3D Animated Painting: Walking Inside of the Painting of *The Goddess of the Luo*

by

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Digital Art History and Computational Media
Duke University

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Augustus Wendell

Thesis submitted in partial fulfillment of
the requirements for the degree of
Master of Arts in
Digital Art History and Computational Media in the Graduate School
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ABSTRACT

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Abstract

Increased consumption of virtual museum content today has fueled the development of new ways of improving the ‘museum experience.’ The sophisticated needs and expectations of the modern visitor in the pursuit of education, leisure, and adventure within museums, can be fulfilled through the application of modern-day solutions. The objective of this study is to improve the experience of paintings through providing audiences three-dimensional immersive virtual experiences. In order to achieve this goal, a case study was created to explore in depth the idea that three-dimensional interventions with interactive elements will improve experience and enhance museum engagement. A practice-based methodology was used to develop a three-dimensional virtual environment of the painting of *The Goddess of the Luo* by Gu Kazhi. The expertise and knowledge of the researcher concerning photo-editing software and three-dimensional game engine were instrumental in the design and implementation of the virtual environment. The results indicated that through the combination of two-dimensional and three-dimensional elements, the design of instrumental interaction and interpretive materials based on the original painting, various techniques and strategies could be applied to improve the experience of the three-dimensional animated painting. The approach described in this case study could
be applied to the physical museums as a supplement to interpret the original painting, as well as being displayed on the official website of the museums.
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1. Introduction

Three-dimensional animation of paintings is a potential tool that could be applied in the design of virtual museums. Three-dimensional digitization has been applied in the preservation of cultural heritage and development of virtual museums (Skamantzari & Georgopoulos, 2016) for education and edutainment purposes (Ghouaiel et al., 2016); non-naturalistic rendering of objects and “omnidirectional and gravitation-free” motions (Kim, 2017, p. 227); and animations of the body in exhibitions of fashion (Mida, 2015). The current study is dedicated to the actualizations of these possibilities by evidencing the potential of the Unity 3D game engine and Virtual Reality (VR) tools in the enhancement of the museum experience through improved storytelling, using a case-study example that integrates interpretive and contextual content into a virtual museum-based experience of the work.

1.1 Introduction of the Problem

The necessity for continuous improvement of exhibition techniques is fueled by the perception of the future museum as a deconstructed form of its present-day structure, and which takes into consideration the accelerated technological transformations already taking place in museum contexts today. The future museum is exceedingly adaptable and creatively enabled by the contemporary view of the museum as a “living organism,” as opposed to a passive institution (Gheorghila, Dumbraveanu,
Tudoricu, & Craciun, 2017, p. 61). Museums are permanently adapting to new actualities and circumstances (Schilling, 2016). As a living organism, the museum locates and utilizes emerging resources to suit prevalent conditions rather than adhering to conventional procedures (Gheorghila et al., 2017). Constant improvements, such as the enhancement of interactivity between artifacts and audiences, the application of multimedia that facilitates interpretation and story-telling, are crucial in meeting the sophisticated needs and expectations of the 21st Century audience. Therefore, my project aims to explore possible techniques that could be applied to enhance the interactivity of virtual museums and help interpreting the connotation of the paintings.

Experience and deliverability are among the primary avenues for addressing the changing needs of consumers. The “museum experience,” which implies the entirety of a client’s interactions with staff, other visitors, exhibits, interpretive materials, and programs, is the crucial act influencing learning, satisfaction, and the frequency of subsequent visits (Brida, Meleddu, & Pulina, 2016; Falco & Vassos, 2017; Goulding, 2000). Museums rely on public interest to succeed. Failure to meet the expectations and needs of guests threatens the sustainability of the institutions by diminishing return visits. Ensuring continuous patronage by new and return guests is a critical goal for museums. Therefore, museums are expected to inquire, create controversies, and assume strong positions in the application of suitable solutions to ensure survival (Falco & Vassos,
2017). By transforming two-dimensional still images into three-dimensional animated paintings, and creating an immersive and interactive virtual environment for audiences, three-dimensional game engines and VR tools are effective techniques that could be applied to attract and maintain the attention of guests through enhanced experience and deliverability.

1.2 Research Aim and Objectives

The objective of this study is to improve the experience of engaging with paintings through providing audiences three-dimensional immersive virtual experiences. In order to achieve this goal, I am creating a case study to explore in depth the idea that three-dimensional interventions with game-based elements will improve experience and enhance museum engagement.

The painting I picked is a famous ancient Chinese painting titled *The Goddess of the Luo* by Gu Kaizhi, of the Eastern Jin Dynasty (344-406) (Liu, 2010; Yang, 2019). It is a long comic scroll composed of a sequence of storylines derived from *The Ode of the Goddess of the River Luo*, a poem written by Cao Zhi (192-232) in 222 CE (Yang, 2019). In the original poem, Cao Zhi narrates his encounter with the Nymph of the Luo River. Kaizhi used his remarkable painting and storytelling talents to recreate Cao Zhi’s words, depicting the story in the form of image (Liu, 2010). However, the original scroll painted by Gu Kaizhi has been lost. Only four transcripts of the original scroll have been
handed-down, which are currently collected in the Palace Museum (two pieces), the Liaoning Provincial Museum and the Freer Gallery of Art. This study uses one of the transcripts currently collected in the Palace Museum.

