the artwork, match colors easily, and achieve symmetrical designs when necessary. Additionally, the software's diverse range of brush options enabled the creation of textures and strokes that mimic traditional painting techniques, such as the smooth, flowing lines of Chinese ink brushstrokes or the textural richness of oil painting.

The hardware setup for this project consisted of an Oculus Quest 2 headset tethered to a high-performance computer, which provided the computational power necessary for rendering detailed and immersive three-dimensional paintings. The headset allowed for precise control of brushstrokes and movement within the VR space, ensuring that the lines and forms created in the virtual environment were fluid and expressive. Through this combination of software and hardware, the project aimed to maintain the integrity of traditional Chinese painting techniques while exploring new artistic possibilities unique to the VR medium. Detailed specifications are provided below to support transparency and reproducibility of the practice-based workflow.

- **VR Headset**: Oculus Quest 2
- **Host Computer**: Desktop PC
- **Operating System**: Windows 10 (64-bit)

- **CPU**: AMD Ryzen 9 5950X
- **GPU**: NVIDIA GeForce RTX 3050
- **GPU Driver**: NVIDIA Studio Driver (version current at the time of the study)
- **System Memory**: 64 GB DDR4 RAM (3200 MHz)
- **VR Painting Software**: Tilt Brush (Steam version)
- **Tilt Brush Version**: Latest stable release available during the study
- **Plugins**: No third-party plugins were used

Throughout the process, the use of digital brush tools in VR played a crucial role in simulating the expressive brushwork characteristic of traditional Chinese paintings. Various brush sizes, visual behaviours, and stroke strategies were explored to achieve a visual aesthetic comparable to that of the original works. Rather than relying on a wide range of stylistic brush presets, this study focused on a limited set of core brushes whose functions could be adapted through scale, layering, and compositional use.

Within Tilt Brush, Marker-based brushes were primarily used to construct structural and planar elements, while tapered brush variants were employed to create expressive lines, contours, and flowing details. Light-based brushes were selectively applied to introduce focal illumination and atmospheric emphasis where appropriate. This restrained selection allowed greater control over visual coherence and supported a practice-based exploration of how traditional pictorial qualities could be reinterpreted within an immersive environment (see Fig. 3.2).

In the VR environment, brushstrokes do not adhere to the two-dimensional constraints of traditional canvas painting. Each stroke exists within three-dimensional space, requiring careful spatial control to maintain visual clarity. In particular, the positioning of strokes along the depth axis needed to be consciously managed to avoid

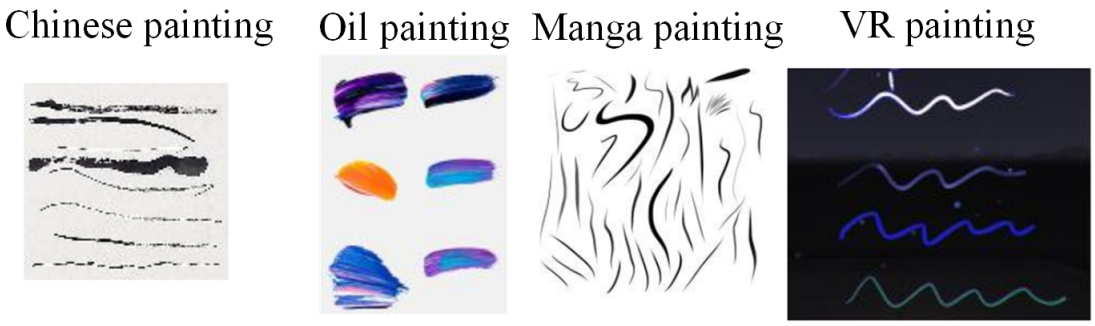


Figure 3.2: Lines in different paintings

unintended volumetric distortion. While this added complexity to the recreation of traditional techniques, it also enabled spatial and atmospheric effects that are not achievable in conventional painting.

This project therefore involved balancing the expressive principles of traditional Chinese painting with the affordances and limitations of VR technology. Although certain qualities of traditional brushwork, such as natural tapering at stroke endings, could not be fully replicated, the immersive nature of VR enabled alternative forms of expression through spatial composition, layering, and atmospheric emphasis. These adaptations demonstrate how traditional artistic techniques can be selectively transformed rather than directly replicated within a digital medium.

3.3 Reflective Practice and Iterative Development

In this research, reflective practice served as a key method for evaluating and refining both the artistic and technical aspects of the VR painting process. Throughout the creation of each VR artwork, I used reflection to assess the decisions made, such as the selection of tools, brushstroke techniques, and environmental design choices. This reflective approach allowed for a deeper understanding of how traditional Chinese painting techniques can be adapted and evolved within the modern medium of VR.

The process involved continuous reflection during the creation of the VR repro-

ductions, where observations on the effectiveness of various methods and tools were documented in real-time. This includes noting how well digital brushes replicated the fluidity and texture of traditional Chinese ink painting, as well as identifying areas where the virtual medium presented unique challenges or opportunities. After each painting session, I engaged in post-creation reflection to critically assess the outcomes, considering whether the VR artwork successfully conveyed the emotional, aesthetic, and philosophical elements of the original paintings by Wu Guanzhong.

The insights gained through this reflective process were then used to inform subsequent iterations of the VR artwork. By creating a feedback loop that incorporated personal reflection, the project benefited from continual refinement, ensuring that both the technical execution and artistic expression improved over time. The reflective practice was also documented in a reflective journal, capturing the daily challenges, breakthroughs, and adaptations. This documentation not only supported the iterative nature of the project but also served as a record of the evolving interplay between traditional Chinese art techniques and VR technologies. In this way, reflection played a crucial role in guiding the project's development and in ensuring that the VR reproductions remained faithful to the spirit of the original artworks while embracing the new possibilities offered by the digital medium.

While reflective practice constitutes the primary evaluative framework of this study, it is important to acknowledge that the assessment of the VR reproductions is largely based on internally driven analysis. The evaluation therefore focuses on artistic decision-making, technical experimentation, and iterative self-reflection, rather than on data derived from user interviews or questionnaire-based studies.

This methodological choice places certain limitations on the discussion of audience experience and reception. Due to constraints of time and research scope, this study does not incorporate structured interviews, questionnaires, or systematic audience evaluation. Future research could extend this work by integrating external viewer or

expert perspectives through interviews, surveys, or museum-based audience studies, in order to more comprehensively examine user experience, immersion, and reception of VR-reproduced artworks.To further contextualise the methodological scope of this practice-based research, it is useful to consider how VR reproduction relates to other established approaches to digital preservation.

3.3.1 Comparison with Other Digital Preservation Approaches

In the context of digital preservation of artworks, VR reproduction represents one of several possible approaches, alongside methods such as high-resolution photography, 3D scanning, and screen-based virtual exhibitions. Each of these modalities prioritises different aspects of preservation, resulting in distinct strengths and limitations.

High-resolution imaging and conventional digitisation techniques primarily emphasise visual fidelity and surface detail, making them well suited for documentation, archival purposes, and close inspection of material qualities. However, these approaches generally retain a fixed viewing perspective and limited interactivity. By contrast, VR reproduction prioritises spatial immersion, embodied interaction, and experiential engagement. Rather than aiming for exact surface replication, VR enables viewers to perceive compositional structure, spatial relationships, and scale through bodily movement within a virtual environment.

This shift in emphasis introduces inherent trade-offs. While VR may offer reduced precision in texture and surface detail compared with traditional digitisation methods, it enables forms of interaction and spatial perception that are not accessible through two-dimensional or screen-based representations. In this sense, VR reproduction should not be understood as a replacement for established digital preservation techniques, but as a complementary approach that foregrounds experiential and spatial dimensions of artworks.

The present study does not seek to establish systematic benchmarking data across different digitisation modalities. Instead, it positions VR reproduction as a practice-based method for exploring how traditional pictorial elements can be reinterpreted within immersive digital environments, offering a practice-based perspective within the broader field of digital art preservation.

3.4 Expanding on Digital Brush Techniques

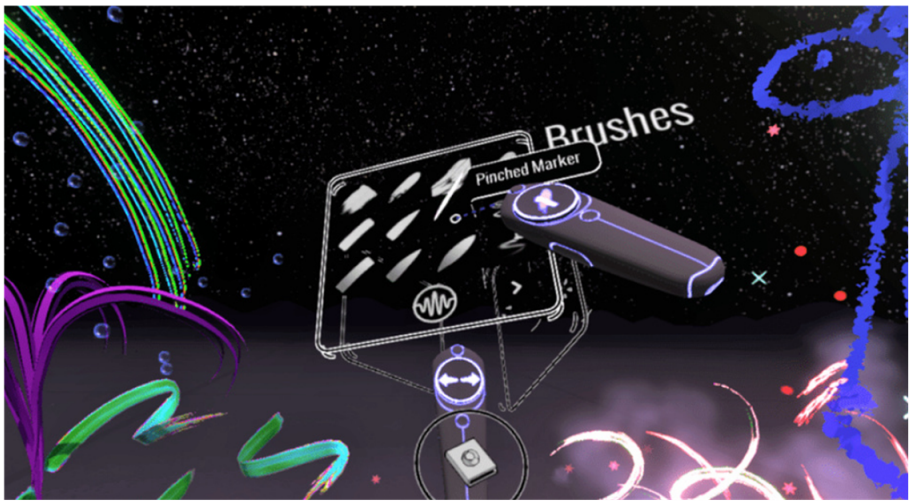
In adapting traditional brush techniques to VR, specific brushes were selected and customized in Tilt Brush to mimic the fluidity and expressiveness of Chinese ink painting. For instance, the "Velvet Ink" brush was particularly suited for long, continuous strokes, creating a calligraphic quality akin to traditional ink brushes. This customization of digital brushes played a critical role in capturing the essence of Wu Guanzhong's work. However, achieving the nuanced tapering effect of natural bristles required intricate control and adjustments along the Z-axis. Such details highlight both the possibilities and limitations in transferring traditional techniques to VR, where each stroke exists in three dimensions rather than on a flat surface (see Fig. 3.3).

3.5 Workflow

The workflow for translating 2D Chinese paintings into a VR environment involves five main steps that bridge traditional art techniques with digital modeling and immersive visualization. Here's an overview of each stage:

- **2D Painting Creation**:The process begins with creating or selecting a 2D painting, typically on paper or canvas, which forms the foundation of the artwork. This step focuses on capturing traditional techniques, brushstrokes, and aesthetic elements that are characteristic of Chinese painting.

Chinese brushes



VR brushes

Figure 3.3: Comparison of Traditional and Digital Brush Techniques

- **Translation to 3D Modeling in VR**: In this stage, the 2D artwork is transformed into a 3D model. This involves creating digital structures that represent the painting's elements, such as shapes, textures, and spatial arrangement. This translation is fundamental to establishing the visual framework for VR, allowing the artwork to exist in a three-dimensional space.

- **Addressing 2D to 3D Differences**: As Chinese paintings are traditionally flat, adapting them to a 3D VR space requires careful handling of visual perspective, layering, and depth. Artists and developers evaluate the essential qualities of the painting that may change or need adaptation when moving from a flat to an immersive environment. This step ensures that the unique aesthetic values of Chinese art are retained in VR.

- **Testing VR Painting Effects**: With the 3D model in place, the next step involves testing various VR painting effects to recreate traditional brushstrokes, textures, and color gradients. By experimenting with different VR tools, artists can simulate ink or watercolor effects and decide which techniques best capture the spirit of the original painting in a new medium.

- **Combining Elements into Final VR Artwork**: The final step involves integrating all the elements into a cohesive VR experience. The artwork is polished, and adjustments are made to ensure that the 3D painting reflects the original's emotional and aesthetic depth. This step also considers how viewers will interact with the piece, enhancing engagement and making the artwork accessible as an immersive experience. (see Fig. 3.4).

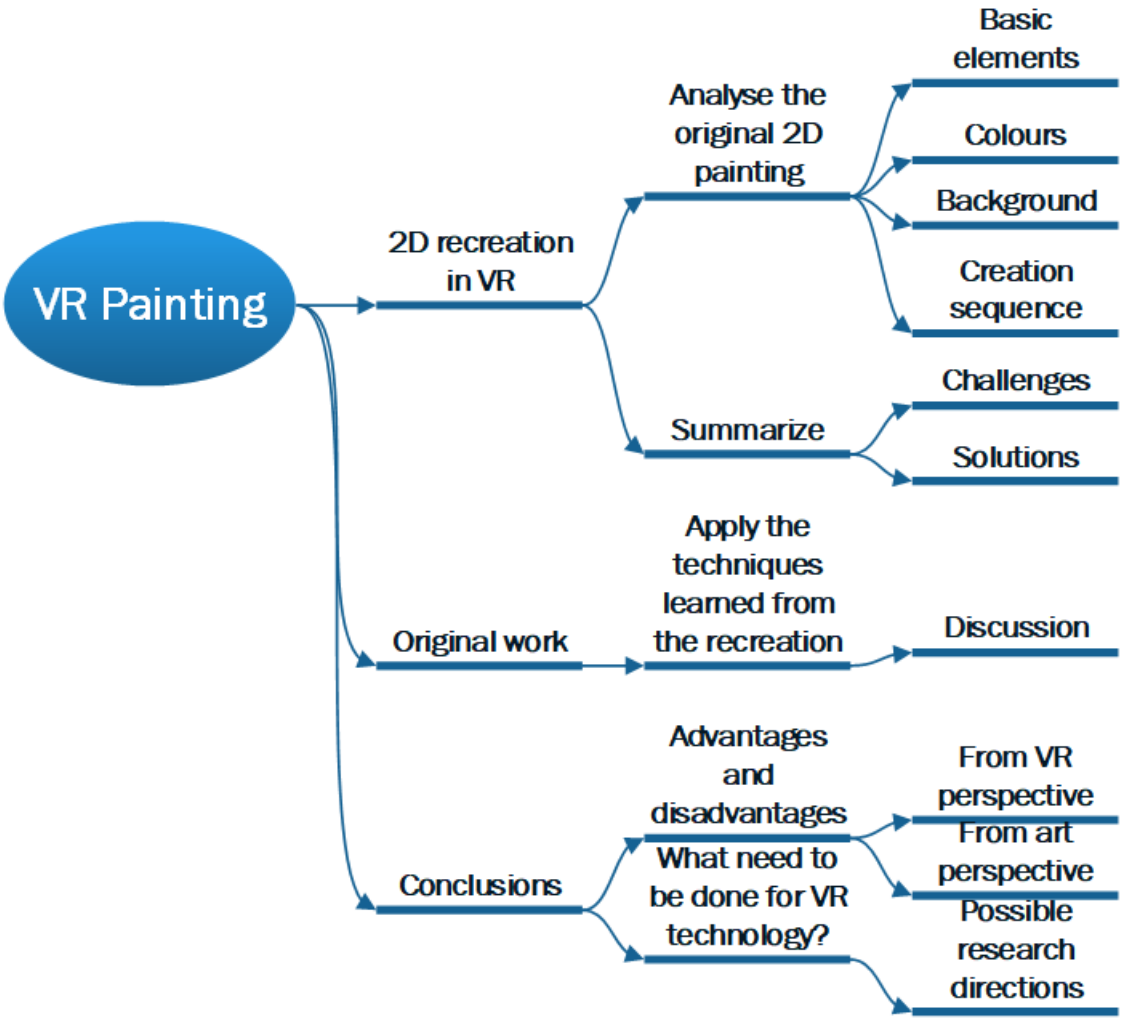


Figure 3.4: Workflow for Creating VR Art Based on Traditional Techniques

CHAPTER 4

Recreation of Water Town

In this chapter, I take Wu Guanzhong's work "Water Town" as an example to study the technical difficulties and artistic compromises encountered in the transformation from 2D works to 3D. Using VR painting tools, I have conducted a detailed recreation of the original work. Additionally, I have summarized and reflected on the problems encountered during this process. Through this example, I gained an initial understanding of the challenges in recreating 2D works in a 3D space and the current shortcomings of VR technology in artistic creation.

4.1 Water Town

As a pioneer in the exploration of modern Chinese painting, Wu Guanzhong dedicated his life to integrating traditional Chinese painting with modern Western techniques. This synthesis is vividly demonstrated in his "Watertowns in the South of the Yangtze" series, which stands as one of his most representative bodies of work. Over his lifetime, Wu created more than 150 paintings on this theme, underscoring its importance in his artistic repertoire.

The "Watertowns in the South of the Yangtze" (WiSoY) series captures the essence of Jiangnan—known as the area south of the Yangtze River. This region is historically significant, hosting two of China's major rivers that have supported Chinese civilization for over 5,000 years. Due to historical developments, the southern part of the Yangtze has been more economically and culturally developed than other regions over millennia. This area has been a cradle for numerous influential figures and has inspired a wealth of artistic expressions including paintings, poetry, and mythologies. For Wu Guanzhong, the South of the Yangtze was not only a recurring theme symbolizing Chinese art but also a sentimental reflection of his homeland.

Today, the most authentic and representative watertowns can be found in Jiangsu and Shaoxing. Characterized by their unique geographical and climatic conditions, these areas feature a moist and rainy climate that influences their distinctive architecture and lifestyle. Buildings are typically constructed along rivers with their foundations submerged, and transportation across these watery landscapes is facilitated by boats and numerous bridges. As a result, artworks depicting this region invariably include elements such as water, buildings, boats, and bridges—elements integral to the daily lives of its residents.

Fig. 4.1 provides an aerial view of WiSoY, offering a comprehensive perspective of a village in Jiangnan. The composition is arranged along a river, incorporating elements

Figure 4.1: Aerial view of “Water Town” by Wu Guanzhong, 1997, highlighting the typical landscape and architectural style of Jiangnan’s watertowns.

like people, buildings, boats, and water. This painting is selected for VR recreation because of its perspective and compositional rules, which bear similarities to Western painting techniques—elements are portrayed smaller when further away and larger when closer. Wu Guanzhong considered the viewer's perspective, ensuring that while shapes might be abstracted, they still adhere to basic physical laws.

Unlike some Western artworks that focus on the precise depiction of objects, Wu Guanzhong's approach is influenced by Chinese painting philosophy, which places greater emphasis on capturing the spirit and mood rather than meticulous detail. His work often features curved lines to enhance spatial dynamics, which contrasts with the straight lines typical of Western art that emphasize a scientific and rational approach.

Wu Guanzhong's exploration of composition was profoundly influenced by his artistic and cultural education, blending Chinese and Western perspectives innovatively. His compositions were more than just arrangements of objects, they were reconceived through imagination, selection, and refinement to surprise and engage the viewer, conveying the richness and vitality of nature. Over time, his style evolved toward minimalism, but this simplicity was deliberate and grounded in a deep understanding of structural harmony and the nuanced creation of pictorial meaning.

The objective of this project is to translate the unique "curved" compositions of Wu's water village into VR, leveraging contemporary technology to recreate and present traditional Chinese artistic themes in a modern format.

4.2 Core elements

Wu Guanzhong's painting, created using watercolor, incorporates several key elements such as buildings, boats, a bridge, water, and figures. Chinese art often embraces the philosophy of omission—a concept that has been revered throughout millennia, starting from the Song dynasty. A famous maxim by the great painter Dongpo Su encapsulates

this philosophy: "If you pursue exact likeness in your painting, then you are no different from a child." This perspective influences Wu's artwork, where he employs techniques like "liúbái", which meansleaving blank to utilize the inherent white space of the paper to suggest elements within the painting, such as water and buildings. This technique informs viewers about the color of the walls and the clarity of the water, while also allowing them the freedom to imagine beyond the visual information provided.

However, when translating these elements into VR, each component must be recreated with greater detail to accommodate the dimensional and perspective demands of virtual spaces. In this section, I discuss the techniques used in this research to adapt Wu's traditional painting techniques to create a VR rendition of the watertown.

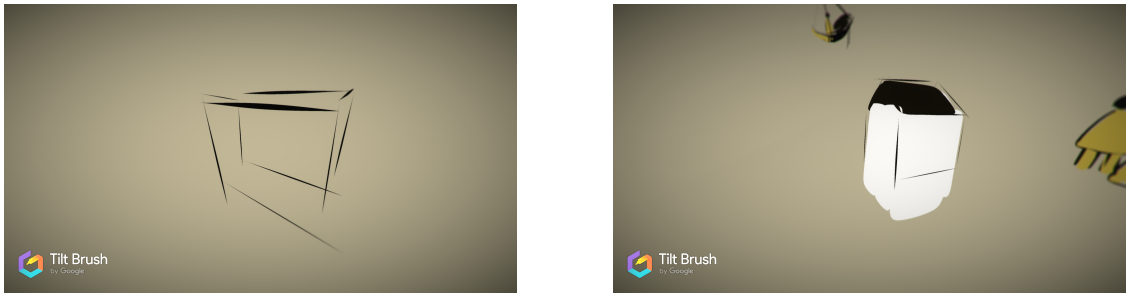
4.2.1 Recreation Process

Buildings

The recreation of the buildings began with constructing their frames. Initially, each building frame was outlined, then filled with white sheets to simulate the surfaces of these buildings, as illustrated in Fig. 4.2. This method ensured that the essence of Wu's style – emphasizing form over detail – was maintained, while adapting to the demands of three-dimensional modeling.

Following the framework setup, terraced houses were developed using the same method, as shown in Fig. 4.3. It is important to note that while the final VR artwork depicts a waterside town, details such as the foundations of the houses were intentionally omitted. In the virtual model, the lower structure of the buildings served solely as a supportive framework. This strategy helped maintain structural consistency and was akin to using outlines in traditional 2D art, assisting artists in visualizing and aligning various elements within the scene.

To construct the roofs of the buildings in this section, I used the software's built-in



(a) Outline of building (b) building with walls

Figure 4.2: VR painting process of buildings

Figure 4.3: Painting of buildings

Figure 4.4: Painting of Roof

models for efficiency and precision. First, I used the rectangle tool to outline the shape of each roof, ensuring that the basic structure was properly defined. After outlining, I proceeded to fill in the outlined areas, which resulted in roofs with regular and consistent shapes. This method allowed for a uniform aesthetic while maintaining architectural integrity, as shown in Fig. 4.4. By repeating this process, I was able to create multiple buildings, each with a distinct architectural style but with a cohesive structural uniformity across the virtual environment. This approach not only streamlined the creation of complex architectural features but also ensured that the overall design remained harmonious within the VR space.

Invisible Structures in 2D Painting

In this part of the VR recreation, I encountered a significant challenge: reconstructing invisible or partially obscured structures. Due to the limitations of Wu Guanzhong's original perspective in his 2D paintings, many of the houses and buildings are either

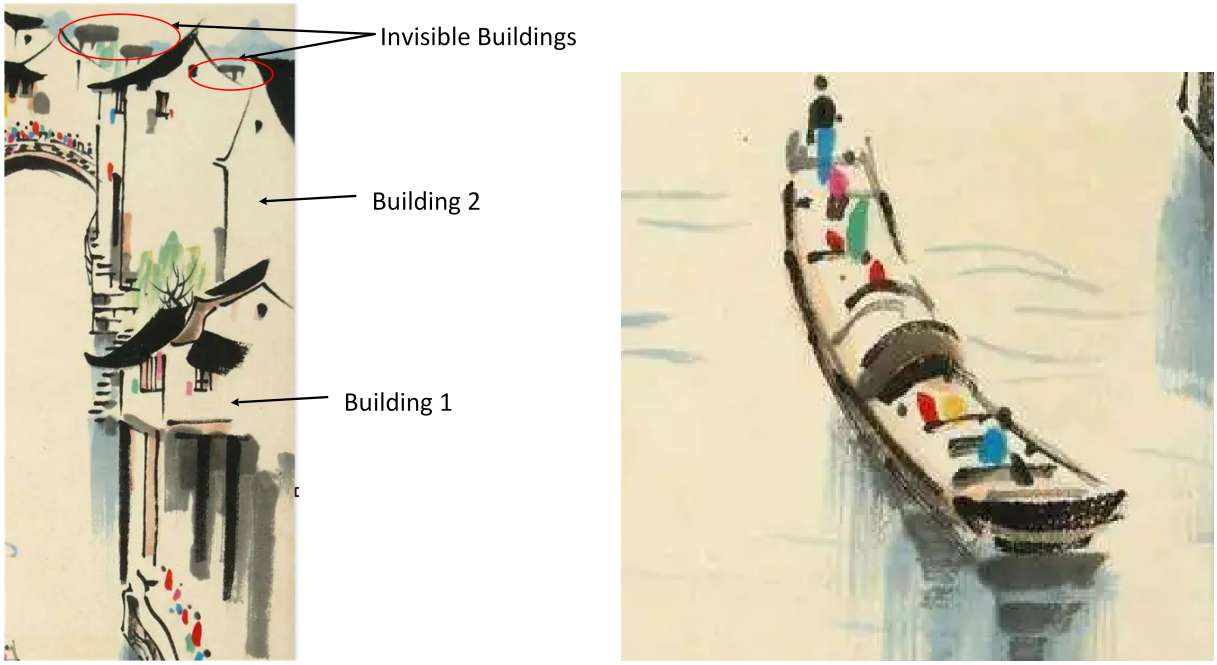
hidden or only partially visible, with only a small section of the roof or a glimpse of the facade peeking through. As shown in Figure 4.5a, this issue presented a unique difficulty when translating these structures into the VR environment. I needed to make creative decisions about completing these hidden structures in a way that maintained the spatial relationships and overall harmony of the composition.

Reflecting on Wu Guanzhong's use of curvilinear perspective, I realized that the grouping of houses in his work is essential for creating a balanced and aesthetically pleasing arrangement. In his paintings, the clusters of houses—sometimes four grouped together, or three placed unevenly—evoke a sense of organic flow and rhythm, often resembling structures arrayed along a winding river. Capturing this arrangement in a three-dimensional space was key to preserving the essence of his work. I carefully studied how he used these groupings to create visual interest and depth, noting how the varying sizes and positions of the houses enhanced the overall composition.

To translate this into VR, I used the software's copy function to duplicate these groupings of houses multiple times, strategically placing them along both sides of the virtual scene to emulate the natural flow of a river flowing through a village. I paid particular attention to the curvature of the river and the placement of the houses, ensuring that their sizes and positions varied to match the uneven and organic feel of Wu Guanzhong's original composition. Adjusting the width and shape of the river was a crucial part of this process, as it dictated the placement and spacing of the houses in relation to one another.

This process required both artistic judgement and technical precision. I frequently paused to reflect on how these reconstructed and duplicated structures aligned with the original work's artistic intent. It was important not only to fill in the gaps left by the hidden parts of the buildings but also to ensure that the new additions felt natural within the virtual environment. By carefully adjusting each element, I aimed to capture Wu Guanzhong's distinctive use of space and perspective, blending the

technical demands of VR with the artistic qualities of traditional Chinese painting. This attention to detail allowed me to recreate a scene that felt cohesive and immersive, preserving the spirit of the original work while adapting it to a new, three-dimensional context.



(a) Invisible buildings (b) Figures and boat in Wu's painting

Figure 4.5: Comparative study of invisible architecture and human figures in art

Figure Painting

In the painting "Water Town," Wu Guanzhong intentionally refrains from meticulously detailing elements such as buildings and figures, choosing instead to focus on simplicity and abstraction, as seen in Figure 4.5. When recreating this artwork in VR, I consciously adopted a similar approach, resisting the temptation to add excessive detail in order to stay true to the original work's minimalist essence. The challenge was to preserve the

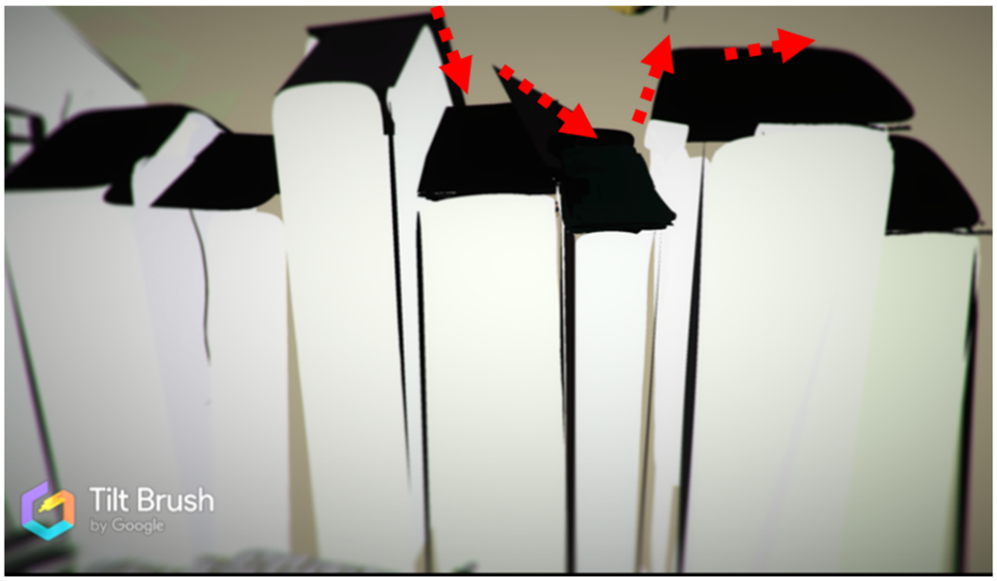


Figure 4.6: House with different heights

delicate balance between abstraction and form that Wu employed, ensuring that the VR version maintained the subtlety and expressiveness of the original painting.

One of the key areas where this approach was particularly evident was in the depiction of the figures. In "Water Town," Wu avoids rendering facial features and limbs in a detailed manner, instead representing the figures with a few ink dots and simple lines. These figures, while sparse in detail, still convey a sense of life and movement, capturing the spirit of the scene without overwhelming it with unnecessary specifics. As shown in Figure 4.7b, this minimalistic portrayal aligns with Wu's broader artistic philosophy of suggesting rather than explicitly depicting.

In my VR recreation, I mirrored this approach by using simple shapes and gestures to represent the figures (Figure 4.7). I deliberately avoided adding detailed facial features or intricate body shapes, as this would have deviated from the original painting's aesthetic. Instead, I used the VR tools to place small, minimalistic representations of the figures within the scene, focusing on capturing their posture and placement rather than individual details. This allowed me to evoke the same sense of life and movement

that Wu achieved with just a few strokes of his brush.

For the depiction of boats, I began by establishing the base of the vessel in the VR space using lines. I then outlined the deck, hull, and mast on this base, refining the details to enhance the sense of depth and space of the boat. The detailed painting process for the boat in VR is provided in Figure 4.8. In the process of painting the boat, I first drew the curved outline of the boat in 3D space, which was crucial in determining the final shape and proportions of the boat. This step required a steady hand and spatial awareness, as the manually drawn curved lines were vital to maintaining the aesthetic appeal of the boat.

Once the outline of the boat was complete, I proceeded with the coloring stage. In Wu Guanzhong's original work, the interior of the boat was colored yellow to create a shadow effect and harmonize with the river water. However, this choice would appear unrealistic and diminish the viewing experience in VR. To resolve this, I modified the boat's structure and adjusted its colors to create a more visually appropriate and engaging result for the virtual environment. This process will occur multiple times throughout the VR painting project, presenting one of the significant challenges of VR art creation. The artistic cultivation and skill level of the VR creator will directly impact the final artwork's artistic effect and its fidelity to the original.

Reflecting on this process, I found that the restraint required in the VR medium was similar to the restraint Wu demonstrated in his painting. It was tempting to add more detail, particularly because VR technology allows for such intricate precision, but the essence of "Water Town" lies in its simplicity. By embracing this minimalist approach, I was able to maintain the painting's emotional and philosophical depth, preserving its quiet, contemplative mood while translating it into a new, immersive context. This experience reinforced the importance of not just replicating visual elements in VR but also capturing the underlying artistic intent and emotional resonance of the original work.

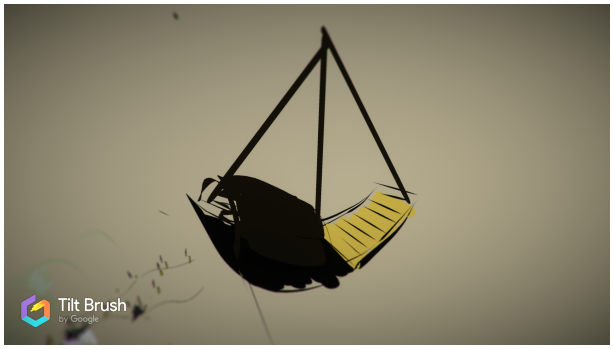
(a) Building with walls

(b) Person

Figure 4.7: Elements in VR

(a) Step1

(b) Step2



(c) Step3

Figure 4.8: Boat creation process in VR

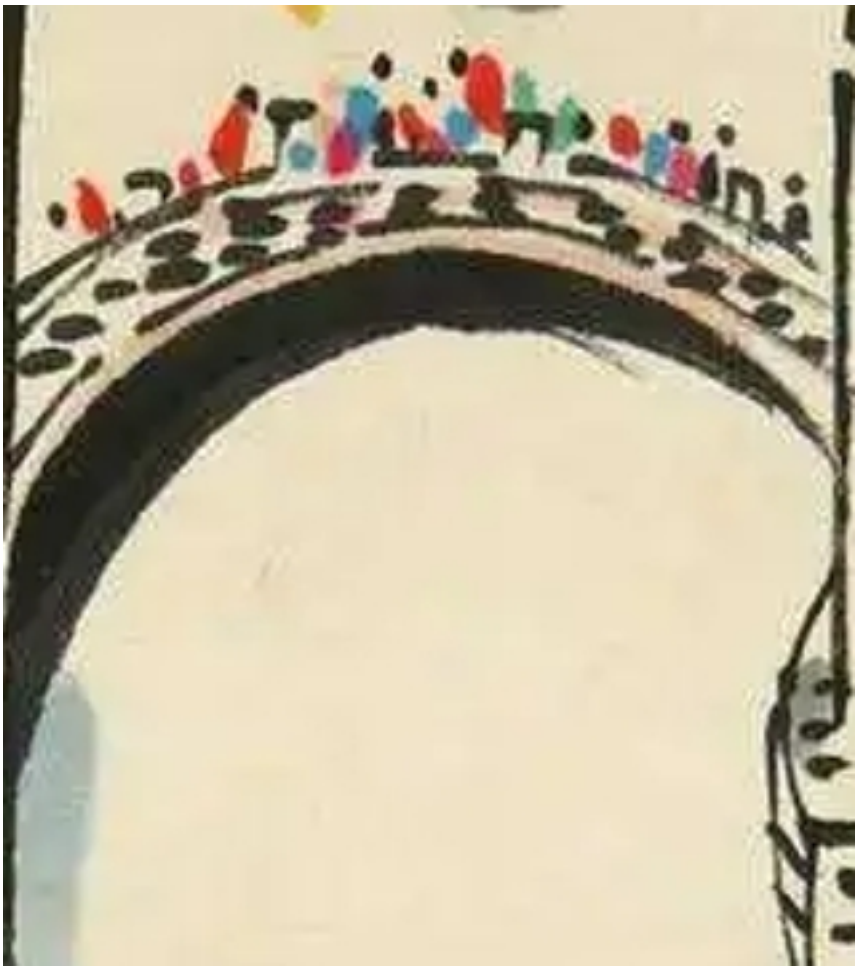


Figure 4.9: Bridge in original painting

Bridge

The bridge occupies a very important position in "Water Town," serving not only as a central physical structure but also as a key compositional element. Located at the center of the painting, it spans the entire composition, guiding the viewer's gaze from the lower left corner to the upper right, extending into the distance. In Wu Guanzhong's original 2D work, the bridge acts as a visual connector, unifying the two halves of the painting into a cohesive whole. The pedestrians crossing the bridge subtly highlight the vibrant life of the small town, making the bridge an essential feature in creating the overall atmosphere of the painting. Because of its significance, careful attention was

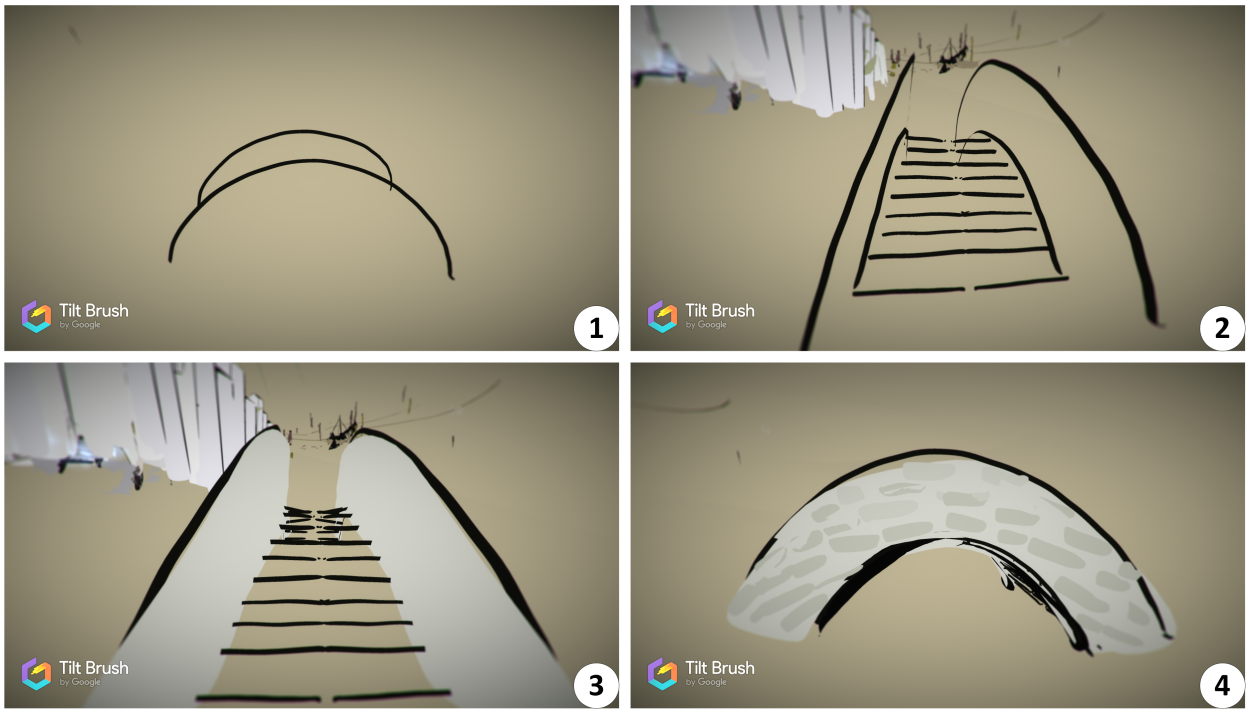


Figure 4.10: Bridge in VR (Version 1)

required during the VR recreation process, and I conducted two different attempts to accurately depict it.

In the first version, as shown in Figure 4.10, I focused on faithfully reproducing the structure as it appears in the original painting. Similar to the process I used for painting the boat, I began by establishing the outline of the bridge in the VR environment. Once the outline was in place, I filled in the structure, ensuring that the proportions and placement matched those in the original painting. To add texture and detail, I included gray bricks along the surface of the bridge, aiming to capture its architectural style. The final result of this version is presented in Figure 4.11.