The reason for picking this particular case study for exploring the potential of three-dimensional immersive animation of a painting is that this painting is rich in storylines that might be opaque to viewers without additional interaction and engagement, especially to those audiences who haven’t read the poem before. Moreover, this painting incorporates six scenes depicting stories derived from different paragraphs of Cao Zhi’s poem, but, Gu Kaizhi did not use rigid and obvious division such as large blanks and borders to separate the entire painting (Xu, 2019), which increases the difficulty for viewers to distinguish each scene and comprehend the contents. Therefore, the study aims at improving the experience of the painting of *The Goddess of the Luo* through the transformation from a two-dimensional to interactive three-dimensional form, and by providing an interpretative framework for understanding the work. By applying various digital aids, viewers are enabled to ‘jump’ into and ‘walk’ inside of the painting, exploring different scenes with guided instructions. The project’s ultimate goal is helping audiences better comprehend the scenarios depicted in the painting and their underlying connotations.


1.3 Research Context and Approach

Since the aim is to design a three-dimensional animated prototype of the painting of *The Goddess of the Luo*, and develop effective animation techniques for improving user experience, this research will be based on the practice-led research methodology. Practice-led research is based on two principles. First and foremost, practice-led research suggests that works produced through creativity are in themselves a form of research with measurable research outputs (Smith & Dean, 2009). The result of creative work, in this case a three-dimensional animated prototype of the painting of *The Goddess of the Luo*, represents the outcomes of a research process, and is critical in resolving the set hypothesis.

Secondly, creative practice, which refers to the expertise and knowledge of creative professionals and the procedures used in the making of art, is instrumental in generating specified insights that can be filtered and incorporated into research (Smith & Dean, 2009). Smith and Dean’s approach demonstrates that the processes, procedures, and content of creative practice produce knowledge and improvements that are both diverse and complementary with existing research methods. Practice-led research is an appropriate framework for understanding this study, which emphasizes the creative processes and content involved in the creation of the three-dimensional animated painting prototype, and strives to articulate lessons learned from this example that are
applicable to other three-dimensional animated painting projects in virtual museum contexts.

The three-dimensional animated painting prototype is developed based on the expertise and knowledge of myself and my collaborator, Mingyong Cheng, the technical artist. Mingyong create the two-dimensional animated characters for me through Photoshop and Animated2D, a plug-in which could be used in Unity 3D game engine. The scenarios, the interactions, the sound effects, the interpretive material and the entire virtual world built in Unity 3D game engine, were designed and executed by me.

1.4 Significance of the Study

The significance of the study rests in providing feasible designing strategies and tactics for virtual exhibitions and museums. The proposed study is significant to museum professionals and visitors, as well as literature on virtual museums. Museum professionals involved in the development and implementation of technological solutions to improve visitors’ experience will gain critical insights into the potential of three-dimensional game engines and virtual reality techniques. The resulting knowledge will be essential in the improvement of current infrastructure and policy to ensure the appropriate application of animated three-dimensional and two-dimensional effects on exhibits.
2. Literature Review

According to Pascon (1997), multimedia and hypertext technologies reformed museums by providing the means necessary to process and display information in non-linear forms. Museums changed significantly as data management developed, and users gained improved access to cultural and historical information. Multimedia tools were applied to provide friendlier interfaces compared to what was possible using single medium mechanisms. New technologies and digital tools introduce new possibilities for the virtual museum, providing an extension of the museum by preserving man’s culture through digital information. Digital information is collected and processed, and in digital form, for sharing in various formats. Objects, such as paintings, gain additional value as intangible assets. Parry (2008) used the term e-tangibles to refer to digital information and displays in virtual museums, highlighting that these are often also associated with actual physical relics. With the development of virtual museums, more digital information could be shared online without any limitations on time and space.

The research for this study focuses on relevant innovations in the improvement of virtual museums. This research is primarily based on prior research and exploration in Chinese virtual museums. As technology continues to advance rapidly in the digital age, museum construction in China is developing towards digitalization, virtual museum has become one of the focus of Chinese museum development. Each of the nine most famous provincial museums in China has its own virtual museum, which could be
visited on their official website by audiences. However, according to Chen and Wang (2020), the limitations of virtual museums in China are mainly reflected in the displaying methods these museums apply, in that are too simple and conventional to provide novel and attractive experience for audiences. The most commonly used displaying methods applied by the nine most famous provincial museums in China is to exhibit the objects with high resolution images, and with interpretive texts, which makes the virtual museum more like an online exhibition or gallery. Additionally, seven of these museums provide 360 panoramic tour on their websites. However, apart from these three display methods, high resolution imaging, interpretative texts, and 360 imaging, other technologies and digital tools, such as animation technology and VR technology, haven’t been applied sufficiently yet, and need more explorations and research.

2.1 Chinese Painting Animations

The characteristics and techniques of Chinese painting animations and films generate critical lessons for animators of Chinese paintings today in regard to costumes, continuity, unity of action, masks, and language.

Animation of paintings is a preserve of the fine arts practice. The movements of animation are out of the elements which comprise a painting. Thus, the quality of painting techniques influences the method and style applied during the animation substantially. According to Wells (2009), the art of animating paintings emerged in the West from Walt Disney creations, and shortly after commenced in Chinese art. The
inventors of animations at Disney were inspired primarily by Western art, particularly by the works of artists such as Daumier and Kley (Wells, 2009). The approaches to drawing and presenting animations, thus, were largely Western. Initially, Chinese art imitated the processes and procedures established by Western animators initially before undergoing significant transformation (Chen, 2017). The same author refers this change as the nationalization of Chinese art. Consequently, local ideologies and traditions replaced western techniques of animation, particularly in the animation of classical Chinese painting.