While this first attempt successfully recreated the physical form of the bridge, I reflected on whether it fully captured the artistic essence and function of the bridge in the painting. The bridge in the original work not only serves as a structure but also as a dynamic visual element that draws the viewer into the scene, leading their gaze

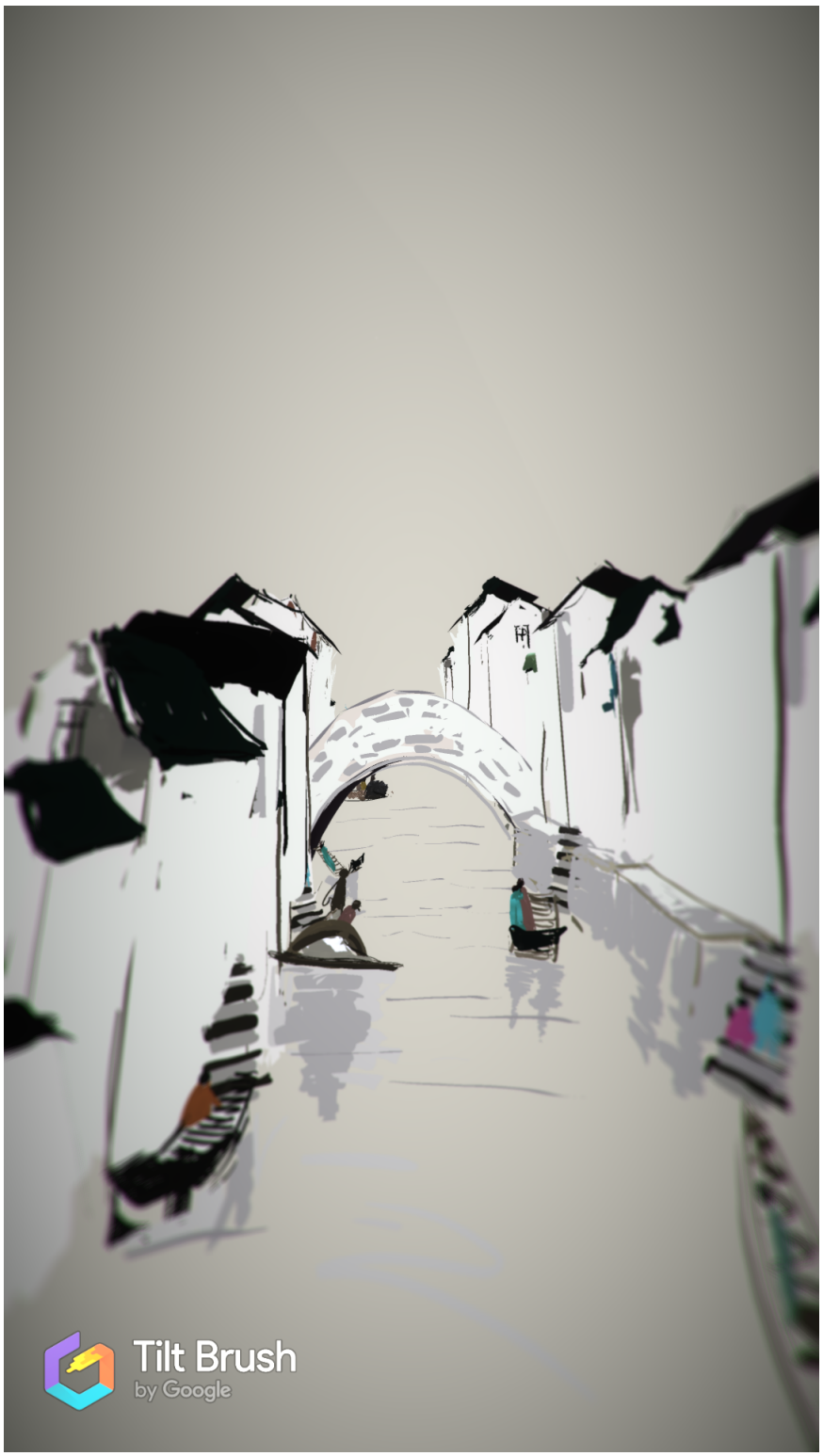


Figure 4.11: painting with bridge, version 1

across the composition. This prompted me to explore alternative methods for depicting the bridge, considering adjustments that might better convey its role as both a physical and compositional connector in the painting.

Upon further reflection, I observed that in the initial version (Figure 4.10), the similarity in color between the bridge and the surrounding walls made it difficult to distinguish their boundaries in the 3D space. This lack of distinction hindered the ability to highlight the unique characteristics of the bridge, making it blend too closely with the background. Recognizing this issue, I sought to refine the depiction of the bridge by utilizing specialized painting tools available in VR technology, aiming to enhance its visibility and better convey its importance in the composition.

In the revised version (Figure 4.12), I addressed the issue by modifying the bridge's lines to be transparent, while incorporating black spots to represent the bricks. This approach significantly improved the overall clarity and depth of the bridge within the scene. The transparency of the lines created a more distinct separation between the bridge and the background, ensuring that it stood out as a central focal point in the painting. By making this adjustment, I was able to better capture the dynamic role of the bridge in guiding the viewer's gaze across the composition.

Additionally, the use of black spots to subtly suggest the texture of the bricks introduced a nuanced layer of detail, adding realism without overwhelming the minimalist style of the original artwork. This technique maintained the structural integrity of the bridge while contributing to a more visually engaging and intricate scene. The new approach emphasized the bridge's position within the composition, creating a greater sense of spatial hierarchy and complexity. As a result, the bridge was effectively highlighted, enriching the viewer's experience and reinforcing its essential role in connecting the two halves of the painting into a cohesive whole.

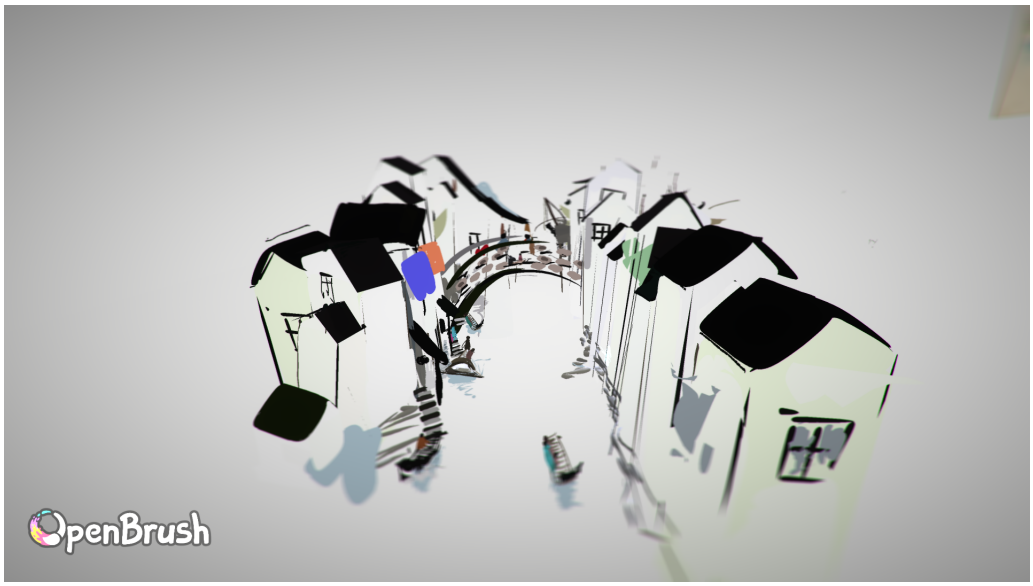


Figure 4.12: painting with bridge, version 2

4.2.2 Challenge: Color Reuse in 2D Painting

In traditional 2D painting, artists often adapt the colors of elements based on the materials they are working with. In "Water Town," Wu Guanzhong uses the inherent color of the paper, leaving significant blank spaces to depict the sky, river, and other elements like houses. This technique, commonly seen in Chinese painting, allows the viewer to imaginatively fill in the blanks, as the untouched white of the paper creates depth and suggests these features without directly coloring them (see Figure 4.13). Wu's mastery of composition and element arrangement enables viewers to perceive the river and sky without the need for additional color.

However, when translating this technique into a 3D VR environment, several challenges arise. From a realism perspective, leaving the sky and river entirely white in VR does not have the same effect as in a 2D painting. An overabundance of white can make the virtual space appear too bright, causing elements to blend together and reducing the visual clarity of the scene. Furthermore, unlike in 2D, 3D environments lack natural boundaries, meaning that using the same color for the sky and river can

Figure 4.13: 2D painting use the inherent white colour of paper for elements

lead to an indistinguishable blend between the two.

In our VR recreation, we experimented with rendering the water in realistic hues, such as blue and green (see Figure 4.15). However, this introduced a visual conflict, drawing too much attention to the water and disrupting the overall harmony of the painting. In the context of Chinese painting, it is often unnecessary to reflect the real world with complete accuracy. Chinese art, particularly Wu Guanzhong's, focuses on the relationship between nature and humanity, emphasizing meaning over form. Excessive realism can detract from this balance, and many VR tools, such as special effect brushes, are not suitable for recreating the subtleties of Wu's work.

To address these challenges, we adopted a more stylized approach to the water and sky in the final version (see Figure 4.16). We used varying gray tones to depict the water and sky, applying a gradient of grayscale to the sky to create depth. Additionally, we incorporated a glowing sun using the VR software's built-in tools, which added a natural highlight to the scene without overwhelming it. For the water, we replicated Wu's minimalistic style using a nearly white brush, adding gentle ripples highlighted with a slightly darker brown. This allowed us to maintain visual harmony while ensuring the water was recognizable and distinct from the sky.

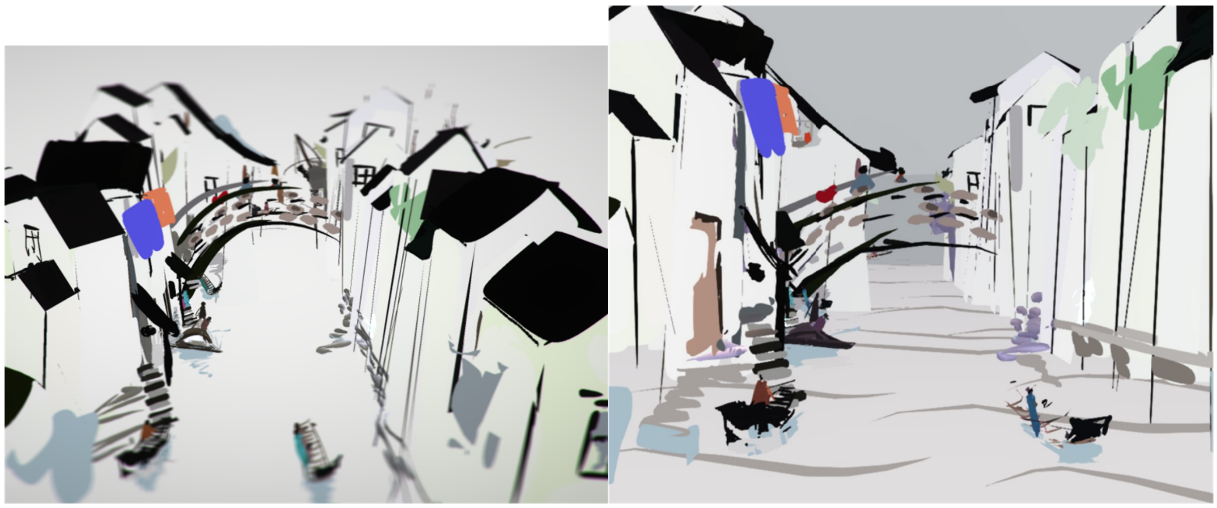
When adapting 2D paintings into 3D, especially those like Wu Guanzhong's that rely on minimalist techniques, it's crucial to make thoughtful adjustments that honor the original work's artistic integrity. Here are some strategies to consider:

1. *Color adjustment:* Adjust the colors of the sky and river to more realistic hues while preserving the artistic integrity of the original work. In the transition from 2D to 3D, the same color arrangement can lead to confusion between different elements, as shown in Figure 4.14(a), where the river and sky are indistinguishable. In 3D, this issue can be avoided by using subtle gradients or soft blues for the sky, and varied tones of blue and green for the river, which

enhances both depth and realism while maintaining the harmony of the scene.

2. *Differentiate elements:* In 2D, limited space often allows for color overlaps without causing significant visual issues. However, in 3D paintings, it becomes crucial to clearly distinguish between different elements. Applying subtle color variations between key components, such as the river and sky, can help maintain their individual presence while avoiding visual blending. To further enhance depth and realism, utilizing gradients and tone variations is effective. Gradual shifts in the sky's colors or adding different shades to the river can create a more immersive environment, allowing the viewer to step into a realistic yet artistically faithful interpretation of the original painting. Additionally, introducing subtle visual cues like gentle shading or light outlines can help define the boundaries between these elements without disrupting the composition's overall harmony.

3. *Lighting and shadows:* In VR environments, lighting and shadow techniques can be used to create natural separations between elements, adding depth and dimension by defining the contours of houses, rivers, and the sky. However, in the case of this painting, traditional Chinese art relies heavily on the contrast between black and white to express the core themes and aesthetic. Introducing prominent lighting effects could disrupt this delicate balance, causing the painting to lose its original depth and visual impact. Therefore, while lighting and shadows can enhance 3D compositions, they should be used sparingly or avoided when working with artwork that depends on high-contrast, minimalist techniques like Wu Guanzhong's work.



(a) All white

(b) Gradual gray

(c) Light orange

Figure 4.14: Different treatment for the colours of water and sky in VR

Figure 4.15: Paint the water in a realistic manner

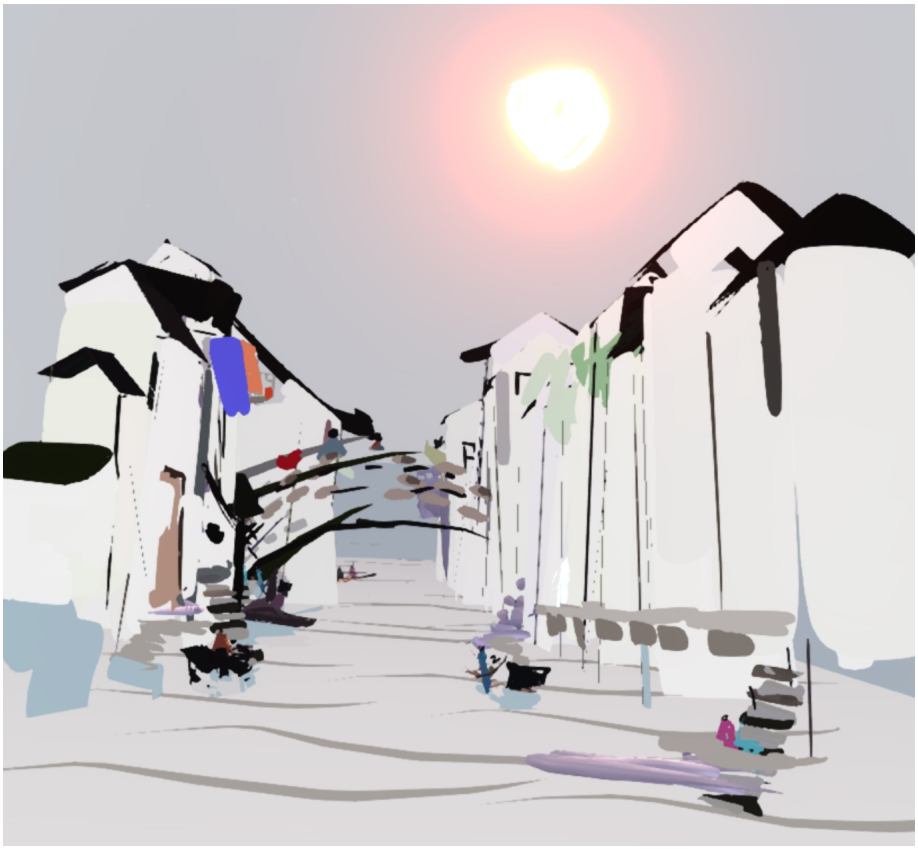


Figure 4.16: Final solution for color of river and sky

4.3 Challenge: Inherent Boundary in 2D Painting VS. 3D Space

In 2D painting, artists often adapt colors based on the painting medium, a practice evident in Wu Guanzhong's "Water Town," where he makes significant use of the inherent white background of the paper. As seen in Figure 4.13, Wu employs blank spaces to depict elements such as houses, the sky, and the river, allowing the untouched paper to form a part of the composition. This minimalist technique is a hallmark of Chinese painting and invites viewers to imagine these elements rather than see them explicitly rendered. Wu's choice to leave areas like the sky and river uncolored still allows the viewer to perceive them clearly, thanks to his masterful arrangement of elements.

However, when translating this into a 3D VR space, certain challenges arise. From a realism perspective, it is clear that the sky and river cannot remain entirely white. In VR, an excess of white would make the environment too bright, potentially washing out the scene and making it difficult for viewers to distinguish between different elements. Moreover, in 3D painting, the lack of natural boundaries, which are inherent in 2D works, could lead to an indistinguishable blend between the sky and river if both are represented in white.

To adapt Wu's minimalist approach to the VR environment, I employed several strategies. First, I adjusted the colors of the sky and river to more realistic hues while maintaining the original work's artistic integrity. As shown in Figure 4.14(a), replicating the exact color arrangements from the 2D painting caused the sky and river to merge indistinctly. This problem, which is not an issue in 2D due to limited space, necessitated a different approach for VR. To resolve this, I introduced subtle gradients and soft blue tones for the sky and varied shades of blue and green for the river, creating depth while keeping the scene balanced.

In addition to color adjustments, I used boundary definition techniques to subtly separate the sky from the river without disrupting the composition. This included adding light shading and gentle gradients to differentiate the elements, ensuring a clear visual distinction between them. While lighting and shadows can often enhance depth in VR, I avoided heavy use of these techniques because Chinese paintings, including Wu's works, typically rely on black and white contrast to convey depth. Overusing lighting effects would have disrupted the intended visual style, reducing the painting's original impact.

During the water recreation process, I experimented with a more realistic depiction, rendering the water in blue, as shown in Figure 4.15. However, this created a stark visual conflict, drawing too much attention and detracting from the overall effect of the painting. Ultimately, I adopted a more subtle approach, using lines of varying gray tones to depict the water and sky, as illustrated in Figure 4.16. For the sky, I applied a gradient of grayscale to add depth, and I incorporated a sun into the 3D scene using the built-in glowing brush from the VR software. Drawing a circular disc with this brush created a natural halo effect, simulating the afternoon sun. This addition enriched the visual experience without overwhelming the scene, allowing for variations like simulating sunrise or sunset.

For the water, I used a nearly white brush to maintain the minimalism of the original painting. To ensure a smooth surface, I utilized the VR software's auxiliary drawing module, which provided geometric shapes to aid in creating regular forms. I used a cuboid model to help define the water's surface, and to enhance its realism, I added gentle ripples highlighted in a slightly darker brown. These subtle ripples provided a sense of motion without breaking the overall harmony of the scene. Once completed, the water elements were carefully placed at the bottom of the virtual environment.

This adaptation process exemplifies the delicate balance required when transitioning a 2D artwork into a 3D space. Chinese painting, especially Wu Guanzhong's work,

does not focus on replicating reality but rather on capturing the relationship between humanity and nature. Excessive realism, particularly in VR, risks undermining the artistic charm and philosophical depth inherent in Chinese painting. Therefore, many of VR's special effect tools were unsuitable for this project.

As with any 2D to 3D transition, one of the greatest challenges was addressing the boundary issue. In 2D painting, the medium itself—whether paper, canvas, or another surface—provides natural boundaries that frame the content. These boundaries often add artistic value, allowing the artist to omit unnecessary details and focus on the core elements of the composition. In the virtual space, such boundaries do not exist, and artificial ones often appear jarring. Without careful handling, the virtual recreation can seem disconnected from the original artwork's essence.

To overcome this, it was crucial to supplement the artwork with additional elements that harmonize with the original painting. This required a deep understanding of Wu Guanzhong's intentions and the philosophical underpinnings of Chinese art, where the form is less important than the meaning. By carefully integrating the digital elements with Wu's artistic vision, I was able to create a VR painting that retained the vitality and depth of the original work, while utilizing the unique capabilities of digital art to enhance the viewer's experience.

Let's return to the works of Wu Guanzhong. As illustrated in Fig. 4.17, Wu Guanzhong uses the scenery along a river to represent the living environment and customs of the people in the Jiangnan water town. Through elements in the painting such as the river, houses, boats, bridges, and figures, he creates a cohesive whole that allows viewers to imagine the entire Jiangnan landscape from these partial scenes. Due to the constraints of the 2D medium, painting must capture the essence and selectively choose which elements to include. For example, in this painting, Wu omits the distant mountains, merely suggesting their presence with a few shadows. Additionally, the river's main section is only a short segment of the whole river in the 2D painting.

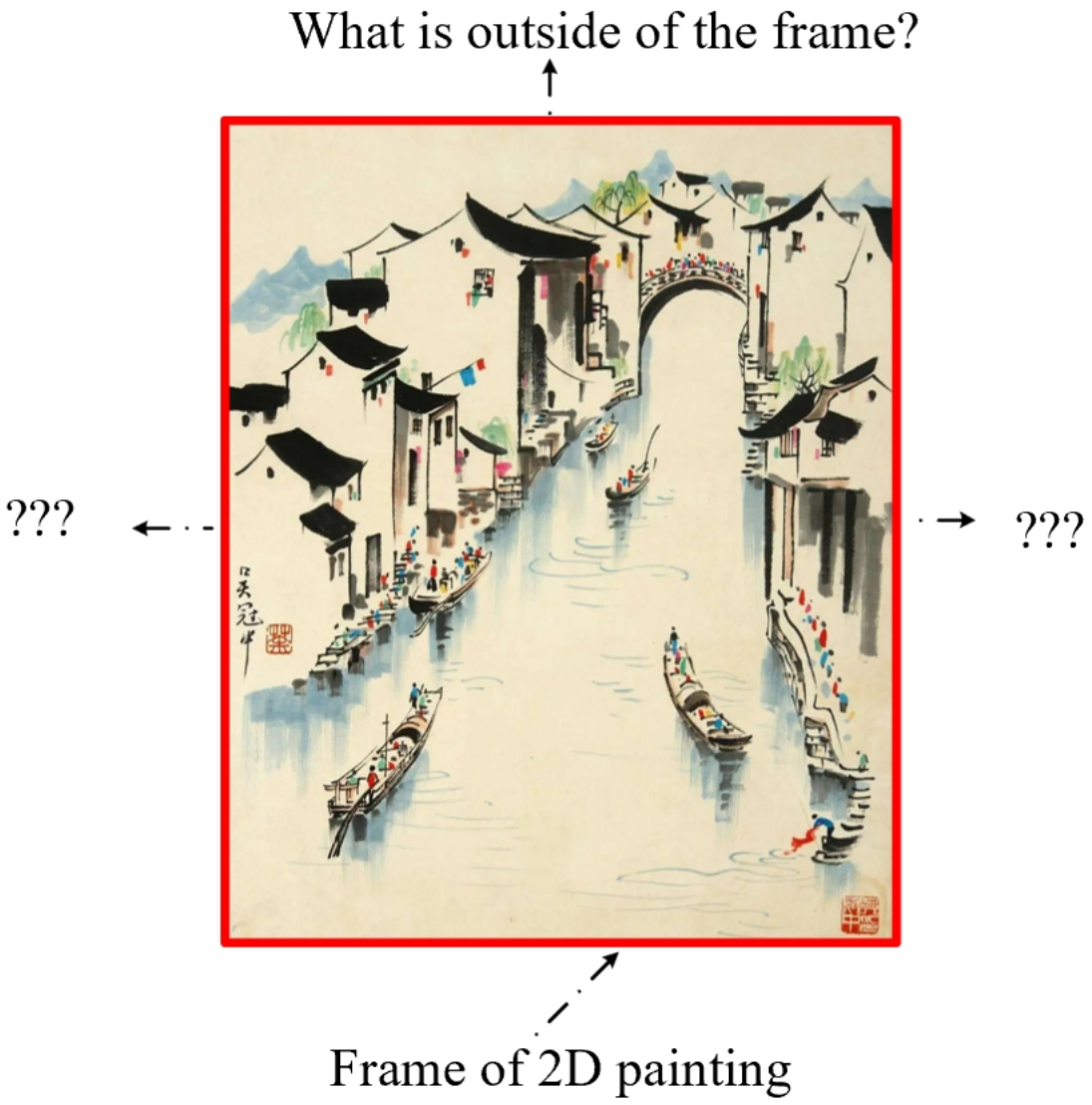


Figure 4.17: Inherent boundary in 2D painting

The remainder of the river can only be imagined by the viewer. When creating a 3D representation, we must carefully consider all these omitted aspects.

In Chinese art, most works typically focus on a central theme rather than being scattered. The artist uses their painting techniques to guide the viewer's attention to specific areas they wish to highlight, thereby conveying their emotions and thoughts. In Wu Guanzhong's painting, for instance, it is evident that he places the emphasis on the central river, the people and objects on the river, and the houses along the riverbanks. Therefore, when transitioning to a 3D representation, we must also consider this focus. It is crucial to maintain the painting's focal point in the 3D creation, avoiding dispersion. Otherwise, there is a risk of losing the original artistic quality within the complex structures of the 3D space, turning the 3D art creation into mere digital modeling. This is something we should avoid.

Based on this understanding, I made some modifications and additions to the original work as follows:

Firstly, I chose not to extend the houses and villages on the sides of the painting. This decision was made to ensure that the focus remains on the river and the related elements in the center of the scene. The size of the 3D space in VR depends on the device's processing capability and is usually quite large. Therefore, when creating in 3D, we cannot fill the entire space. We need to focus on the content we want to express. Excessive extension can make the scene less interesting. If we extend the houses on the sides, the viewer may struggle to quickly identify the central focus of the painting, thus missing the artist's intended message.

In contrast, we have added extensions to the distant parts of the river. This is because the river is the centerpiece of the painting, guiding the viewer's gaze from near to far. This aspect should remain unchanged in the 3D transformation. Thus, the design of the river is crucial. In this work, we also use this feature to guide the viewer's perspective. However, in the original work, the river was simulated using the white

Figure 4.18: Extended river in 3D painting

space of the paper, making it visually intangible. From the 2D original, we only see that the river extends to the edge of the painting. Using this edge, the artist presents an endless river, flowing to the painting's edge and to the distant horizons in each viewer's imagination. This is one of the highlights of the painting. In 3D recreation, we cannot directly reproduce this effect. The points that were inherent to the 2D work are constrained by the concept of 3D virtual space. To faithfully restore the original work and retain its artistic essence, we have extended the river as shown in Fig. 4.18.

Fig. 4.19 shows the effect of not extending the river. As can be seen, due to the presence of the 3D space, if the river is not addressed, the background of the scene appears empty, leading to a sense of incompleteness for the viewer. The addition to

Figure 4.19: River in 3D painting without extension

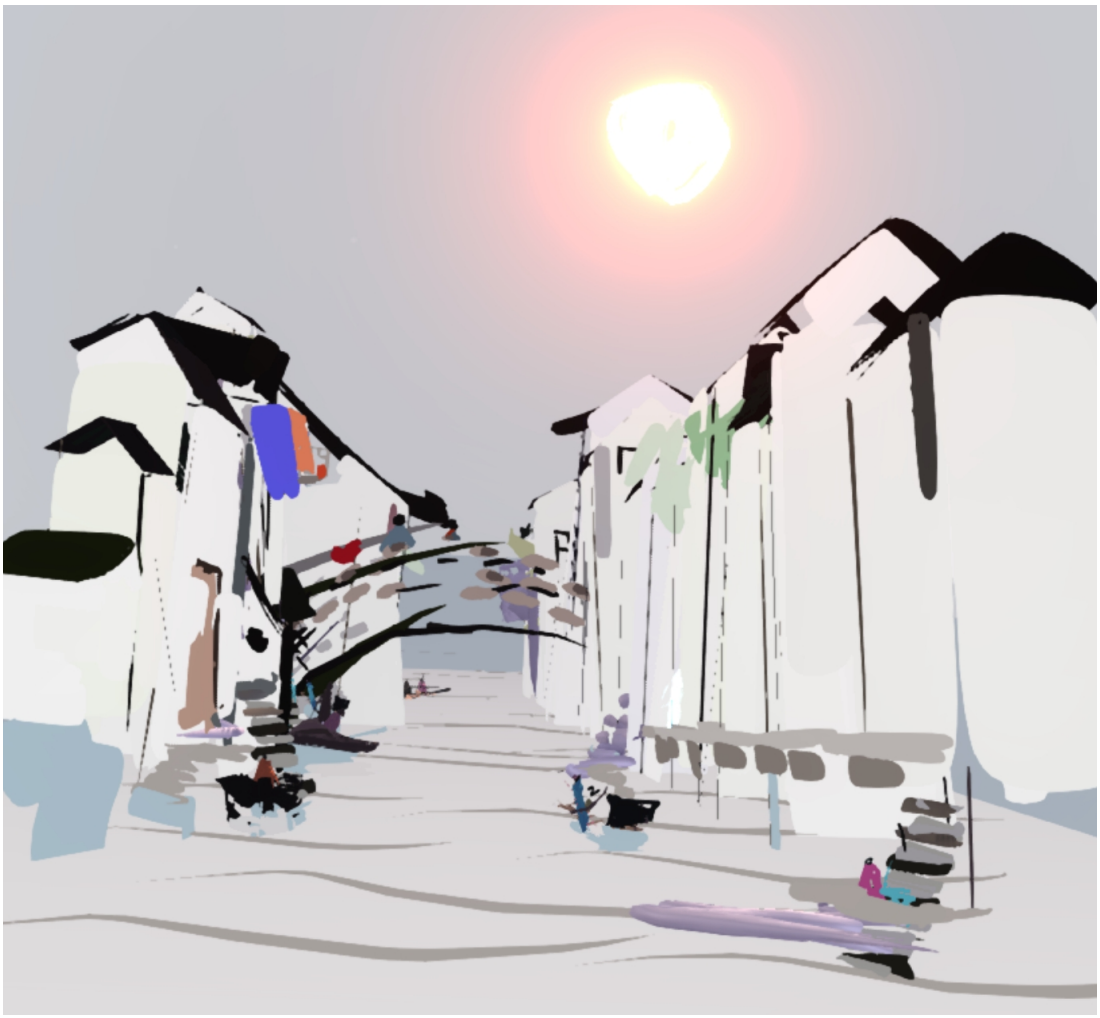


Figure 4.20: Recreated 3D painting in VR

the scene effectively resolves this issue. However, this addition should not be overly detailed. Fig. 4.18 illustrates that we used very simple lines and color blocks to depict the distant river.

The final effect is shown in Fig. 4.16. The viewing perspective in this work is the same as in the original piece. In other words, the appreciation of this work is also from one segment of the river, looking towards the other end. The figures and objects in the painting are rendered in an abstract style similar to the original work. I have appropriately supplemented the surrounding environment and the scene. Overall, this

3D work achieves a good effect.

4.4 Conclusion

In this chapter, I took Wu Guanzhong's work "Water Town" as an example to study the transformation from traditional Chinese 2D painting to VR painting based on digital technology. The main elements in this creation include water, houses, people, boats, the sky, and bridges. We have detailed the characteristics of Chinese 2D painting, the challenges of corresponding 3D creation, and possible solutions.

Based on this chapter's research, the main technical difficulties can be summarized as follows

1. **Balancing Tradition and Modernity:** One of the most significant challenges in this project was to maintain the philosophical depth and artistic essence of Wu Guanzhong's work while leveraging the immersive potential of VR. Traditional Chinese painting emphasizes abstraction, symbolism, and minimalism, often leaving space for the viewer's imagination. Adapting these qualities to a medium as precise and immersive as VR required thoughtful compromises and creative solutions. This balance between tradition and modernity underscores the importance of preserving artistic intent in the face of technological innovation. Traditional Chinese painting emphasizes meaning over form, which means that their 3D creations are not just simple modeling art. Artists need to infuse their own thoughts and appropriately transform the scenes to retain the original artistic essence.

2. **Boundary Treatment in VR space:** The natural boundaries of the medium in 2D paintings lead to specific artistic techniques. Artists often use the edges of the paper to add artistic value to their work. However, in 3D space, these clear boundaries do not exist. Handling the boundaries and their effects from 2D originals in 3D VR painting is a significant challenge.

3. **Recontextualizing Composition in VR:** The role of composition in Chinese painting differs significantly from Western traditions, with an emphasis on guiding the viewer's emotions and imagination rather than replicating physical reality. In VR, this compositional philosophy had to be reinterpreted to consider factors like viewer movement, spatial navigation, and interaction. By strategically extending certain elements, such as the river, and minimizing others, such as peripheral structures, the recreation preserved Wu's focus on the central theme while enhancing the immersive experience.

4. **Technical Challenges of Color and Form:** Traditional Chinese paintings are mostly created on white paper. Artists utilize the characteristics of the paper in their creations. When recreating these scenes in 3D space, due to the existence of the three-dimensional space and different backgrounds in VR, we need to appropriately optimize the colors, structure, and even content of the scenes. Additionally, translating abstract forms, such as Wu's minimalist figures and dynamic architectural groupings, into 3D required innovative approaches to maintain spatial coherence and visual harmony. The colors in traditional Chinese paintings are primarily black, white, and gray. However, the colors and brushes in VR software find it challenging to replicate the subtle gradations of light and shadow in Chinese paintings. Therefore, relevant painting software still needs further optimization to address this issue.

CHAPTER 5

Animals in Wu Guanzhong's Paintings

Chinese paintings, particularly those focusing on animals, often emphasize not just the form but also the spirit and movement of the creatures. Recreating these in VR presents unique challenges and opportunities. VR painting tools can offer new dimensions and interactions that traditional media cannot, allowing artists to bring these ancient artworks to life in immersive ways.

In this chapter, the water buffalo, panda, and swan are selected as animal subjects because they embody distinct modes of movement, line quality, and pictorial emphasis, providing a focused set of cases for examining how the expressive qualities of animal painting can be translated into a VR environment.

Wu's animal depictions are characterized by expressive, lively brushstrokes that convey movement and vitality. His approach focuses on capturing the spirit of the animal rather than meticulous anatomical accuracy, which aligns well with the strengths of VR painting tools that can create dynamic and fluid strokes. One of the central tenets of Wu's art is "qì yùn)" , or the resonance of spirit and life. This principle emphasizes the

importance of capturing the essence and vitality of the subject, a concept that is crucial for creating compelling VR experiences. VR technology, with its ability to animate and create interactive environments, offers a unique opportunity to bring this principle to life. Studying Wu's work can guide VR artists in focusing on the emotional and spiritual resonance of their animal creations, making their virtual artworks more engaging and lifelike.

5.1 Water buffalo

The water buffalo (Bubalus bubalis) plays an essential role in Chinese rural life, particularly in southern China [59, 60]. Historically vital for agricultural activities such as plowing fields and transporting goods, the water buffalo transcends its practical functions to hold significant cultural symbolism. It represents perseverance, hard work, and the agrarian spirit deeply embedded in Chinese culture. Its frequent depiction in Chinese art and literature underscores these values and makes it an intriguing subject for exploration in the context of virtual reality painting [61].

Physically, the water buffalo is notable for its large, muscular frame, robust limbs, and broad shoulders, making it a compelling subject for detailed artistic representation. Its distinctively curved horns, often arching upwards or outwards, contribute to its unique and recognizable silhouette. The thick, dark skin of the water buffalo, with its rough texture, can be effectively depicted using detailed virtual brushstrokes to enhance realism in VR painting. Behaviorally, water buffaloes epitomize diligence and reliability, known for their endurance and strength. Their typically docile and patient demeanor makes them ideal subjects for conveying a steady, unwavering presence in art [62].

The water buffalo holds deep symbolic meaning in Chinese culture. Often portrayed to symbolize perseverance and the relentless spirit integral to the agrarian lifestyle, the water buffalo also represents the harmonious relationship between humans and nature, a concept deeply rooted in Chinese philosophy and aesthetics [63]. In traditional Chinese paintings, artists frequently incorporate water buffaloes into idyllic rural landscapes, underscoring their essential role in farming communities and their symbolic significance. They also feature prominently in Chinese stories and poems, symbolizing agricultural virtues and the simplicity of rural life [64].

In terms of artistic techniques, the robust form of the water buffalo is typically

rendered with bold, expressive brushstrokes, capturing their physical strength and resilience. Traditional techniques like ink and wash are employed to convey the textures of their skin and the natural environments they inhabit, such as muddy fields or lush grasslands.

The water buffalo is emblematic of China's agrarian roots, symbolizing the vital connection between people and the land. Depictions of water buffaloes evoke themes of rural life and the enduring spirit of the farmer, central to Chinese cultural identity. In Chinese philosophy, particularly Taoism, the water buffalo symbolizes a life of simplicity and contentment, living harmoniously within natural cycles. Studying water buffaloes in Chinese art provides insights into the socio-economic and cultural history of China, reflecting the importance of agriculture and the values associated with it.

Painting water buffaloes in VR combines the strengths of traditional Chinese art with modern technology, offering a unique way to explore and appreciate this iconic animal's cultural and artistic significance. VR allows for a more immersive experience, giving the artist the ability to create life-like representations of water buffaloes in their natural environments. The dynamic interaction enabled by VR technology allows viewers to explore different perspectives and appreciate the details from various angles.

VR tools can replicate the fluidity and expressiveness of traditional Chinese brushstrokes, allowing for an authentic representation of the water buffalo's form and texture. Additionally, VR enables comprehensive scene creation, incorporating not just the water buffalo, but also the surrounding landscape, thus capturing the essence of rural China.

In general, painting water buffaloes in VR is not only about replicating traditional Chinese art in a new medium but involves a creative process that respects and enhances the cultural and artistic heritage of the original. The artist must possess a deep understanding of both the subject matter and the technical capabilities of VR to achieve a harmonious and compelling work of art. Through VR, traditional subjects like

Figure 5.1: Water buffalo in Wu Guanzhong's painting

the water buffalo can be revitalized, offering new dimensions of appreciation and engagement for contemporary audiences.

The painting under consideration, created by Wu Guanzhong, depicts two water buffaloes immersed in a tranquil setting, partially submerged under a canopy of drooping willow branches (see Fig. 5.1). The artwork showcases Wu Guanzhong's mastery in blending traditional Chinese ink painting techniques with modern aesthetic sensibilities. The use of fluid brushstrokes and minimalist color palette captures the serene and pastoral atmosphere, while the expressive portrayal of the water buffaloes emphasizes their gentle yet strong nature [65].

To recreate this painting in VR, I began by reconstructing the water buffalo. As illustrated in Fig. 5.3 and 5.2 , I only needed to depict the part of the buffalo above the water surface, while the rest could be omitted similarly to the original work in Fig. 5.1. Initially, I created a water surface and used the gray color of the water to fill the voids in the scene. On this foundation, I then drew the main subject, the water buffalo. Lastly, I adjusted the water surface and ripples according to the original background, and added the willow branches from the original painting.

In this artwork, I did not extend any of the elements. Instead, I focused solely on recreating the existing elements. The viewing perspective of this 3D piece will be the

Figure 5.2: Recreated water buffalo, main body

Figure 5.3: Recreated water buffalo

Figure 5.4: Recreated 3D water buffalo

same as the original. This decision was made because the original work contains very few elements, with a highly prominent subject. I believe that for such compositions, maintaining the same viewing angle in 3D reconstruction as in the 2D original can be effective. This requires a balanced approach between staying true to the original and leveraging the capabilities of 3D art.

By adhering to this method, I ensure that the essence and focus of the original artwork are preserved, while still taking advantage of the immersive qualities offered by VR technology. The final 3D artwork is illustrated in Fig. 5.4. By adopting a specific frontal viewing angle, I have been able to achieve an artistic effect similar to the original painting while leveraging 3D technology to enhance the depth of the scene. This approach allows us to retain the essence and focus of the original work while benefiting from the immersive capabilities of 3D visualization.

Figure 5.5: Panda by Wu Guanzhong

5.2 Panda

In this section, I have recreated Wu Guanzhong's "Pandas" in 3D. The original work is shown in the Fig. 5.5. Recreating the panda in this research is significant for both its cultural and technical implications, particularly within the context of Chinese painting and VR technology. In traditional Chinese art, animals often serve as symbols of cultural and philosophical values. The panda, a national symbol of China, embodies harmony, peace, and balance—qualities deeply ingrained in Chinese philosophy [66]. By selecting the panda as the subject for VR recreation, this work not only engages with these cultural values but also offers an opportunity to explore how symbolic representations in traditional Chinese animal painting can be translated into a modern, digital medium.

From a technical standpoint, recreating the panda presents unique challenges within VR. Traditional Chinese animal paintings emphasize fine line work to outline forms, often leaving interior details abstract or minimally suggested through brushstrokes.

Translating this into a 3D environment, where the viewer can experience the subject from multiple angles, requires careful consideration of line work, shading, and spatial representation. Successfully reproducing this in VR demonstrates the potential of virtual environments to capture and adapt the techniques characteristic of Chinese painting.

Furthermore, traditional Chinese paintings, especially those depicting animals, often use negative space as a critical compositional element [67]. In many panda paintings, the surrounding environment is left intentionally sparse to emphasize the form and symbolic importance of the subject. Recreating the panda in VR allows for an exploration of how negative space—an essential feature of Chinese art—can be adapted to a three-dimensional, immersive environment, pushing the boundaries of how virtual spaces can handle balance, abstraction, and focus.