Chinese painting animations prioritized unique painterly techniques, as evidenced by “Fine Arts Film” in the mid-1900s. These changes can be accredited to the unique backgrounds of Chinese animators as well as the stature of classical Chinese paintings. In addition, within the Chinese contexts, animators also doubled up as painters, illustrators, and caricaturists, all of which inspired experimentation with different animation and painterly techniques (Wei, 1984). Furthermore, the Chinese enjoy custody of some of the oldest art in existence to date. As such, there are noticeable differences between Chinese art and paintings from the West. Chinese paintings are also highly appreciated by local and international enthusiasts. Thus, there exists a need to preserve the aesthetic standards and appearances of Chinese art in its own terms. These factors have facilitated and nourished Chinese animations.
According to Chen (2017), traditional Chinese paintings can be classified into two primary categories, including freehand brushwork (xieyi) and detailed brushwork (gongbi). Detailed brushwork is characterized by decorative effects as painters emphasize delicate and elegant lines. Vibrant colors and exquisite details also form an essential part of gongbi (Chen, 2017). This technique defines details precisely without dramatic variation. Again, such art usually features narrative subjects. Numerous Chinese paintings have been produced using gongbi, including *Havoc in Heaven*, which consists of delicate outlines and vivid colors that portray significant decorative effects (Chen, 2017). Xieyi painting is popular with painters specializing in ink-and-wash animation. Compared to the gongbi, xieyi emphasizes simple images. Casual brushwork and an artist’s subjective attitudes and emotions are encouraged. Xieyi is dedicated to the depiction of the spirit of the beings. *The Deer’s Bell* can be classified as a Xieyi style painting as it contains distinctive landscapes based on simple strokes of the brush and a narrow palette of colors. The character of the Deer is simple but outstanding, particularly since the eyes and mouth are demonstrated using two ink strokes. The nose is a simple ink point while the body is a combination of light brush strokes consisting of ink and color wash.

The uniqueness of Chinese painting animation originates from the tendency to use customized calligraphic methods (Wells, 2009). Wells provided the example of Shanghai studios, which continues to employ classic techniques of Chinese painting.
Chinese also follow local philosophy and rules to create and recreate representations of
the world. For instance, Chinese animators rely on a multiple-shot perspective (Chen,
2017). This technique breaks disregards conventional painterly techniques in which
characters follow the logic of the human eye characterize by a vanishing point likened to
when a viewer is watching phenomena from a window. Instead, Chinese paintings
consist of multiple vanishing points (Farquhar, 1993). The eye of the viewer is freed from
a static position. The observer can engage with the painting since the painting is
depicted as if the viewer is moving. Consequently, paintings Chinese paintings such as
The Goddess of the Luo were painted on long scrolls. The multiple-shot perspective is
influential in Chinese animation, particularly when recreating landscape scenery. It
leads to the “dull camera language” (Chen, 2017) effect whereby the camera appears to
move in slow horizontal and vertical motions. The resulting animation generates the
feeling that the viewer is engaging with a still, long scroll painting with limited track
and zoom movements owing to contradictory spatial relations produced by a multiple-
shot perspective.

Besides the multiple-shot perspective, Chinese animations are characterized by
stylized icons and colors that are unrealistic and intangible in the depiction of the world.
As a result, characters and objects in Chinese art are easily recognized. On the upside,
viewers can easily identify with Chinese art while on the downside, artists often fail to
include facial expression. Essentially Chinese art tends to lack details and close-up shots.
In addition, Chinese paintings are based on liner brushes featuring a round shape and sharp tip. According to Zhang (2002), characters defined using lines while details affecting light and shadow are often disregarded. The prominent role of lines in Chinese paintings must be considered while developing animated VR environments of Chinese painting, so that the viewer is guided to notice these important aspects of the work.

Other notable characteristics of Chinese paintings relevant to this example concern masks and operatic costumes, all of which present specialized challenges while handling animations for virtual museums. Different facial masks within the Chinese culture denotes diverse characters and personality traits, which are displayed using divergent colors or patterns. Ancient costumes are based on the ancestral clothes of the Chinese. Differences in textures, colors, and design were used to imply diversity in roles. Chen uses the example of the animation of Havoc in Heaven to demonstrate these differences as the King of the Monkeys is adorned with yellow costumes featuring a special collar and decorated skirt. This characteristic is evident in Princess Fan, for example, who appears in an armor-like dress, which is costume reserved for military women. While animating Chinese paintings, animators should therefore emphasize the unique features of the culture to avoid compromising the authenticity of these art pieces.

Chinese animations also apply schematic movements and pose related to traditional opera. The feature is especially prominent when handling fighting scenarios. Farquhar (1993) grouped conventional Chinese opera into two major categories,
including civil and military opera. Military themes concern war and warlike conditions, including the adventures of heroes and criminals. Viewers can discern the character and purpose of characters within an animation by recognizing the dressing and body language. These characteristics also depict the intention of the character immediately. To create the correct effect for military opera, for example, animators are encouraged to manifold camera motions and fast editing techniques to generate tension of actions. The movements of these characters should be presented in suggestive movements. Research indicates that the civil opera developed from the Qing dynasty (1613-1912) and blossomed in the mid-1900s. Characters within civil opera-themed paintings perform recognizable movements that are both suggestive and symbolic. To represent actual events within a Chinese painting, thus, the animator must take into account the specific appearances and actions of different Chinese characters.

Music and language are also an integral part of traditional Chinese animations. For instance, art pieces often feature traditional gong and drum (Cooler, 1995). These are key constituents of the Chinese opera that accompanies most characters in art. For animators to engage and influence the emotions of viewers, the incorporation of music and language within the videos therefore should not be omitted. Music and language also help in the development of the plot to a notable climax. Animations also constitute classic languages and voices. For instance, the term “Wa-ha-ha” implies happiness, while “Ai-ya-ya” to express anger (Chen, 2017). These features are essential in the
creation of animated Chinese paintings. Characters can also voice the last words of a statement using a specialized drawl that indicates ancient opera singing techniques.

Incorporating these aspects in Chinese animations of art attracts the attention of viewers by improving engagement with art and the museum experience, and by connecting the work visually and aurally with their artistic and cultural contexts.

As demonstrated through the characteristics of Chinese art above, traditional opera exerts a significant influence on the audio-visual recreation of Chinese art. Operatic movements, costumes, poses, and masks attract museum enthusiasts with the familiar appearance of endeared cultural items. The international audience, as well, can recognize and appreciate the unique features of Chinese art (Chen, 2017). By animating paintings using two-dimensional, three-dimensional, and VR technologies, animators can recreate traditional Chinese features of characters already also in evidence in Chinese films, for example. Painting’s static state and film’s dynamic space can be incorporated to produce remarkable and immersive replicas of museum artifacts (Panofsky, 2009). Panofsky (2009) emphasizes the importance of moving space for viewers. Space should be manipulated such that objects approach, recede, and dissolve in an animation as necessary to create the appropriate effect on viewers. These motions are responsible for creating the feeling that an individual has jumped into and is walking around within a virtual reality space. Cutting edge editing of shots and motions enable the recreation artifacts in remarkable detail.
2.2 Similar projects for inspiration

Applying various techniques and digital aid to animate painting has been explored by other researchers in China for years. During previous research, several digital projects of animating painting has inspired me in various aspects.

2.2.1 Walking inside of the painting in the form of 360 Video

![Figure 1: 360 Video of the painting of Autumn picture of magpie and China](image)

In this example, an animation of a traditional Chinese painting of *Autumn picture of magpie and China*, 360 Video that allows the audiences to drag the mouse to look around while watching the video is proven potential and effective as a digital tool for animating paintings. This example is where the inspiration of letting the audiences ‘jump’ into a two-dimensional painting came from. This video (see the screenshot in Figure 1 above) creates a virtual world based on a famous ancient Chinese landscape painting, *Autumn picture of magpie and China*. In this three-dimensional virtual world, some of the objects are animated three-dimensional models, while others seem like two-dimensional objects derived from the original painting. The combination of two-
dimensional objects and three-dimensional models successfully preserves the crucial
details of the original painting while transforming the still two-dimensional painting
into an immersive three-dimensional virtual world, which is capable of providing novel
experience for audiences in compare with displaying the plain painting conventionally.
Additionally, the application of a Chinese poem related to the painting (see Figure 1)
would help interpreting the connotation of the painting, as well as fully representing the
style and features of a Chinese ink painting. In this project, the critical feature of Chinese
ink painting that paintings and poems are usually combined together is successfully
displayed.

2.2.2 the Virtual Reality tour of the T-shaped silk manuscripts

![Figure 2: T-shaped silk manuscripts collected in the Hunan Museum](image)
As has been mentioned above, the limitations of virtual museums in China are mainly reflected in the display methods these museums apply, in that are too simple and conventional to provide novel and attractive experience for audiences. While other Chinese museums are mostly doing zooms, interpretative texts and 360 imaging, the Hunan Museum is an exception that is famous for its success in applying various kinds of techniques and digital aids to improve experience and engagement of the museum in China. One of the most precious collections in the Hunan Museum is the T-shaped silk manuscripts excavated from the Mawangdui Han Dynasty Tomb in Changsha, Hunan (see figure 2 above). The silk manuscript which could be divided into three parts depicts the Chinese abstraction of the world, the cosmos and the afterlife at the time of the Western Han Dynasty. Since the creator of the silk manuscript does not separate each part obviously by means of borders and large blanks, it is difficult for viewers to distinguish the world, the cosmos and the afterlife part of the manuscript. Evidently, the abundant scenes, storylines and the connotations of the manuscript is opaque to viewers and difficult to be comprehended. In order to make the message delivering more effective, the Hunan Museum designs a virtual reality tour for the T-shaped manuscript to interpret the stories behind the artwork. The virtual reality tour brings the audiences into the place where the owner of the silk manuscript lived in, depicting their daily life and thoughts, which is exactly the contents of the manuscript. Dialogues and scenarios
are designed to represent the connotation of the manuscript, which make the opaque graphics and symbols easier to be comprehended.