Additionally, the distinct characteristics of the panda, such as its black-and-white fur and rounded, soft form, offer a specific test of VR's capacity to render detailed and textured elements. Unlike simpler subjects, the panda's intricate patterning and unique physical features present a challenge to VR technology, requiring advanced handling of texture, lighting, and spatial awareness. This makes the panda an ideal case study for testing the efficacy of VR in recreating complex and culturally significant forms.

By recreating the panda, this research bridges the gap between traditional Chinese painting and modern technology. The panda, a familiar subject in Chinese art, gains new dimensions in VR, offering a contemporary interpretation while preserving the essence of its traditional representation. This work demonstrates how VR technology can be leveraged to preserve and reinterpret traditional Chinese artistic techniques, ensuring their relevance in a digital age and offering new ways for global audiences to engage with Chinese culture.

In the original, Wu Guanzhong depicted a scene of two pandas eating bamboo, surrounded by bamboo. The background is filled with colorful pebbles to showcase

the pandas' living environment. Wu Guanzhong left nearly half of the area in the original blank. He used the white background of the paper to fill the shapes outlined by the lines, thereby presenting the various elements in the painting. Unlike "Water Town" in Chapter 4, most of Wu Guanzhong's animal paintings describe partial scenes, focusing primarily on the animals themselves and their immediate surroundings. To highlight the main subjects, the pandas, Wu Guanzhong used a light color treatment for the background, while the pandas themselves were emphasized using black and white contrast.

The issues of boundary handling and color reuse mentioned in Chapter 4 are also evident here. Additionally, compared to "Water Town," this painting describes a small scene. Through this example, I will demonstrate how to address the challenges encountered in VR when painting small scenes.

5.2.1 Practicality of Sample Shapes in VR Software

Firstly, I reconstructed the pandas. During this process, I observed that the bodies of the pandas are outlined with several curved lines. VR painting tools provide ready-made spherical auxiliary shapes. By using these tools, regular spheres can be drawn quickly and efficiently. Utilizing this feature, I created a sample panda body. As seen from Fig. 5.6, objects created with regular shapes appear very rigid. Art is a human creation that embodies the creator's emotions and style. Variation and uncertainty are the soul of art. However, if digital models interfere too much with the creation, the entire VR painting can become rigid and lifeless. Fixed shapes also fail to reveal the artistic elements behind the scene to the viewer. Therefore, I cannot overly rely on these auxiliary shapes in VR painting tools. For the main parts of small scenes, manual drawing remains the best choice. Even when using auxiliary models, further processing on these overly regular models is necessary to make the shapes more natural.

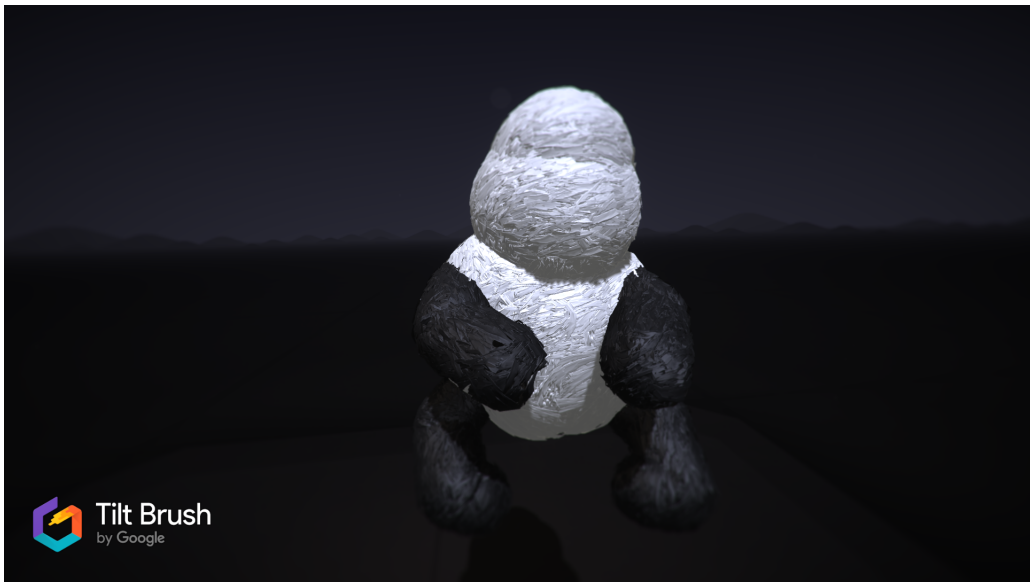


Figure 5.6: Panda created with sample shapes

Fig. 5.7 illustrates the manually drawn pandas. In this instance, I have refined the shapes initially generated by the software. By overlaying additional details on the original regular shapes, I achieved a more natural representation of the pandas' bodies. Compared to the automatically generated structures, the manually drawn pandas exhibit a greater sense of harmony and naturalness.

5.2.2 Reconstruction of Background Elements

In the original work, the pandas live amidst a bamboo forest. For VR artworks, painting such small scenes requires more emphasis on the background. This is because, while VR space provides greater freedom, it also demands more effort from the artist. The treatment of the background determines whether the main subjects can harmoniously exist within the VR space. To address this, I first reconstructed the bamboo and the ground. The results of this reconstruction are shown in the illustration. Based on the elements and color treatments in the original work, I have rebuilt these components, striving to use colors similar to those in the original.

Figure 5.7: Manually created pandas

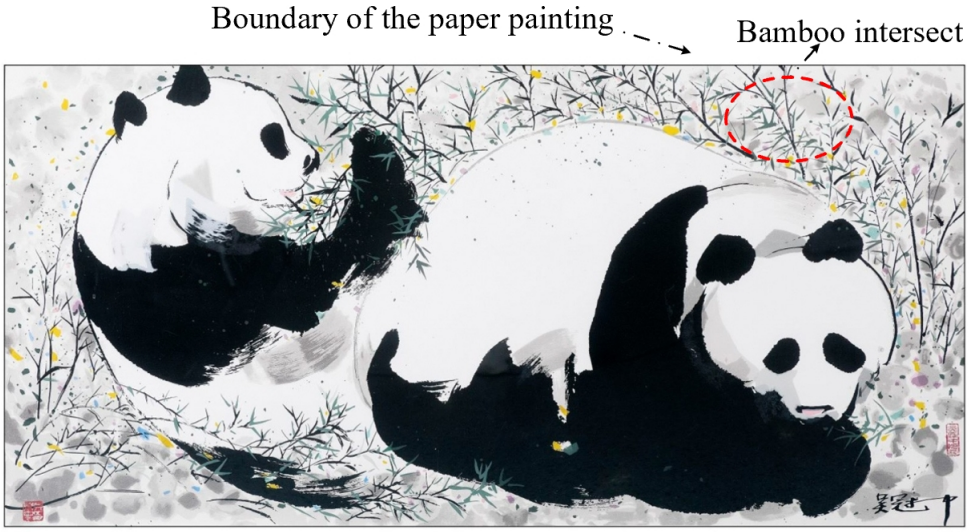


Figure 5.8: Boundary and bamboo intersect in 2D painting

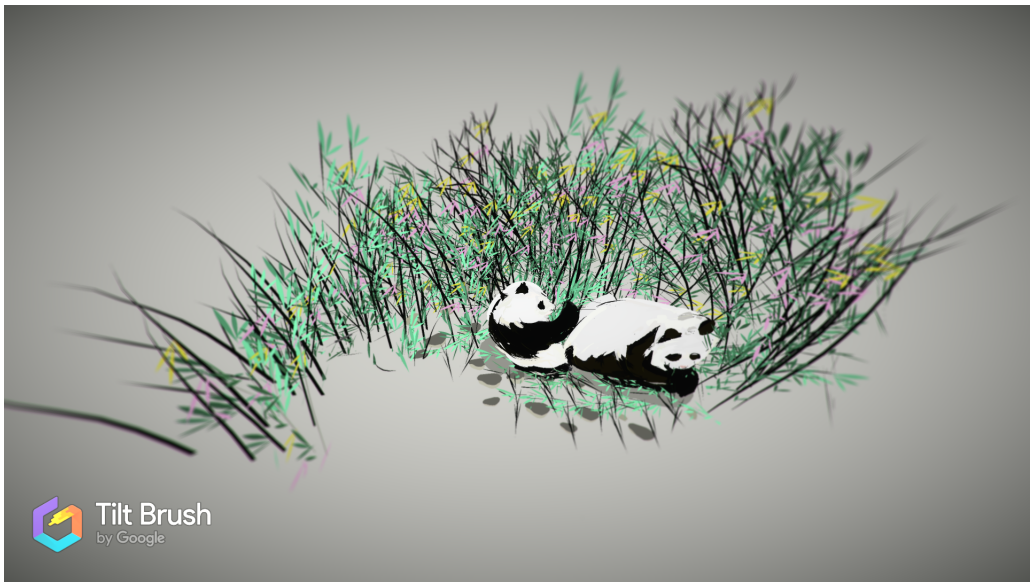


Figure 5.9: 3D painting with extended background and rearranged bamboo

Similar to "Water Town," the boundaries of the 2D image in this work also result in some elements not being fully visible to the viewer, as shown in Fig. 5.8. Here, I appropriately extended the tops of the bamboo. Additionally, I did not completely follow the original placement of the bamboo. Instead, I reconstructed the bamboo to make it more realistic. For instance, in the 3D space, the bamboo needs to have roots in contact with the ground. Unlike in the 2D artwork, the bamboo cannot intersect each other in the same manner. In the 3D space, I need to rearrange them to comply with basic physical principles.

Special handling is required for the intersecting bamboo. To achieve a natural and realistic appearance, I need to ensure that the bamboo stalks intersect in a manner consistent with physical laws. This involves adjusting their positions and angles so that the intersections appear logical and natural within the 3D space. The final effect is shown in Fig. 5.9

However, for small scene compositions, I must avoid overextending secondary elements. Overextended secondary elements can dominate the scene, preventing viewers

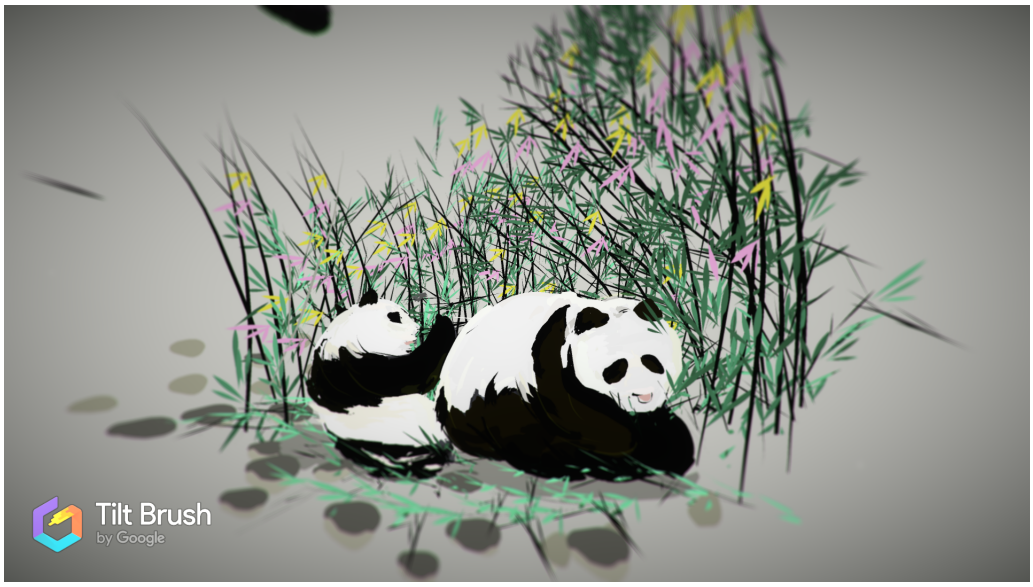


Figure 5.10: Panda with limited ground

from quickly focusing on the main subject. In this painting, the pandas are the primary subjects, while the bamboo and the ground serve as the background, secondary elements. Therefore, when extending the ground and bamboo, it is crucial to ensure they do not occupy too much of the scene.

To showcase the pandas' living environment while maintaining their prominence as the main subjects, I made the following adjustments: First, I reduced the size of the ground area. As shown in Fig. 5.10, I depicted only a small portion of the ground beneath the pandas, and I confined the bamboo to this limited area. This approach makes the scene resemble a small diorama, allowing viewers to immediately recognize the pandas as the main focus.

Additionally, I experimented with changing the background color to highlight the pandas further. As shown in Fig. 5.11, by adjusting the scene to a nighttime setting in VR, I can accentuate the pandas more effectively.

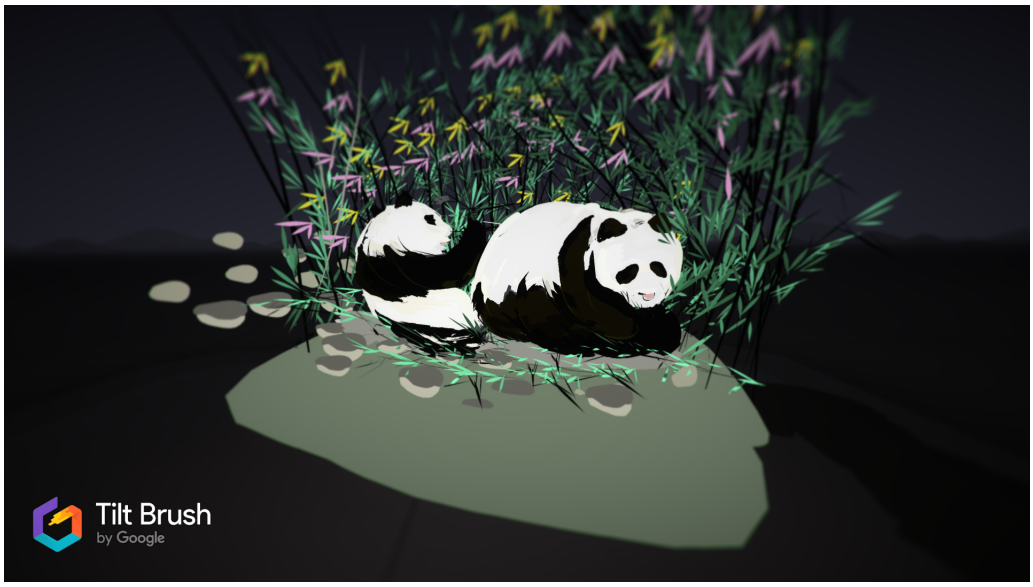


Figure 5.11: Panda with limited ground and dark background

5.3 Small animals

The previous two paintings are about large animals. However, Wu Guanzhong also created works about small animals. Recreating small animals in Tilt Brush differs from depicting large animals due to the need to manage scale, detail, and interaction within a 3D space. Large animals often require broad strokes and can dominate the virtual environment, allowing the viewer to feel immersed and dwarfed by their presence. In contrast, small animals necessitate finer, more intricate brushwork and closer attention to detail, as they invite the viewer to move in closer and explore the subtleties of their form. The immersive nature of Tilt Brush emphasizes these differences, as scale plays a crucial role in how the artwork is experienced and felt within virtual reality. In this section, I will use Wu Guanzhong's work Swan as an example to show how to reproduce small animals in traditional Chinese paintings in 3D space. As shown in Fig. 5.12, Wu Guanzhong's painting presents a serene scene featuring black swans swimming among reeds and willow branches. This composition highlights the elegant interplay of flowing lines and vibrant colors, a hallmark of Wu's unique style that blends traditional

Chinese painting techniques with modern aesthetics.

5.3.1 Swans

Swans hold symbolic meaning in Chinese philosophy and culture, often connected to ideals of purity, grace, and elegance. Their serene and graceful appearance makes them a symbol of purity, which aligns with Confucian values of self-cultivation and moral integrity [68]. In Confucian thought, qualities like elegance and refinement are important for cultivating one's character, and the swan embodies these traits through its poised demeanor. The beauty and calmness of the swan's movement through water can reflect the Confucian ideal of self-discipline and graceful behavior in society.

In Daoism, swans can also resonate with the philosophy of natural flow and harmony. The swan's ability to glide smoothly on water, seemingly with minimal effort, mirrors the Daoist concept of wu wei [69] (non-action or effortless action), where one harmonizes with nature and life's natural rhythms. Swans, often seen in peaceful natural settings, embody the Daoist belief in living in harmony with the world and aligning oneself with the natural order. Additionally, their association with water, a fluid and adaptive element in Daoism, symbolizes the importance of being flexible and yielding in life.

Furthermore, swans also represent transformation and transcendence. In Chinese literature, they are sometimes depicted as mystical or otherworldly creatures, capable of flying between the earthly and celestial realms. This idea resonates with Buddhist notions of spiritual ascension or enlightenment [70], where the swan becomes a symbol of transcending earthly attachments and achieving higher states of consciousness.

Figure 5.12: Swans by Guanzhong Wu

5.3.2 Painting Techniques and Content in 2D Swans

The painting employs expressive brush strokes to delineate the swans and the reeds. The flowing lines create a sense of movement and grace, capturing the essence of the swans' fluid motion. Wu uses a limited yet effective color palette, predominantly featuring black for the swans and branches, yellow for the leaves, and red for the swans' beaks. This restrained use of color enhances the painting's elegance and focus. A significant portion of the painting is left as white space, a technique often seen in traditional Chinese ink paintings. This use of negative space not only provides a balance to the composition but also evokes a sense of tranquility and openness. Wu's depiction of the swans and the environment is abstract rather than realistic. The swans are simplified into flowing, almost calligraphic forms, highlighting the artist's emphasis on capturing the spirit rather than the precise details of the scene.

Recreating Wu Guanzhong's painting in VR involves translating the fluid, expressive qualities of his 2D work into a 3D immersive experience. Modeling the swans should

begin with using soft, flowing shapes to mimic the brush strokes, avoiding rigid, geometric forms to maintain the organic feel. Textures applied should reflect the painterly quality of the original work, using gradients and slightly blurred edges to simulate the ink wash effect.

The environment creation must include a water surface with gentle ripples to emulate the flowing lines representing water in the painting. Willow branches need to be modeled with smooth, curved lines, paying attention to the way they interact with the swans to ensure a cohesive scene. Soft, diffused background is essential to recreate the gentle ambiance of the painting, avoiding harsh shadows to maintain the serene atmosphere. Sticking to the original color scheme, emphasizing the black, yellow, and red hues, ensures fidelity to Wu's artistic vision.

5.3.3 Painting process

First, I need to outline the primary subject of the painting: the swan. In the original work, Wu Guanzhong utilized techniques from traditional Chinese painting. He sketched the shape of the swan using black lines and then filled in certain areas with color to convey its form. Notably, Wu Guanzhong did not depict the swan's body in detail as one might for larger animals. Instead, he used various shades and color blocks to represent the swan's form. These color blocks are not strictly connected according to physical laws. This approach is deliberate and serves several purposes. Primarily, it reflects a characteristic of traditional Chinese expressive painting. Wu Guanzhong used this technique to prevent viewers from focusing excessively on the swan's physical form, thereby highlighting its posture and temperament. Additionally, unlike the water buffalo and panda, the swan in this painting is relatively small, occupying only a minor portion of the canvas. By abstracting the swan, the artist enhances the connection between the elements, creating a more harmonious composition.

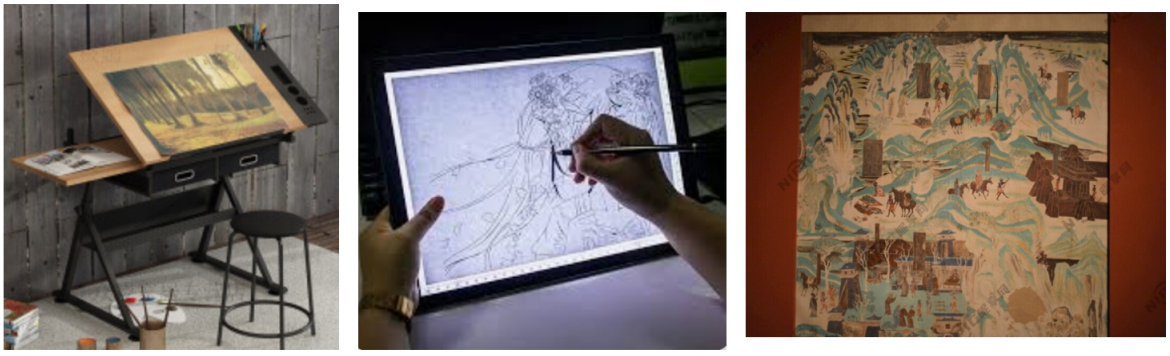


Figure 5.13: Different painting platforms

When recreating this painting in 3D, capturing the swan's posture is crucial. To stay true to the original's intent, I chose not to model the swan in detail. Instead, I used black and white color blocks and lines in VR to represent the swan.