### 2.2.3 Puzzle Game: A thousand Miles of Rivers and Mountains

![Screenshot of the game A thousand Miles of Rivers and Mountains](image)

Figure 3: Screenshot of the game *A thousand Miles of Rivers and Mountains*

This digital project (see figure 3) is a collaborating work created by the Palace Museum and a Chinese game company NetEase that transformed the painting of *A thousand Miles of Rivers and Mountains* by Ximeng Wang into a three-dimensional puzzle game. The player has to speak with the characters in the game to collect key items and find clues to unlock the map and explore the world. There is a sequence of interactable objects in the game, the way the player interacts with objects and the choices made by the player would lead them to different scenes, storylines and endings.

### 2.3 Virtual museum example using Unity3D engine

The three-dimensional game engine is a powerful tool that could be applied to construct the virtual museum. Currently Unity3D software and Unreal Engine are two
most commonly used three-dimensional game engines. Unity3D software has already been applied in the field of virtual museums in China to construct three-dimensional immersive environment, and has been proven accessible and effective as an authoring environment, as these and other virtual museum projects, including mine, shows.

![Figure 4: Screenshot of the virtual palace museum](image)

The virtual Palace Museum project (see figure 4), developed with the Unity3D game engine, is intended to provide a virtual tour in the Forbidden City for visitors and to help propagate the historical and cultural value of the Forbidden City. The construction of the virtual tour scene of the Forbidden City is completed in Unity3D and incorporates the use of avatars and a virtual reconstruction of key sites. In this project, three-dimensional objects such as dynamic water, lighting and panoramic sky are set to enhance the degree of simulation of the virtual environment. Additionally, various
viewing modes are provided for audiences: three-dimensional virtual roaming
controlled by keyboard and mouse, VR tour and AR-based three-dimensional cultural
relics exhibition. This project also incorporates interactive functions, such as weather
system, map view, and virtual tour guide to help message delivering and provide
diverse experiences. Compared with a 360 panoramic tour that has a fixed route, this
three-dimensional virtual tour provides visitors the opportunity to decide the visiting
route and viewing perspective themselves. In this way, visitors can explore the
Forbidden City freely, which preserves the advantage of visiting a physical museum.
Additionally, user experience is improved since novel and interactive experiences are
provided here. For instance, users can experience different weathers and seasons in one
day when exploring this virtual world, which is impossible in the real world. The
scenery of the Forbidden City varies greatly in different weather conditions and seasons,
which requires multiple visits to experience all of them. By providing audiences the
opportunity to change the weather condition of the virtual world, they can experience
the change of the scenery in a short time, which is novel and attractive compared with
the normal visit in the physical world.
3. Methodology

The proposed research will be based on the practice-based research methodology. Practice-based research is a form of original research designed to gain new knowledge through the means of practice and related outcomes. Based on this definition of practice-based research, the current study will seek new knowledge, insights, and skills through the creation of a three-dimensional animated prototype of The Goddess of the Luo painting.

Practice-based research is based on two fundamental principles. The first principle concerns the nature of creative works. Smith and Dean (2009) established that creative works are in themselves a form of research with measurable research outputs. The result of creative work, a three-dimensional virtual world of the painting of The Goddess of the Luo, in the case of this research, represents the outcomes of a research process. By transforming the two-dimensional painting into a three-dimensional immersive environment that incorporates various scenes and a sequence of storylines, the study combines the painting and the original poem written by Cao Zhi organically. To be more specific, by displaying words from the poem and storylines derived from the poem in the three-dimensional world, the appearance of different characters and scenes can be better comprehended by viewers. Additionally, the interactions designed to enhance engagement also function as instructions for exploring this virtual three-dimensional painting, an approach that is more effective than displaying a two-dimensional painting conventionally because scenes are more distinguishable in the
three-dimensional painting and audiences are guided to explore different scenes depicted in the painting in the correct order. Thus, the model will contribute significantly to the resolution of the set hypothesis that techniques and digital tools such as three-dimensional technique could be applied to enhance digital storytelling and provide better user experience. The second principle of practice-based research concerns the role of practitioners in the design and completion of the work. Research has established that the expertise and knowledge of creative professionals and the procedures used in the making of art are central in the production of specialized insights that can be filtered and incorporated into research (Smith & Dean, 2009). Practice-based research was chosen for this study due to emphasis on the creative processes and content involved in the creation of the three-dimensional animated painting prototype. In this case study, the primary approaches explored include the two-dimension and three-dimensional character design, the design of scenes and scenarios, the soundtrack, the Chinese narration, and English interpretive text. Taken together, these techniques and tools facilitated the production of an immersive and interactive animation of the painting of *The Goddess of the Luo* to enhance the experience of viewers by aiding in their engagement with and understanding of the work.

### 3.1 Practice-Based Research Method and Design

A critical consideration of practice-led research concerns the documentation of the research process. For instance, since the current research is based on the simulation
process of *The Goddess of the Luo painting*, the researchers will provide detailed documentation of the process. Video documentation, figures and textual analysis will be provided.

### 3.2 Role of the Researcher

In practice-based research, the researchers assume an active role throughout this study. As opposed to quantitative research, whereby the role of the researcher is ‘theoretically non-existent,’ the results of this study depend on the active involvement of all the researchers. Therefore, this research can be classified as a qualitative study in which the researcher probes, questions, and experiments to develop an in-depth understanding of phenomena. Based on the findings of Smith and Dean (2009), qualitative data is an effective method of collecting data about an issue or idea and allow researchers to express individual thoughts independently. In addition, while qualitative research is a process of abstraction from evidence, qualitative research encourages the documentation of evidence. Therefore, textual analysis and video documentation is provided for this project.

### 3.3 The Ode Goddess of the Luo River

The painting of *The Goddess of the Luo* illustrates the poem titled *The Ode to the Goddess of the Luo River* by Cao Zhi. The poem details an encounter between Zhi, who was a state official, who is making his way home from an official visit to the capital. Zhi decides to stop by River Luo for a rest. Zhi records that “The sun had already dipped in
the west/ The carriage unsteady, the horses fatigued/ And so I halted my rig in the spikenard marshes” (lines 7-9). While he rests at the river, Zhi experiences a vision involving a goddess. Zhi was let’s his eyes wander over the river when he suddenly spots a “lovely lady by the slopes of the riverbank” (lines 17). Zhi cannot believe his eyes owing to the extraordinary beauty of the goddess. However, when he asks for confirmation from his coachman, the latter is clueless as he cannot see the goddess. The body of the goddess is described as soaring “lightly like a startled swan/ Gracefully, like a dragon in flight/ In splendor brighter than the autumn chrysanthemum” (lines 20-22).

The beauty of the goddess causes Zhi to fall in love with her. Zhi then describes the ethereal physical appearance of the goddess in detail, including clothes and adornments. Gold and kingfisher hairpins adorn her hair and her white teeth gleam. Other notable details that are critical to the current research include bright peals that make her body shine, a balance between pale and frail, white neck, red lips, and water birds flying about her person as guards. The goddess disappears from Zhi’s sight just as suddenly as she had appeared. Zhi is disappointed. He states that although he left the shores of the River Luo, his heart remained behind. His thoughts are forever taken by the memories of the beautiful goddess. He turned severally upon the riverbanks in the hope of catching another glimpse of the goddess. However, the goddess has disappeared.
3.4 The Painting of The Goddess of the Luo

Gu Kaizhi was inspired by Zhi’s Ode to the Goddess of the Luo River when he produced the painting of The Goddess of the Luo. Based on the descriptions in the poem, the painting consists of the character of Cao Zhi, the coachman, and a horse. Kaizhi illustrates the emotions of Zhi vividly when he first encounters the goddess of the Luo. The facial expressions, especially, are intense. Further, he emphasized the size and texture of the stones, water, trees, hills, and the goddess’ clothes. Gu (2011) noted Kaizhi’s effort in depicting the inner spirit and personality of the characters. By viewing the painting, individuals can discern the wave of emotions Zhi encounters upon setting his eyes on the goddess and his disappointment at her disappearance. The painting portrays the events of the poem in “life-like charm” (95). Fufei’s clothes are depicted with astounding detail (Kyo, 2012). He paid special attention to the eyes of characters to emphasize the unnatural quality of the encounter and resulting emotions of love, happiness, disappointment, and sadness. Gu (2011) notes that Kaizhi appears to have shared the belief among Greek painters that emphasizing the quality of the eyes had the positive effect of inviting viewers to engage with the painting. The rich history of the painting of the Goddess of the Luo, as well as the artistic value of the artifact, was instrumental in the selection of this painting for this project.
4. Research Analysis and Future Possibilities

The three-dimensional animated prototype of the painting of *The Goddess of the Luo* was created through several distinct steps and processes. Strategies were applied to enhance the deliverability and user experience of the project. However, this project has certain limitations and there is considerable room for its future development and improvement. It was designed as a standalone experience, but in the future, the project has the potential to be applied both on the website of the museum and in the physical museum.

4.1 Research Analysis

The primary development strategies included the design of two-dimensional characters, the exploration on methods to ensure the authenticity of the three-dimensional prototype, the design of interaction, the design of soundtracks and the application of interpretive material.

4.1.1 Character Design

The original painting my collaborator and I used is shown in Appendix A below. The painting consists of multiple characters, including Zhi, the coachman, The Goddess of the Luo, horses, and other individuals in the company of both Caozhi and the goddess. The two-dimensional characters appearing in the virtual environment were derived from the transcript of the painting of *The Goddess of the Luo* by the technical artist
Mingyong Cheng. The materials for the animation was derived from these characters. The initial steps involved the extraction of images and the creation of life-like designs.

To achieve the objectives of this study, the technical artist generated the critical body parts of each of the characters, including the head, hands, and feet using the photo editing software, Adobe Photoshop. Adobe Photoshop contains useful tools for the extraction and creation of frames and related layers for animation. For instance, in order to create the two-dimensional character Caozhi whose long sleeves were to be animated (see figure 5 below), the technical artist used the quick selection tool and lasso tool to extract the character Caozhi from the original painting, as well as dividing the character into three parts. After generating a new layer for each part and exported these layers separately, the technical artist successfully created the image package of Caozhi’s body parts for later animation in Unity3D game engine. Additionally, in this process, the colors of the characters were slightly altered and adjusted as needed to suit the palette in Kazhi’s painting.
Secondly, the character design process in Unity3D software primarily involved the application of the Animated2D plug-in, which was also mostly finished by the technical artist. As the critical body parts that require appropriate animation are generated and imported into Unity3D engine, the technical artist uses Animated2D plug-in to create the animation effect. For instance (see Figure 5 and 6), in the first memory scene, the character Caozhi is required to wave his long sleeves. In order to create this animation effect, by applying the Animated2D plug-in, a start and end position for these long sleeves’ parts are set to make the sleeves move to the specific
position. Then by applying a loop mode to this move animation and adjusting the looping speed, the animation effect of waving sleeves is generated successfully.