I began by outlining the swan's contours in 3D space with black lines. This step requires particular care because drawing non-3D structures in VR is challenging. Unlike 2D painting, where there is a tangible support for the object, ensuring that the drawn structure is correctly positioned in 3D space is difficult. In 2D painting, the artwork is typically created on a physical surface, such as a table, tablet, or wall, as illustrated in Fig. 5.13. This medium provides tangible feedback to the artist, allowing adjustments in brush pressure, angle, and speed. Different surfaces lead to varied artistic experiences and distinct styles. Currently, VR technology focuses more on visual quality, user comfort, and spatial freedom, with less attention given to the drawing experience. Given that most art today is in 2D, prolonged exposure to and practice of flat art means that many people lack the ability to draw effectively in a 3D space without physical support. Moreover, most VR painting tools are designed for drawing on specific surfaces and lack features for multi-layered painting.

The creation of the swan in this instance resembles a 2.5D structure. I must consider not only the shape of the swan on a plane but also the relative positions of its body

Line drawing

Filled with colors

Final Swan

Figure 5.14: Painting steps for the swan

parts along the forward and backward axes. This is a significant difference from 2D drawing. To achieve the desired effect in 3D space, I employed a step-by-step painting approach. First, I outlined the swan's contours to establish the relative positions of its body parts. Next, I filled in the body areas with different colors. Finally, I adjusted the color contrasts to highlight various parts of the swan. For the swan's white feathers, I used a technique of leaving spaces, creating cutouts in the 3D space to reveal the background color behind the swan's body. As shown in Fig. 5.14, this method allows us to achieve a 2D-like effect within a 3D space.

To recreate all three swans, I followed the same steps. I then placed them in their appropriate positions as per the original artwork. It's important to note that in the original painting, the swans exist on a single plane in a real space, and their spatial relationships are left to the viewer's imagination. When translating this into a 3D space, I must carefully consider the relative positioning of the swans to ensure that the overall arrangement does not conflict with the original painting's atmosphere. To provide a base for the swans, I needed to model the water surface. This can be represented by a gray plane with simple ripples to indicate the water waves, thereby distinguishing the water surface from the background. Fig. 5.15 shows a photo for the final swans in the VR space.

5.3.4 Recreation of the invisible part of the 2D painting

From the original artwork, it is evident that the primary background elements are the willow branches. Guanzhong Wu employs these hanging willow branches to depict the swans' habitat. By leveraging the boundaries of the 2D canvas, the artist only illustrates the tips of the branches. The expressive nature of 2D art allows viewers to imagine the rest of the tree beyond the canvas. This intentional omission introduces additional vitality and complexity to the composition, offering viewers greater freedom

Figure 5.15: A photo for the swans in VR space

in their interpretation and appreciation of the work. However, when translating this painting into a VR environment, the absence of natural boundaries inherent to the 2D canvas presents a significant challenge.

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To address this issue, I propose three different approaches for consideration. The first approach, as illustrated in Fig. 5.16, involves mimicking the original artwork by allowing the willow branches to float in mid-air. In this scheme, the branches lack any

Figure 5.16: Painting with floating willow branches

physical support. I can use lighter colors for the branch tips to concentrate the visual elements. However, this method defies physical reality and fails to provide viewers with imaginative space due to the absence of natural boundaries, resulting in a strong sense of discord.

To mitigate this, I propose a second approach. As shown in Fig. 5.17, I simulate 2D painting by placing the entire scene within a virtual frame. Through this frame, viewers can observe a scene similar to the 2D artwork. I use a traditional Chinese scroll-style frame to create this effect. As evidenced by the photographs, this virtual frame isolates the painting's content from the external 3D space, thus achieving an effect similar to the boundaries in 2D art. However, this approach evidently restricts the viewer's perspective within the 3D space, effectively compressing the original 3D work into a 2.5D structure. This method sacrifices part of the 3D perspective, rendering the frame ineffective if viewed from the top or sides.

In Fig. 5.18, I propose an alternative solution. I have completed the willow tree

Figure 5.17: Painting with a frame

based on the observation of the lines and colors of the willow branches in the original work. The branches arch over the swans and then hang down to the water surface. This approach maintains the scene's fidelity to the original artwork, especially in the region close to the swans. Additionally, a complete willow tree makes the scene more plausible within the 3D space. However, it is crucial to ensure that the willow tree does not dominate the composition. The painting's main subject is the swans, and an overly prominent tree might mislead viewers into thinking the artwork is about the willow tree. To prevent this, I position the willow tree at the edge of the scene and simplify its depiction as much as possible to ensure the swans remain the focal point of the composition.

Figure 5.18: Painting with a whole willow

5.4 Conclusion

In this chapter, I examined the challenges and potential solutions for converting traditional Chinese animal paintings into VR space, using Wu Guanzhong's animal paintings as an example. The primary challenges identified include:

Familiarity with 3D Space: Currently, artists are not well-versed in creating artwork within a 3D space. Ensuring accurate proportions while drawing animals directly in a 3D environment is difficult. Although software often includes auxiliary polyhedrons, these tools can result in a very rigid appearance. To address this issue, I proposed a step-by-step drawing method. Similar to starting with a rough sketch and then filling in details, this approach can help mitigate the deformation of animal forms.

Background Elements and Boundary: In traditional Chinese animal paintings, the animals themselves are typically the primary subjects. Artists often add background elements, which are frequently simplified or omitted. When converting these paintings into a 3D space, handling these background elements becomes crucial. It is necessary to adapt these elements to fit within the rules of VR space without detracting from the main subject of the painting. To achieve this, I proposed several methods, such as simulating 2D floating background elements, adding virtual boundaries to the artwork, and completing the background elements.

From this chapter, several shortcomings of VR technology in adapting Chinese animal paintings can be summarized:

Conceptual Representation of Animals: In Chinese paintings, animals are depicted with an emphasis on conceptual forms rather than realistic details. To preserve this characteristic in VR, it is essential to draw intricate lines within the 3D space. Ensuring the spatial relationship between these lines is crucial. Future VR tools could benefit from offering more flexible alignment tools to assist artists in creating VR works with Chinese elements.

Medium-Specific Techniques: Traditional Chinese paintings are often created on paper, with artists exploiting the unique properties of paper, ink, and brushes to achieve effects that are unique to traditional media and challenging to replicate digitally. VR technology, however, tends to aim for a high degree of realism with a slight cartoonish element. This limits the ability to reproduce many of the unique effects found in Chinese paintings, resulting in works that are overly influenced by Western styles. To address this, VR painting software should expand the variety of brushes available to meet the diverse needs of creators.

In conclusion, this chapter provides insights into the process of adapting Chinese traditional animal paintings into VR space, highlighting the specific challenges and offering practical solutions. It underscores the need for VR technology to evolve to better accommodate the unique characteristics of Chinese art.

CHAPTER 6

A Original VR Painting: A Traditional Chinese Village

In this chapter, I present an original VR painting, "A Traditional Chinese Village," synthesizing techniques, insights, and challenges explored throughout this thesis. This chapter extends previous studies on VR's potential to preserve and adapt traditional Chinese art (see Chapter 2) and applies the iterative and reflective methodologies discussed in Chapters 3-5 to a new context. The immersive artwork created in this chapter combines architectural elements, landscape, and cultural symbols to recreate the aesthetic and thematic qualities characteristic of traditional Chinese painting within a fully immersive VR space.

This chapter explores VR's capacity to serve as both a preservation tool and a transformative medium, evaluating its strengths and limitations in capturing the essence of traditional Chinese village scenes. In addition, it proposes a structured framework for adapting traditional art to VR, offering a replicable methodology for preserving and reimagining cultural heritage in digital formats. This framework is designed to guide future projects in balancing artistic fidelity with interactive engagement, ensuring that

VR adaptations retain the cultural and philosophical depth of the original works.

6.1 Artistic and Cultural Context

Traditional Chinese painting, particularly landscape painting, is rooted in a worldview that intertwines natural philosophy, symbolic representation, and aesthetic expression. These paintings are more than visual representations; they embody a philosophical framework that emphasizes harmony between humanity and the cosmos, reflecting a worldview where humans are seen as an integral part of a larger, interconnected natural order [71, 72], as examined in Chapter 2. This perspective, deeply influenced by Taoist and Confucian thought, manifests in artistic conventions such as the use of negative space, symbolic motifs, and compositional balance. Negative space, or "leaving blank," is a philosophical choice, not only an artistic one—it invites viewers to engage in quiet contemplation, allowing room for personal interpretation and a sense of infinity that transcends the physical limits of the artwork. In this way, traditional Chinese landscape paintings encourage a reflective state, prompting viewers to experience the landscape as both a visual and meditative experience.

Wu Guanzhong's work is emblematic of this philosophy, synthesizing traditional techniques with modern aesthetics to create a style that bridges the cultural divide between Eastern and Western art (discussed in Chapter 4). Wu's paintings retain the essence of Chinese art's contemplative and symbolic qualities, yet they incorporate simplified forms and bold compositions that resonate with modern sensibilities. His art illustrates the "spirit resonance" (qì yùn), a vital quality in traditional Chinese painting that emphasizes capturing the underlying energy or spirit of a scene rather than its literal appearance. This approach aligns with the Taoist notion that art should reflect the dynamism and balance found in nature, a principle that Wu incorporates through minimalist forms, fluid brushstrokes, and rhythmic compositions.

By creating a VR painting inspired by Wu's artistic approach, this project investigates how VR technology can preserve these deeply embedded cultural values while in-

troducing new dimensions of interaction and immersion. Unlike traditional paintings, VR can provide a dynamic, three-dimensional experience that allows users to "enter" the artwork, experiencing it from multiple perspectives. This immersion offers a unique opportunity to extend the contemplative nature of Chinese landscape painting into an interactive format, where viewers can engage with symbolic elements, explore spatial relationships, and experience the sense of interconnectedness central to traditional Chinese philosophy.

However, translating these philosophical and aesthetic qualities into VR also poses challenges. VR environments inherently emphasize spatial realism and detail, which may conflict with the intentional abstraction and symbolic minimalism characteristic of traditional Chinese art. This project thus explores methods for integrating elements like negative space, symbolic objects, and compositional flow into a medium that invites active viewer interaction, all while maintaining the artwork's cultural and philosophical integrity. By doing so, this VR painting becomes not only a new medium for experiencing traditional Chinese art but also a model for how digital technology can be adapted to respect and enhance culturally significant art forms.

6.2 VR as a Medium for Cultural Heritage

6.2.1 Challenges in Translating Traditional Aesthetics to VR

The translation of traditional Chinese aesthetics into VR presents a unique set of challenges, particularly given the fundamental differences between the mediums. Traditional Chinese paintings, and Wu Guanzhong's work especially, prioritize abstraction, suggestion, and a sense of boundlessness—qualities that are naturally constrained by VR's emphasis on immersive, bounded environments and realistic spatial detail. Traditional Chinese art often aims to evoke rather than depict; it seeks to guide the

viewer's perception subtly, allowing space for individual interpretation rather than directly engaging the viewer through interactive elements.

One of the significant challenges in VR is replicating the delicate balance of form and emptiness that characterizes traditional Chinese art, particularly the use of negative space as a compositional and philosophical tool. This balance often serves to invite contemplation, creating a pause for the viewer to project their own thoughts and emotions into the work. In VR, however, blank spaces may feel unsettling or underdeveloped, potentially reducing the intended effect of simplicity and serenity. To navigate this, the project integrates elements like mist, gradients, and diffuse lighting to create "soft" negative spaces that visually reference the quiet openness of traditional landscapes. These additions aim to capture the suggestion of depth and atmosphere without overwhelming the viewer, maintaining the subtlety of Wu's approach within VR's more spatially demanding environment.

Another challenge is preserving the symbolic and minimalist aspects of Wu's style while inviting viewers into a three-dimensional experience. Traditional Chinese paintings are often rich with symbolic meanings that are conveyed through brushstrokes, color tones, and object placement rather than explicit details. Translating these subtleties into VR requires careful adaptation, as VR's high level of detail and viewer agency can risk over-defining or altering the intended meaning. For instance, in Wu's "Water Town" series, the essence of water is often implied through brushstrokes rather than depicted directly. In the VR scene, achieving this requires strategic use of dynamic elements, such as gently animated water textures or soft ambient lighting, to suggest movement and fluidity while preserving the minimalism of Wu's original concept.

6.2.2 Spatial Composition and Viewer Interaction

Unlike traditional two-dimensional compositions, which guide the viewer's eye in a relatively fixed manner, VR compositions involve a fully navigable, immersive environment. This shift in spatial composition changes the way viewers experience art, requiring creators to think in terms of navigational flow and interactive engagement rather than static viewing. VR environments, unlike traditional paintings, must anticipate and accommodate user interaction from multiple angles, ensuring that each perspective enhances rather than detracts from the artwork's thematic cohesion.

In designing this VR painting, Wu Guanzhong's compositional techniques—particularly his use of central focal points like rivers or paths—provided a guiding principle. Traditional Chinese paintings often have a deliberate, flowing arrangement that invites the eye to travel across the scene in a particular sequence, balancing focal points with negative space to evoke harmony. In VR, this visual "journey" becomes a physical experience, with viewers able to "walk" along paths, pause by rivers, or explore village scenes from different perspectives. Positioning the river as a central axis, with surrounding houses, mountains, and villagers, allows the VR environment to mirror Wu's style while offering a more embodied engagement with the landscape.

This interactive element introduces a form of "spatial storytelling," where viewers not only observe but participate in the scene, navigating through spaces that gradually reveal details and symbolic nuances. Literature on VR and cultural engagement supports the idea that spatial immersion can deepen cultural appreciation by fostering a sense of "presence" within the artwork [73, 74]. Studies indicate that VR can enhance users' understanding and appreciation of cultural artifacts, as it allows them to experience these artifacts in a simulated physical environment. This aligns with constructivist learning theories, which suggest that knowledge is constructed through active experience and personal interpretation [75, 76].

The VR adaptation also introduces new compositional challenges. Traditional paintings are designed to be experienced from a single vantage point, whereas VR allows and encourages movement throughout the space. This means that focal points must be arranged in a way that feels cohesive from multiple viewpoints. For instance, elements like trees, mountains, or buildings must be strategically positioned to create continuity, guiding the viewer's movement without overwhelming them with visual stimuli. This iterative design process involved constant adjustments to ensure that as the viewer moves, the scene reveals itself in a harmonious flow, preserving the contemplative quality of traditional Chinese landscapes while also embracing VR's potential for interaction and spatial exploration.

Adapting Wu Guanzhong's style to VR involves both embracing and transcending the medium's inherent qualities. The project seeks to balance VR's interactive nature with the contemplative qualities of traditional Chinese painting, creating a space where users can engage with symbolic elements, experience spatial harmony, and explore cultural narratives in an immersive, thoughtful manner. This process highlights the unique opportunities VR offers for cultural preservation, while also underscoring the need for deliberate design choices that respect and extend the philosophical depth of traditional aesthetics within a modern digital framework.

6.3 Methodology and Artistic Process

6.3.1 Translating Key Elements: Architecture and Environment

Building on the methodologies outlined in Chapters 3 through 5, this project began by carefully constructing core architectural elements rooted in Wu Guanzhong's stylistic themes, which emphasize organic structures, subtle irregularities, and the use of negative space. To preserve the authenticity and cultural resonance of traditional

village architecture, each house was manually outlined and textured, capturing the unique imperfections and organic qualities found in Wu's paintings, as shwon in Fig. 6.1. Unlike standardized 3D models, which can feel rigid and uniform, this approach allowed for aesthetic irregularities that reflect the fluidity and character of traditional Chinese structures (see Fig. 6.2). This method mirrors Wu's philosophy of focusing on the "essence" of a scene rather than precise, literal representation, lending the VR environment an authenticity that aligns with his approach to capturing cultural and emotional depth [77].

The architectural structures were designed with an emphasis on both interior and exterior perspectives, creating a harmonious "interior-exterior" duality, as shwon in Fig. 6.3, and 6.4 This duality allows each building to serve as both an object within the landscape and a viewpoint through which users can experience the scene from different vantage points, as shwon in Fig. 6.5. The integration of inside and outside spaces reflects the spatial philosophy seen in traditional Chinese gardens and paintings, where structures and landscapes are interwoven to create a sense of harmony and fluidity between built and natural environments [78]. For instance, doorways and windows were positioned to frame specific views, giving users curated glimpses of rivers, mountains, and other elements that gradually reveal the scene's depth as they move through the virtual space.

To capture the asymmetry and organic flow that characterize traditional Chinese architecture, the layout of the houses was intentionally varied, echoing the meandering village streets and courtyards found in Wu's work. This method involved positioning each building in a way that appears both deliberate and naturally unplanned, creating a composition that feels lived-in and spontaneous. The architectural layout was further enhanced by slight imperfections in scale and alignment, which are hallmarks of traditional construction and contribute to the immersive, handcrafted quality of the VR scene.