![Animated2D plug-in for animation](image)

**Figure 6: Animated2D plug-in for animation**

### 4.1.2 Experiments on authenticity

Transforming the two-dimensional Chinese painting into the three-dimensional virtual prototype creatively was a key concern considering the objectives of this research. To achieve this goal, the design strategy of combining two-dimensional graphic characters, three-dimensional models and three-dimensional terrain as well as the application of the Chinese ink painting effect shader are explored in this project.

Firstly, inspired by the 360 Video of the painting of *Autumn picture of magpie and China*, the tactic of combining two-dimensional objects and three-dimensional objects is also intended for preserving the critical details, such as the main characters, of the original painting while transforming the plain image into a three-dimensional virtual world. The two-dimensional characters generated from the original painting are
instrumental in boosting the trustworthiness of ‘jumping’ into the painting of *The Goddess of the Luo*, since it provides audiences the opportunity to interact with the real characters that appeared in the painting closely. Additionally, using characters generated from the original painting is crucial to preserve the main aesthetic values of the painting. As is shown in Figure 7 below, the characters are depicted most detailly by Gu Kaizhi, and are huge in compare with other objects, such as mountains and trees, which indicates that characters are the most important parts of the painting of *The Goddess of the Luo* (Xu, 2019). Apparently, replacing these two-dimensional characters with three-dimensional figure models downloaded online would cause the loss of aesthetic values for viewers to appreciate. As for other objects in the painting, such as the mountains, trees and animals, we determined that for our purposes they were less crucial than the characters were to the overall experience of the original work that we were trying to convey. Therefore, these are the parts that we transformed to three-dimensional forms in the project, a process we undertook by applying three-dimensional animated models downloaded online and three-dimensional terrain tools provided by Unity3D software.
In addition to creating the animated characters and a 3D rendering of the environment, a Chinese ink painting effect shader is applied to the whole three-dimensional virtual environment in Unity3D engine. Before applying the shader, I first tried to use terrain tool in Unity3D to mimic the outlines of the mountains and hills displayed in the original painting, as well as importing the most similar three-dimensional models I could find online. However, after viewing the results I concluded that the aesthetic outcome was more like a three-dimensional modeling work rather than a Chinese ink painting in a three-dimensional form (see Figure 8 below). Therefore, in order to make the project being capable of representing Chinese ink painting style (see Figure 9 below), a special shader is attached to the main camera Game Object whose function is rendering scene in Unity3D engine. This shader consists of several coding
files, whose principle to apply Gaussian blur to the original image, calculating the edges and stroking them, and finally using the brush effect to filter the image. I found this method in a blog on the CSDN website (URL: https://blog.csdn.net/qq_36107199/article/details/86507737). This technique improved the similarity between the three-dimensional virtual world and the two-dimensional Chinese ink painting, thereby enhancing the authenticity of walking inside a Chinese ink painting.

Figure 8: Three-dimensional virtual world without the shader
Figure 9: Three-dimensional virtual world with the shader

4.1.3 Interaction design

Interaction design is another crucial part for interpreting artworks and improving the user experience of the three-dimensional virtual painting. In this case study, since the painting of *The Goddess of the Luo* roughly contains six scenes that have not been divided obviously, and are interpretatively opaque to viewers, the main goal of the interaction design is to distinguish each scene and to guide viewers to explore the different scenes depicted in the painting in the determined order.

Generally, in navigating the environment, the audience needs to keep interacting with objects in the three-dimensional virtual environment in order to explore the scenes in the same order as depicted in the painting and the original poem. Gamification elements are lightly involved here, by which I refer to the application of typical aspects of game playing in non-game contexts (Dopker, Brockmann, & Stieglitz, 2013).
Gamification here is meant to engage viewers and increase their interactions with the three-dimensional environment. In this case study, I attempt to design the project as a puzzle game similar to the game mentioned above, *A thousand Miles of Rivers and Mountains*, which requires the ‘player’ to interact with objects in the scene to unlock more scenes and scenarios. For example, in order to indicate the concept that only after there is a bridge in your heart, you could draw the bridge in the painting, the game set a broken bridge that prevent the player from continuing their exploration. The player needs to talk to the Non-Player Character to view this saying and finish the conversation to repair that bridge and unlock new scenes.

![Figure 10: Interaction example: feeding the horse](image-url)
The interactable objects in my project are designed based on pivotal elements of the poem written by Cao Zhi. For instance, when entering the first scene, the audience is required to pick up the grass to feed the horse (View Figure 10 above). Only after finishing these steps would the next scene be unlocked. The reason for designing the interaction ‘feeding the horse’ is that in the original poem and painting, it is because the horses are too tired to continue moving forward so that Cao Zhi and his company stop by the river Luo, feeding the horses and encountering the goddess of the Luo. Therefore, not only does these interactions enhance engagement by turning the painting into an edutainment, but also the storylines and scenarios are interpreted through the interacting process.