Figure 6.1: Outlined building

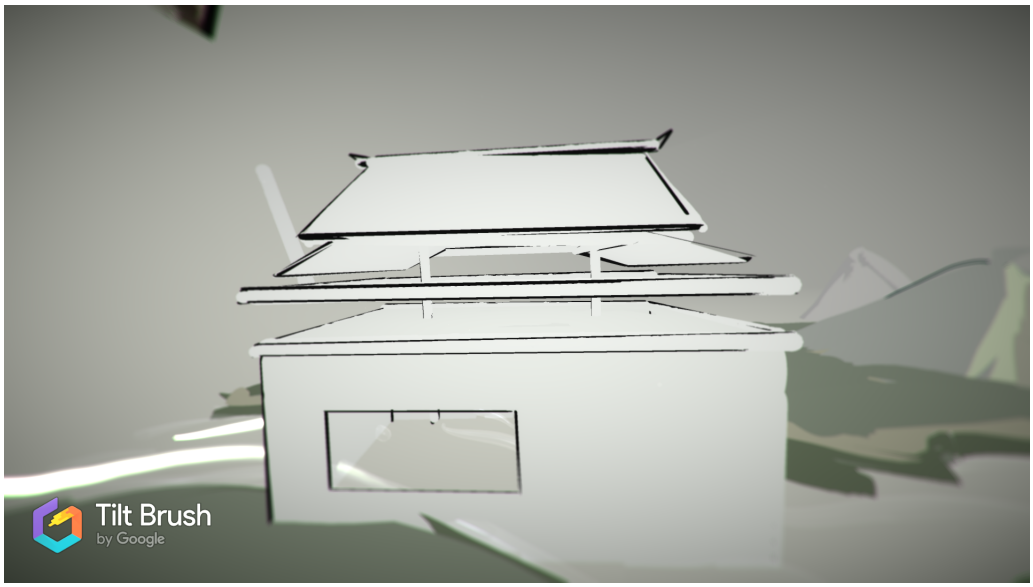

Figure 6.2: Building with wall

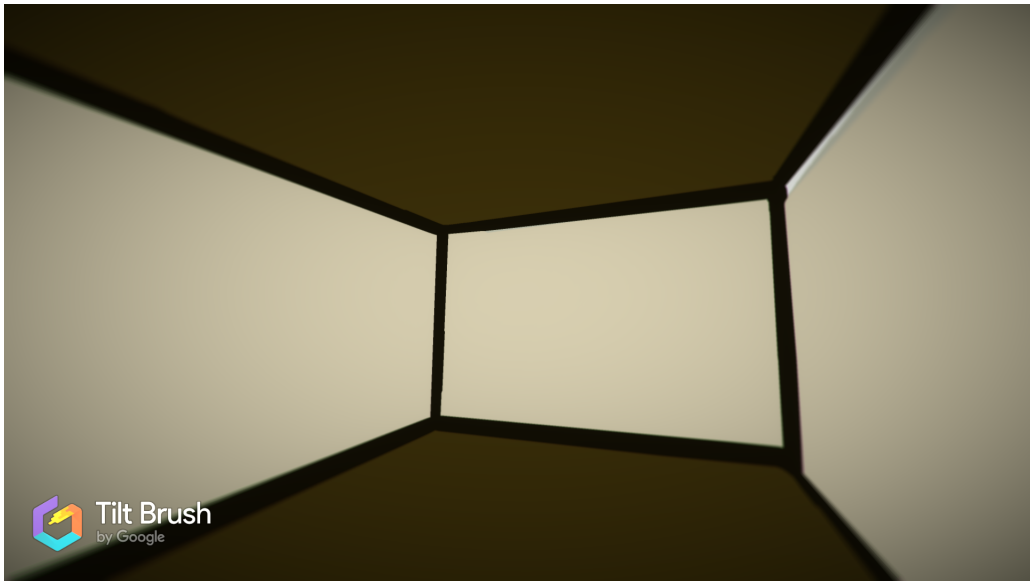

Figure 6.3: View inside the building

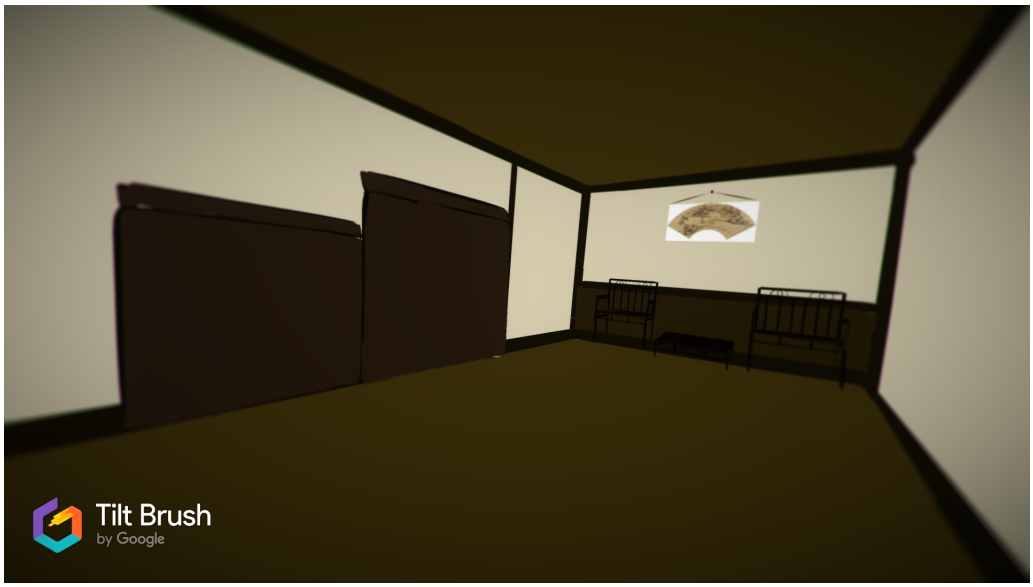

Figure 6.4: Decoration inside the building

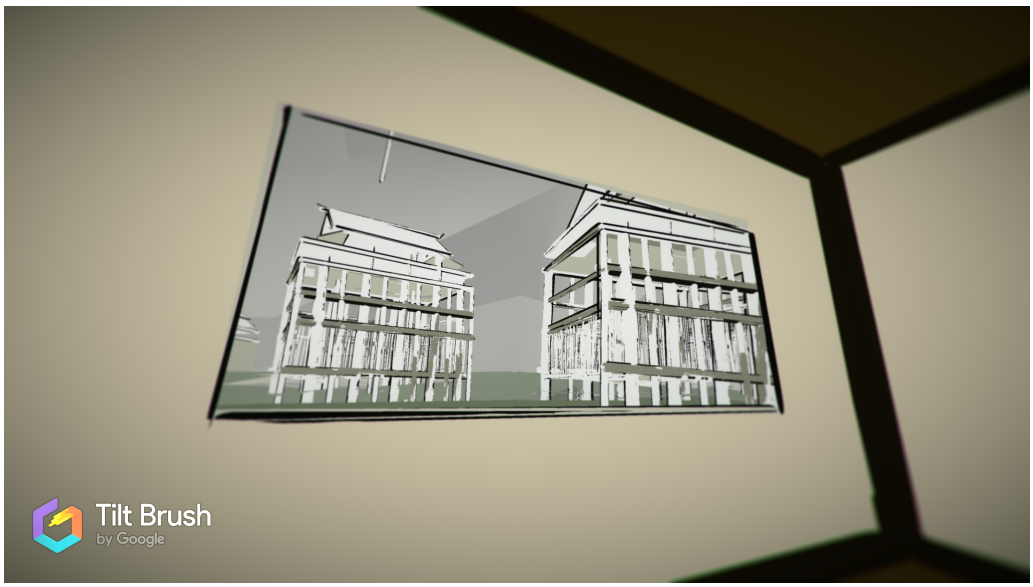

Figure 6.5: The view through the window, scene 1

Figure 6.6: The view through window, scene 2.

In translating environmental elements, special attention was given to landscapes and natural textures. Rather than using VR's inherent emphasis on realism, the landscape elements were rendered with a stylized approach, using brush-like textures and soft lighting to evoke the tranquil quality of Wu's landscapes. Trees, rocks, and water were crafted to mimic the flowing, almost impressionistic style of Wu's brushstrokes, reinforcing the sense of harmony and continuity across the environment. This approach allowed the VR painting to retain an aesthetic coherence, bridging traditional Chinese techniques with the spatial opportunities unique to VR.

Together, these architectural and environmental choices transform the VR space into an immersive environment that respects traditional aesthetics while inviting users to explore it interactively. Fig. 6.7 shows a screenshot of the architecture and environment of the VR village. By aligning digital design methods with Wu Guanzhong's artistic principles, the project creates a cohesive experience where traditional Chinese philosophies of space, harmony, and balance are expressed within a modern digital format. This careful consideration of both interior and exterior perspectives allows

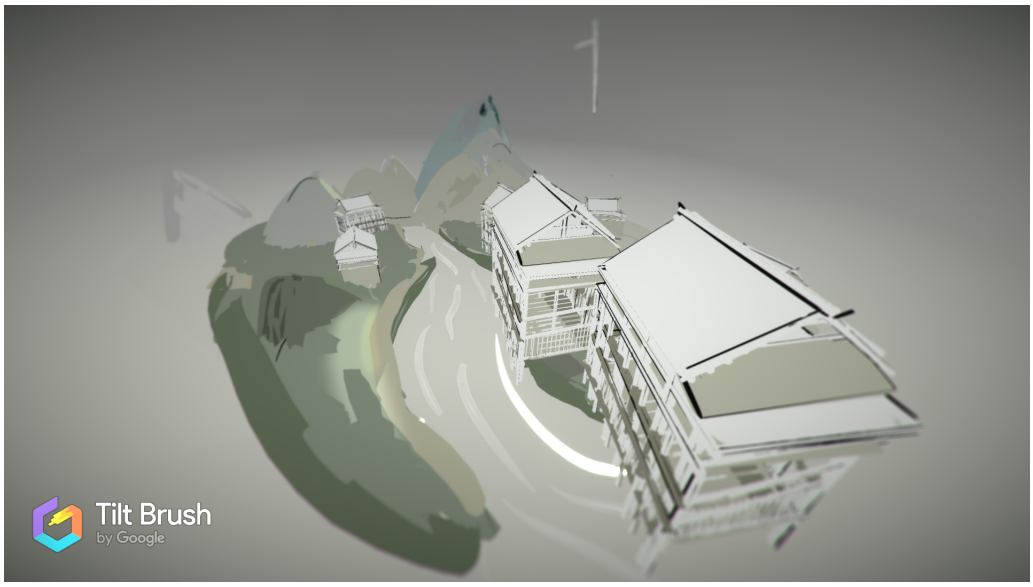

Figure 6.7: Architecture and environment in VR

users to not only observe the environment but engage with it, moving through layers of space that are both visually and conceptually linked to traditional Chinese art and philosophy.

6.3.2 Adding Cultural Significance: People, Boats, and Animals

In line with Chapter 5's exploration of symbolic elements in Chinese art, this VR scene integrates traditional village inhabitants, animals, and boats, each positioned with intention to enhance the scene's narrative flow, cultural resonance, and immersive depth. These elements are more than visual decorations – they are carefully chosen symbols that embody central themes of traditional Chinese painting, such as community, harmony with nature, and the cycles of rural life. Their dynamic inclusion brings a storytelling dimension to the VR environment, drawing users into an experience that is both culturally rich and contextually engaging.

The village figures, depicted in motion—such as fishing, rowing, or gathering—are designed to create a living, breathing environment that resonates with the rhythms

Figure 6.8: People, Boats, and Animals

of rural Chinese life, as show in Fig. 6.8 The VR environment mirrors, through the inclusion of these elements, the symbolic narratives often found in traditional art, where villagers are portrayed in simple, harmonious acts that reflect an interwoven relationship with their surroundings. This approach allows viewers to feel as though they are stepping into a moment of everyday life, fostering an emotional connection with the scene and enhancing its cultural depth.

Animals play a similarly vital role in enriching the symbolic landscape of the VR scene. Water buffalo and swans, both highly significant in Chinese culture, embody virtues of prosperity, strength, and peace, reinforcing the traditional belief in the interconnectedness of humans and nature. The water buffalo, often associated with

agricultural life and diligence, is depicted grazing or resting by the riverbank, representing the harmony between rural labor and the natural environment. Swans, symbolizing peace and purity, are shown gliding across the water, adding an element of serenity to the scene. Together, these animals contribute layers of meaning to the VR experience, creating visual metaphors that resonate with the viewer on both an aesthetic and symbolic level.

The strategic placement of boats within the scene serves as both a visual and narrative tool. Boats are traditionally associated with journeys, exploration, and the flow of life. Here, they are animated to float gently along the river, inviting viewers to follow their paths, which subtly guide them through the environment. This flow echoes the compositional movement found in Wu Guanzhong's work, where rivers or pathways lead the viewer's gaze through the scene. By enabling viewers to "follow" these boats as they move, the VR environment brings to life a narrative which encourages exploration while immersing the viewer in a journey that reveals layers of cultural symbolism as they progress.

Interactive learning studies emphasize VR's potential for deepening cultural understanding through multi-perspective exploration [73, 74]. In this scene, VR allows viewers to observe symbolic elements from various angles, which creates a multi-dimensional experience of Chinese cultural motifs. Viewers can choose to pause beside a fisherman, observe a water buffalo from up close, or follow a swan's gentle glide, experiencing the scene from both a literal and metaphorical perspective. This flexibility not only enhances engagement but also encourages personal reflection on the symbolic and thematic nuances embedded in the artwork.

By weaving these figures, animals, and objects into a virtual environment, the VR painting goes beyond passive viewing, inviting viewers to experience cultural symbols as part of an interconnected landscape. This approach aligns with constructivist theories of learning, where knowledge and understanding are constructed through

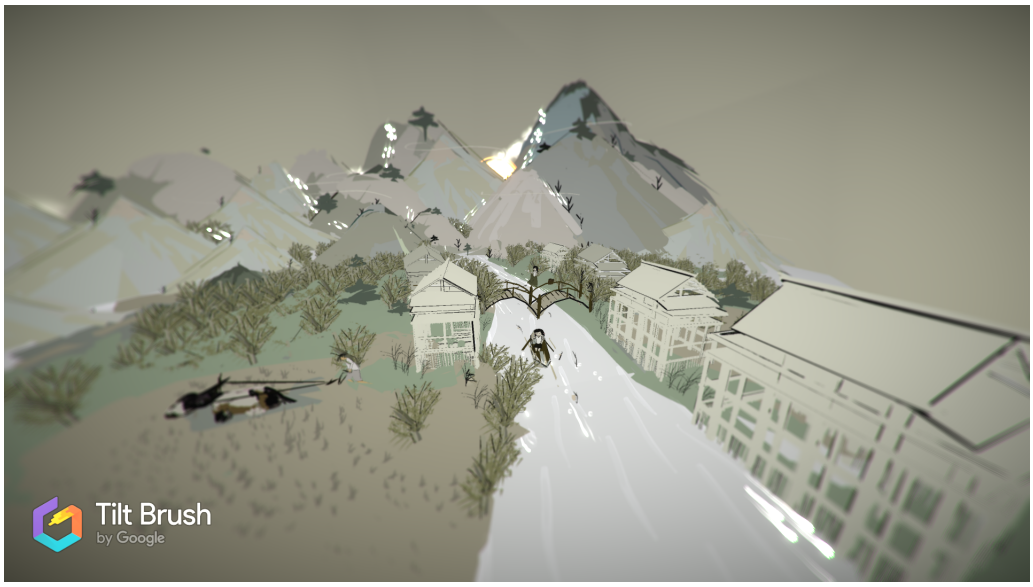

Figure 6.9: A screenshot of the final 3D painting

direct interaction and personal interpretation [75, 76]. In engaging with these symbolic elements, viewers are encouraged to discover deeper meanings at their own pace, allowing for an organic connection to the themes of interconnectedness, harmony, and respect for nature that lie at the heart of traditional Chinese art. In this way, the inclusion of people, boats, and animals in the VR scene not only brings life to the environment but also enriches it with layers of cultural significance, transforming the digital space into a medium for both experiential learning and cultural preservation.

6.4 Technical Challenges and Adaptations

6.4.1 Achieving Realistic Atmosphere

Creating a realistic, immersive atmosphere that complements the foreground without overwhelming it presented a complex challenge. In traditional Chinese painting, negative space often suggests distant landscapes or open skies, evoking vastness and encouraging contemplative engagement. However, VR environments require a bal-

anced distribution of spatial elements, as leaving areas blank can create a stark or unfinished feel, detracting from the intended ambiance. To simulate the layered landscapes and atmospheric qualities characteristic of Chinese art, I incorporated elements such as mist, soft gradients, and subtly illuminated mountains, which echo Wu Guanzhong's use of contrast and light to create depth and evoke mood. Literature on VR exhibitions underscores the importance of atmospheric elements in maintaining immersion, as they provide essential visual cohesion and contextual depth for users, encouraging sustained engagement [79].

Achieving this atmospheric realism involved fine-tuning the lighting to maintain a balance between visibility and subtlety. For example, diffuse lighting was used to replicate the soft, ethereal quality often seen in traditional Chinese landscapes. However, balancing light levels across multiple scene elements posed an additional challenge, as overly bright or dark settings can disrupt the immersive quality of VR environments. Implementing lighting that adapts to the user's viewing angle helped to create a consistent experience, maintaining a sense of depth without sacrificing the subtle, contemplative qualities of the scene.

6.4.2 Balancing Detail with Performance

Incorporating intricate details into architectural features, interiors, and culturally significant symbols created a high computational load, challenging Tilt Brush's capacity to maintain smooth VR performance. Unlike more advanced VR platforms, Tilt Brush lacks certain optimization capabilities such as level-of-detail scaling or texture compression, which are commonly used to manage performance in high-detail VR environments. This limitation required a creative approach to balance the cultural richness of the scene with the platform's real-time rendering constraints.

Tilt Brush's design primarily caters to simple, illustrative VR art rather than complex,

textured environments, making it difficult to render detailed architectural features or nuanced cultural symbols without affecting performance. Attempting to add high levels of intricacy to multiple elements simultaneously would often result in visual lag, reduced frame rates, and a less immersive experience. These disruptions, even minor ones, can break the viewer's sense of presence, making it harder for users to fully engage with the scene and reducing the effectiveness of VR as a medium for conveying cultural content.

6.4.3 Preservation of Artistic Fidelity within VR Constraints

Using Tilt Brush to preserve the artistic fidelity of traditional Chinese painting presented unique challenges, as the platform has limited support for advanced rendering techniques such as custom shaders or texture layering. Traditional Chinese paintings often rely on expressive brushwork, ink gradations, and subtle color variations, which can be challenging to replicate in Tilt Brush's relatively simple VR painting environment.

The limitations of Tilt Brush meant that the nuanced textures and gradients characteristic of traditional Chinese art had to be creatively adapted. Without custom shaders or brush types specifically designed for ink wash effects, achieving the "spirit" of traditional brushstrokes required experimentation with the available brush options to approximate the layered look of ink. For example, I used multiple passes with the "soft" brush to create a more diffused, textured effect that echoes the depth and fluidity of ink on paper, albeit within the constraints of Tilt Brush's toolset. This approach involved layering strokes carefully, mimicking the gradual buildup seen in traditional brushwork without overwhelming the VR system's processing capabilities.

Tilt Brush's limited pixel resolution and color depth also posed challenges for preserving fine details and subtle tonal shifts. Traditional Chinese art often uses delicate

gradations and restrained color palettes to evoke a sense of calm and simplicity. However, Tilt Brush's limited color selection and resolution could make these subtle effects appear less refined. To compensate, I simplified certain details, focusing on larger shapes and compositions rather than intricate textures, aligning with the broader themes of minimalism in Chinese art. By strategically choosing colors and brush sizes, I aimed to evoke the essence of traditional aesthetics without overloading the system or sacrificing overall visual coherence.

Another constraint was the lack of adjustable lighting effects within Tilt Brush, which made it challenging to simulate the natural lighting contrasts often seen in traditional Chinese landscapes. Without the ability to control ambient lighting or shadows, I had to rely solely on brush color and stroke density to suggest depth and spatial relationships within the scene. For instance, lighter, more transparent strokes were used to suggest distant elements, while darker, denser strokes emphasized foreground features, creating a visual hierarchy that approximates depth despite the lack of lighting flexibility.

While Tilt Brush lacks advanced tools for achieving the layered intricacies of ink washes or subtle shifts in hue, these constraints also encouraged a simplified approach that aligns with the minimalist nature of traditional Chinese art. The limitations reinforced a focus on compositional balance, negative space, and symbolic placement over hyper-detailed rendering. By working within Tilt Brush's simplified framework, I was able to capture the broad strokes of traditional aesthetics, emphasizing the core elements of harmony, balance, and cultural symbolism central to Chinese painting.

In this way, although some compromises were necessary, Tilt Brush's limitations ultimately guided a process that aligns with the spirit of traditional Chinese art, focusing on the expressive potential of minimal tools to evoke atmosphere and thematic depth. This approach demonstrates that even within restricted VR environments, it is possible to create immersive cultural experiences by strategically adapting traditional

principles to the medium's unique affordances and constraints.

6.5 Framework for Adapting Traditional Art to VR on Limited Platforms

In developing "A Traditional Chinese Village," this project encountered specific challenges in adapting traditional Chinese art to the VR medium, particularly within the constraints of Tilt Brush. From these experiences, a structured framework emerged, offering a practical approach for translating traditional and culturally rich artworks into VR on simplified platforms. This framework serves as a guideline for balancing cultural fidelity, aesthetic integrity, and interactive engagement, and is applicable to other traditional art forms facing similar constraints.

The framework consists of four main phases: Preparation and Analysis, Creative Adaptation within Platform Constraints, Visual and Interactive Composition, and Optimization for Immersion. Each phase outlines key steps designed to work within the technical limitations of VR platforms like Tilt Brush while preserving the core themes and aesthetics of traditional artwork.

1. Phase 1: Preparation and Analysis

   Cultural and Artistic Analysis: Conduct an in-depth study of the artwork's cultural and philosophical context, focusing on essential aesthetic principles and symbolic meanings. This ensures that key cultural values are identified and prioritized throughout the adaptation process.

   Identification of Key Elements: Map out the most significant visual and symbolic elements in the artwork. By identifying which features hold the greatest cultural or narrative weight, this step helps to guide choices about where to allocate Tilt Brush's limited detailing and interactive capabilities.

2. Phase 2: Creative Adaptation within Platform Constraints

   Simplification and Abstraction of Detail: Given Tilt Brush's limited capacity for intricate details, strategically simplify and abstract complex elements. For instance, use broad brushstrokes and minimal textures to represent intricate objects, aligning with traditional art's focus on essence over precision.

   Adapting Negative Space and Atmospheric Effects: Substitute traditional negative space with soft gradients, mist effects, or translucent strokes to imply depth without leaving the scene feeling incomplete. This adaptation retains the meditative and spacious qualities central to traditional art.

3. Phase 3: Visual and Interactive Composition

   Centralized Focal Points and Pathways: Design the VR environment with clear focal points and visual pathways that encourage natural exploration. Use elements like rivers or paths to guide the viewer's movement through the scene, replicating the flow of traditional compositions.

   Placement of Symbolic and Cultural Elements: Arrange culturally significant elements, such as animals or boats, in a way that conveys narrative depth and aligns with traditional symbolism. This strategic placement enhances the cultural resonance of the VR environment.

4. Phase 4: Optimization for Immersion

   Selective Detailing and Prioritization: Focus Tilt Brush's detailing capabilities on key visual areas while simplifying background elements, preserving immersive quality without overwhelming the platform's processing capabilities.

   Adapting Lighting and Color Palette: Use careful color selection and opacity to simulate lighting cues and atmospheric perspective. This creates a visual

hierarchy, guiding viewer attention and conveying depth without the need for complex lighting effects.

6.6 Conclusion

This chapter demonstrated the process and challenges of creating a VR painting inspired by traditional Chinese village scenes, synthesizing previous research and methodologies into a cohesive artwork that celebrates both cultural heritage and technological advancement. Through the creation of "A Traditional Chinese Village" in VR, this chapter explored VR's effectiveness as a medium for preserving and evolving traditional Chinese art, revealing both the possibilities and limitations of current VR tools in capturing the unique aesthetic and symbolic qualities of this cultural heritage.

One of the key contributions of this chapter is the development of a structured framework for adapting traditional art to VR on limited platforms. By detailing the phases of Preparation and Analysis, Creative Adaptation within Platform Constraints, Visual and Interactive Composition, and Optimization for Immersion, this framework provides a replicable methodology for future projects aiming to adapt culturally significant artwork to VR. It offers practical steps for balancing cultural fidelity with technical limitations, ensuring that the VR adaptation remains true to the original's artistic and philosophical essence. This framework serves as a valuable resource for creators working with simplified VR tools, enabling them to navigate constraints thoughtfully and achieve an immersive, culturally resonant experience.

Building on the foundations explored in Chapters 2 through 5, this project contributes a nuanced perspective on VR's role in cultural preservation, highlighting the need for further innovation in VR painting tools to better accommodate traditional art techniques. The limitations encountered suggest directions for future research, such as the development of AI-assisted detailing to enhance accuracy and reduce manual labor in recreating complex art forms. Ultimately, this VR painting and framework illustrate a promising pathway for merging traditional art with immersive technology, offering audiences a dynamic and interactive approach to experiencing cultural heritage in the

digital age.

CHAPTER 7

Discussion

This project explored the feasibility of using VR technology to create artworks that embody the characteristics of traditional Chinese painting, specifically through an adaptation of the work of contemporary Chinese painter Wu Guanzhong. By recreating elements of Wu's art in VR, this project identified both the advantages and challenges of using immersive technology to capture and preserve traditional Chinese aesthetics. The process led to the development of a structured framework tailored for adapting culturally rich artworks to VR platforms, particularly those with limited functionality, such as Tilt Brush. This framework not only addresses the practical and technical limitations inherent in VR but also provides a replicable model that can inform future projects seeking to translate traditional art forms into digital immersive media.

7.1 Addressing the Research Questions

The research questions guiding this study focused on understanding the artistic and technical challenges of adapting traditional Chinese art to VR, the role of a structured framework in facilitating this adaptation, and identifying specific adaptations that

Table 7.1: Mapping between research questions, methods, key findings, and supported claims

RQ	Methods / Artefacts	Key Findings	Supported Claims
RQ1	VR reproduction; reflective practice	Brushwork and negative space are difficult to reproduce due to spatial realism and tool limits	VR adaptation requires selective reinterpretation rather than direct replication
RQ2	Brush layering; colour simplification	Simplification enables coherence but reduces tonal and material detail	Artistic integrity can be preserved conceptually despite technical compromises
RQ3	Focal points; symbolic elements	Harmony and symbolism are conveyed while meditative stillness is altered	VR can reinterpret Wu Guanzhong's aesthetic but not fully replicate it
RQ4	Four-phase adaptation framework	Structured planning improves coherence under platform constraints	A practice-based framework supports VR adaptation on limited platforms

would enhance the VR experience to align with traditional artistic principles. Through the development and application of the VR framework, this study provided nuanced insights into each question.

1. **What are the artistic and technical challenges in adapting traditional Chinese painting to VR?**

   Existing research on VR and cultural heritage emphasizes the difficulty of conveying nuanced artistic qualities in digital environments. Studies by [36, 80], for example, highlight that VR often prioritizes realism over artistic expression, making it challenging to replicate the abstraction and philosophical depth inherent in traditional Chinese art. Artistically, traditional Chinese painting relies on techniques like expressive brushwork, subtle gradients, and the use of negative space to evoke a sense of depth and harmony, as explored by [81] in the context of ink painting. In VR, however, these qualities are difficult to replicate due to the medium's emphasis on spatial realism and interaction. The contemplative nature of traditional Chinese painting, designed to be experienced as a static, meditative

scene, often conflicts with VR's dynamic, interactive environment.

Technically, the limited functionality of platforms like Tilt Brush exacerbates these challenges. Research by [82, 83] discusses how VR painting tools, which are often developed based on Western art techniques, lack the flexibility needed to recreate specific cultural styles. The absence of advanced tools for texture, shading, and negative space in Tilt Brush made it difficult to capture the subtle depth of Wu's work, and creative workarounds such as layering brushstrokes were essential. These constraints reveal broader limitations in VR for high-fidelity cultural preservation, underscoring the need for VR painting software tailored to diverse artistic traditions.

2. **What modifications are necessary to adapt traditional Chinese painting techniques to VR tools like Tilt Brush, and how do these affect the artwork's integrity?**

   Adapting traditional Chinese techniques to Tilt Brush required several creative modifications to compensate for the platform's constraints. Simplification and abstraction were key strategies, with brush layering and careful color selection used to approximate the fluidity and depth of ink painting. Soft strokes and translucent layers were employed to suggest negative space and atmospheric perspective, creating a visual hierarchy that guides viewer attention while maintaining the minimalist aesthetic of traditional Chinese art.

   While these modifications allowed for a functional and visually engaging VR representation, they also necessitated compromises. Certain details, such as the fine gradations of ink or the intricate textures of traditional landscapes, were simplified to avoid overloading the platform. However, these adaptations aligned with the philosophical principles of Wu's work, which emphasizes capturing the "essence" rather than the literal details of a scene. Thus, while some fidelity was

lost in the translation to VR, the overall integrity and spirit of the artwork were preserved.

3. **To what extent can VR recreate the aesthetic and philosophical essence of Wu Guanzhong's artwork? What specific adaptations can enhance the VR experience to align with traditional Chinese artistic principles?**

   The VR painting demonstrated that VR can effectively preserve and reinterpret key aspects of Wu Guanzhong's aesthetic and philosophical vision, while also highlighting certain limitations inherent in the medium. By incorporating focal points such as rivers and pathways to guide viewer movement, the VR environment successfully mirrored the compositional flow characteristic of traditional Chinese paintings. These design choices created a spatial narrative that reflects the structured yet organic balance central to Wu's work. Symbolic elements, such as water buffalo and boats, were strategically placed to reinforce cultural narratives, providing viewers with an intuitive way to engage with the thematic depth of the scene.

   However, VR's inherent emphasis on interactivity and spatial navigation introduces a dynamic quality that contrasts with the meditative stillness of traditional Chinese art. While this dynamism offers opportunities for deeper user engagement, it may detract from the contemplative experience that Wu's paintings aim to evoke. Despite this, the philosophical essence of harmony, balance, and interconnectedness was preserved through thoughtful design choices. These choices aligned the VR scene with Wu's artistic principles by prioritizing symbolic abstraction over excessive detail and emphasizing the interplay between natural and man-made elements.

   Literature on immersive environments underscores the importance of focal points and viewer navigation for guiding attention and sustaining engagement, particu-

larly in culturally significant VR scenes [84]. This project relied on specific strategies to address the limitations of Tilt Brush, including careful brush selection, layering strokes to approximate traditional Chinese brushwork, and adopting simplified color palettes to maintain visual harmony. These methods reflect approaches outlined by [73], who emphasizes that VR's immersive qualities can be enriched through controlled color schemes and soft transitions. These adaptations compensated for the lack of advanced tools for texture and shading within the platform.

Additionally, the implementation of centralized focal points and symbolic elements helped maintain viewer orientation while reinforcing cultural themes. Studies on narrative flow in VR [75] highlight the importance of focal elements in creating meaningful engagement. By positioning culturally significant symbols, such as rivers, water buffalo, and boats, as navigational anchors, the VR painting effectively mirrored the compositional techniques of traditional Chinese paintings. These elements guided users intuitively through the environment, allowing them to explore the symbolic depth and narrative coherence of the artwork.

In conclusion, while VR cannot entirely replicate the contemplative and meditative qualities of traditional Chinese art, it provides a unique medium for reinterpretation and engagement. By leveraging techniques such as centralized focal points, symbolic abstraction, and controlled transitions, the VR painting successfully conveyed the philosophical essence of Wu Guanzhong's work, centered on harmony, balance, and interconnectedness. These findings demonstrate that with thoughtful design and adherence to a framework that balances cultural fidelity and technical constraints, traditional art can be meaningfully adapted to VR, expanding its accessibility and impact in the digital age.

4. **How can a framework facilitate the adaptation of traditional art to VR,**

particularly on limited platforms? A key outcome of this project is the structured framework, consisting of four phases—*Preparation and Analysis, Creative Adaptation within Platform Constraints, Visual and Interactive Composition, and Optimization for Immersion.* This framework is grounded in literature that suggests cultural adaptation in VR requires a careful balancing of authenticity and platform capabilities [85]. The framework's initial phases ensure a deep understanding of the artwork's cultural and philosophical context, aligning with recommendations from cultural studies on VR, which emphasize that cultural fidelity depends on maintaining symbolic and thematic consistency [86]. For example, by mapping culturally significant elements early, this framework helps prioritize these features even when platform limitations necessitate simplification, as also suggested by [87].

This approach proved effective in translating Wu's philosophy into VR, highlighting that structured planning and selective detailing can overcome some of the technical constraints in VR adaptation. Additionally, the framework has broader implications for cultural heritage preservation in digital media, showing that meaningful adaptations are achievable when traditional techniques are strategically reinterpreted for VR's unique affordances. The framework offers a replicable model for artists and cultural institutions, underscoring the importance of balancing platform limitations with cultural integrity.

7.2 From an Artistic Creation Perspective

From an artistic perspective, this project highlighted both challenges and potential solutions for adapting traditional Chinese art to VR:

- **Color and Brushwork**: Traditional Chinese paintings use specific tonal gradations that are difficult to replicate in VR. Tilt Brush lacks specialized brushes

to mimic the fluidity of ink. This project addressed this by layering soft brush strokes and using monochromatic tones, but future software development could benefit from brushes and color palettes tailored to traditional techniques.

- **Boundary Treatment in VR**: Traditional paintings use defined edges to frame compositions, a concept that doesn't translate naturally in VR. This framework suggests implementing visual boundaries or adding subtle gradient edges to give structure, enhancing compositional coherence in VR.
- **Unsupported Creative Environment**: The VR space lacks supportive physical surfaces, unlike traditional painting. To counter this, the framework recommends outlining objects first for spatial alignment, and incorporating haptic feedback could further assist artists in navigating the virtual space.
- **Central Focus of the Artwork**: VR's open space can disorient viewers. To counter this, the framework includes the creation of a central focal element, helping maintain visual clarity and narrative coherence.

7.3 From a VR Technology Perspective

From a technical standpoint, the study emphasized specific areas where VR technology requires improvement:

- **Bulky Equipment**: The physical limitations of VR hardware, such as weight and discomfort, impact the artistic process. This project points to the need for lighter, wireless VR headsets with improved connectivity to enhance freedom of movement.
- **Painting Efficiency**: Many tasks in VR painting are repetitive and could benefit

from AI assistance. Future VR platforms should integrate AI to automate repetitive tasks, reducing the artist's workload and enhancing productivity.

- **Wearing Experience**: Current VR equipment can cause dizziness, particularly for users with glasses. This project suggests advancing display technology to improve comfort, making VR a more viable option for extended creative sessions.

7.4 Practical Implications

This research has several practical implications for artists, cultural practitioners, and institutions seeking to engage with traditional art through immersive technologies. First, the structured framework developed in this study provides a practical guide for artists working with limited VR platforms, such as Tilt Brush, demonstrating how traditional artistic principles can be selectively adapted within technical constraints. By outlining clear phases of preparation, adaptation, composition, and optimisation, the framework offers a replicable workflow that can support future VR-based artistic projects involving culturally specific art forms.

Second, the findings have practical relevance for museums and cultural institutions exploring VR as a tool for exhibition and digital preservation. Rather than aiming for exact visual replication, this research demonstrates that VR can be effectively used to convey the symbolic, spatial, and philosophical qualities of traditional Chinese painting. This suggests that VR exhibitions can complement conventional digital archives by offering immersive and experiential modes of engagement, particularly for audiences who may have limited access to physical artworks.

Finally, the study highlights practical considerations for the design and development of VR painting tools. The limitations encountered in platforms such as Tilt Brush point to the need for greater flexibility in brush behaviour, layering, and spatial control to

accommodate non-Western artistic traditions. These insights may inform future tool development by encouraging the inclusion of features that better support culturally diverse painting practices in immersive environments.

7.5 Limitations of the Study

The scope of this research is intentionally focused on practice-based adaptation of xieyi-style traditional Chinese painting into VR environments using lightweight, general-purpose painting tools. Specifically, the study examines expressive landscape and animal imagery characterised by simplified forms, symbolic composition, and gestural brushwork, implemented within Tilt-Brush-like VR editors that do not rely on custom shaders or advanced rendering pipelines. Accordingly, this research does not aim to address gongbi-style painting that depends on fine-grained detail, precise line articulation, or material-level texture fidelity, nor does it evaluate VR engines that employ shader-heavy workflows or physically based rendering to achieve high visual realism. These exclusions reflect a deliberate methodological choice aligned with the exploratory and practice-led nature of the study.

Despite the contributions of this study, several limitations should be acknowledged. First, the evaluation of the VR artworks is primarily based on reflective, practice-led analysis. While this approach enables in-depth artistic and technical exploration, it does not incorporate structured user studies, such as interviews or questionnaires. As a result, claims regarding audience reception and user experience remain limited.

Second, the practical implementation of this research is constrained by the capabilities of the VR platform used. Tilt Brush offers accessibility and ease of use but provides limited control over brush behaviour, texture rendering, and shading. These technical constraints restricted the degree to which certain traditional Chinese painting techniques, such as subtle ink gradation and material texture, could be replicated within

the VR environment.

Finally, this study focuses on a small number of selected works by Wu Guanzhong as case studies. While this allows for focused and detailed analysis, the findings may not be directly generalisable to the full range of Chinese painting styles or to other artists and artistic traditions. These limitations define the scope of the present research and inform the directions proposed for future work.

7.6 Future Work

Building on this project's findings, several promising directions emerge for future research and development in VR immersive painting:

1. **Refining Artistic Techniques in VR**: Developing more customizable brush tools and linework options would significantly improve the ability to replicate traditional painting techniques. Enhanced line and gradient tools could better mimic the aesthetics of traditional Chinese ink painting.

2. **Integration of Artificial Intelligence**: AI could assist artists by automatically generating textures, patterns, and backgrounds, particularly useful for culturally rich artworks. This integration would allow artists to focus on primary elements while maintaining cohesive style and detail throughout the piece.

3. **Enhancing Interactivity and Immersion**: Future projects could incorporate responsive interactions, allowing viewers to engage with elements of the artwork directly. This could involve subtle animations or soundscapes that react to viewer proximity, enriching the immersive quality of the experience.

4. **Exploring Large-Scale Collaborative Projects**: Multi-user VR platforms could enable collaborative painting sessions, allowing artists to work together on large-

scale cultural projects. This approach could open new possibilities for complex, multi-layered artworks that benefit from diverse skill sets.

5. **Preservation and Exhibition of VR Art**: Preservation remains a challenge for VR art. Research into archiving methods for VR scenes would help ensure these digital works are accessible for future generations, and exploring virtual and physical exhibition spaces could bridge VR art into traditional art spaces.

6. **Expanding Subject Matter and Themes**: Future work should consider a broader range of cultural themes and styles. While this project focused on traditional Chinese village scenes, VR offers an expansive canvas to explore other art forms, creating a diverse and enriching cultural VR experience.

7.7 Technical Parameters of VR Painting Studies

Table 7.2 documents the qualitative VR painting parameters used in the Water Town landscape study. In this work, the Marker brush was primarily employed to construct planar and geometric elements, including buildings, windows, and ground surfaces, where structural clarity and spatial order were prioritised. The Tapered Marker brush was used to establish compositional lines and dynamic elements such as outlines and flowing water, supporting the overall rhythm and directional movement of the scene. In addition, the Light brush was selectively applied to represent the sun, introducing a focal illumination effect specific to the VR medium.

Table 7.3 summarises the VR painting parameters for the animal studies. In these works, the Marker brush was mainly used to depict the animals' bodily forms as well as background planar elements, emphasising mass, silhouette, and spatial presence. The Tapered Marker brush was applied to draw expressive lines and finer details, including contours and water ripple patterns, supporting the representation of movement and

vitality. Colour usage across the animal studies was deliberately restrained, relying primarily on black and white with limited use of light colours in order to maintain a focus on line, form, and rhythmic expression.

Table 7.4 presents the qualitative VR painting parameters for the final integrated origianl artwork. This work synthesises the approaches developed in the previous studies by combining the Marker and Tapered Marker brushes for structural construction and expressive linework. In addition, Light and Smoke brushes were employed to represent environmental effects such as water flow, mist, and cloud-like atmospheres. These effect-based brushes enable the depiction of dynamic and non-material elements within the immersive environment while remaining consistent with the restrained colour strategy established in the earlier studies.

Table 7.2: Qualitative VR painting parameters for Study 1: Water Town (landscape)

Brush name	Size	Colour palette	Primary use	Stroke count	Layer order	Export settings
Marker	Medium to wide	Black and white with limited use of light colours	Constructing buildings, windows, ground surfaces, and other regular structures	High	Primary structural layer (architecture and ground forms)	Standard Tilt Brush export; default scale
Tapered Marker	Narrow to medium	Black and white with limited use of light colours	Establishing outlines, compositional lines, and dynamic strokes such as water flow	Medium	Secondary compositional and linear layer	Standard Tilt Brush export; default scale
Light	Small to medium	Yellow	Creating focal illumination and atmospheric emphasis, primarily for representing the sun	Low	Highlight and focal emphasis layer	Standard Tilt Brush export; default scale

Table 7.3: Qualitative VR painting parameters for Study 2: Animal paintings

Brush name	**Size**	**Colour palette**	**Primary use**	**Stroke count**	**Layer order**	**Export settings**
Marker	Medium to wide	Black and white with limited use of light colours	Depicting animal form, body mass, and background planar elements	Medium	Primary form and background layer	Standard Tilt Brush export; default scale
Tapered Marker	Narrow to medium	Black and white with limited use of light colours	Drawing expressive lines, contours, and water ripple details	Medium	Secondary linear and detail layer	Standard Tilt Brush export; default scale

Table 7.4: Qualitative VR painting parameters for Original artwork

Brush name	Size	Colour palette	Primary use	Stroke count	Layer order	Export settings
Marker	Medium to wide	Black and white with limited use of light colours	Constructing architectural forms, landscape structures, and planar elements	Medium to high	Primary structural layer	Standard Tilt Brush export; default scale
Tapered Marker	Narrow to medium	Black and white with limited use of light colours	Defining expressive lines, contours, and compositional flow	Medium	Secondary linear layer	Standard Tilt Brush export; default scale
Light	Small to medium	Light colours	Creating illumination, focal highlights, and atmospheric emphasis	Low	Highlight and focal layer	Standard Tilt Brush export; default scale
Smoke	Medium	Light colours	Representing water flow, mist, and cloud-like atmospheric effects	Low to medium	Atmospheric and environmental layer	Standard Tilt Brush export; default scale

7.8 Summary

This project demonstrates the feasibility of using VR to adapt traditional Chinese art, presenting a structured framework that balances technical limitations with cultural fidelity. By addressing VR's challenges, refining artistic techniques, and integrating AI, this study highlights VR's transformative potential for cultural preservation and artistic expression. Continued exploration in this field will likely yield groundbreaking advancements, enriching both the art world and the broader cultural landscape.

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Acronyms

VR Virtual Reality

CG Computer Graphics

AI Artificial Intelligence

CPU Central Processing Unit

GPU Graphics Processing Unit

RAM Random Access Memory

PS Adobe Photoshop

PC Personal Computer

UI User Interface

GB Gigabyte