Figure 11: Interactable riverbank with green glow
Additionally, since this project aims to be an edutainment that focuses on delivering messages and improve digital storytelling, unlike the game *A thousand Miles of Rivers and Mountains*, whose core is puzzle solving, I attached green glows to the objects that are supposed to be interacted with as a visual guide for users. For instance, after finishing the feeding interaction, the user should go to the riverbank that could be interacted with to unlock Caozhi’s memory scene of encountering goddess Luo (see figure 11 and 12 above). However, as the figures show, if the green glow hadn’t been attached to the interactable riverbank, the possibility would be that the user would have no idea about where to go next to reach the interactable riverbank. This next element is small in such a big scene, which might confuse the user and stop his exploration here after several failed attempts. Therefore, the glow strategy provides instruction for users are necessary to improve the user experience of an edutainment.
4.1.4 Soundtrack design

After the design of characters, environment and interaction, a soundtrack is synchronized into the experience. When music and sound are synchronized with motion pictures, performance is enhanced, and the believability of scenes and characters improves (Newsome, 1980). Further, the viewers are entertained, which increases the quality and length of engagement with the media. In this project, different ancient Chinese-style musical pieces were used to convey different emotions in different scenes. For instance, in the scene of encountering the Goddess of the Luo, a jovial melody which has a love theme is applied as the background music to show that Cao Zhi is pleasantly surprised at his encounter with the beautiful goddess. In the scene of farewell, the background music is rather melancholy to convey the sorrow of Cao Zhi and the goddess to audiences, as well as indicating the tragic ending of the story. Additionally, Chinese voiceover downloaded online reading the related sentences in the original article wrote by Caozhi is added to provide abundant audio experience for the audiences. Moreover, the voiceover functions to enrich Chinese heritage and complement the English interpretive text on the screen.

4.1.5 Interpretive Material

Additionally, the dialogues in some of the scenes are designed by combining quotations from the original poem and the researcher’s imaginations, building upon information derived from historical materials. Interpretive text is essential in facilitating
the interpretation of the artifact by viewers. Further, the text directs the audience through the storylines. Garcia (2012) supported the idea that interactive displays within museums should include interpretive material that enhances the grasp of cultural information. In this project, as a painting inspired by the poem of *The Goddess of the Luo*, there are abundant storylines and connotations behind the painting that would be opaque to audiences, especially to those who have not read the poem before, or who do not have familiarity with the cultural context. Therefore, a combination of the painting and the poem makes the message delivering more effective. However, merely displaying the originally poem is still not capable of associating the scenes depicted in the painting with the corresponding paragraphs in the poem. Moreover, the long and opaque poem in ancient Chinese version is difficult for visitors to understand, which might cause a loss of interest. To solve this problem, the dialogue system which explains the poem in a simpler way in each of the scene is designed as the interpretive material for the three-dimensional painting. By transforming the long paragraphs of the poem to dialogues and by switching the user from viewers to participants, the storylines and connotations behind the painting are easier to be comprehended and the user’s engagement with the painting is increased.

### 4.2 Future Possibilities

This interactive experiment in three-dimensional animated painting still has considerable room for further development. First, more options could be provided to
users in the dialogue system to further improve the engagement and experience of the project. At present, interactive video is a trendy topic being discussed worldwide. In China, interactive video has become popular among the young generation since 2019. Inspired by the interactive video, this project could also provide several options which would lead to different scenes and scenarios for users in the future. In this case, the role of the user would switch from the information recipient to the creator of the digital art, which would further enhance the interactivity of the project. Additionally, since a three-dimensional project could be developed into VR version in Unity3D software, providing a VR tour in the three-dimensional painting for audiences is also a possibility for my project. Like the virtual Palace Museum project developed with Unity3D software, this project could also be experienced with VR equipment such as HTC VIVE. Compared with controlling mouse and keyboard, using different gestures to interact with object could provide a more novel and immersive experience for users.

The approach described in this case study could be applied to the physical museum as a supplement to interpret the original painting, as well as being displayed on the official website of the museum. Both options would allow users to experience the work in a new way.

On the one hand, Chinese museums are undergoing great innovations towards improvement of digitalization. Among the most famous museums in China, the Hunan Museum is famous for its success attempts and explorations on applying emerging
techniques and digital tools to improve the deliverability and experience of the museum. As is mentioned above, one of the most famous collections in Hunan Museum, the T-shape silk manuscripts, has many of the same features as the painting of The Goddess of the Luo, such as the abundant storylines incorporated in the painting, and the inconspicuous boundaries between each scene, which all makes the painting opaque to audiences with the conventional displaying methods. Except for the interpretive text, the Hunan Museum similarly designs a VR tour to improve the digital storytelling of the manuscript, which makes the message delivering more effective and has gained great popularity. This project serves as an example that exhibits the transcript of the painting of The Goddess of the Luo to function as a supplement for more effective digital storytelling.

User could experience this project in multiple ways. The visitors could play this project on devices provided in the museum and explore the three-dimensional animated painting themselves to better comprehend the connotation of the original painting. On the other hand, this project could also be displayed on the official website of the museums. In the digital age, most museums in China has their online gallery to display their collections. This would be my ultimate wish for this project. The official website of the Palace Museum, which has two of the transcripts of the painting of The Goddess of the Luo, has a column for edutainment and applications developed based on the cultural relics in the Palace Museum. Since the project developed with Unity3D software could
be displayed and played on website, this project could be displayed on this website, becoming part of the virtual gallery of the Palace Museum.
5. Conclusions

The objective of this study is to improve the experience of paintings through providing audiences three-dimensional immersive virtual experiences. In order to achieve this goal, I created a case study to explore in depth the idea that three-dimensional interventions with game-based elements will improve experience and enhance museum engagement. The case I picked is creating a three-dimensional animated prototype for the painting of *The Goddess of the Luo* by Gu Kaizhi. A sequence of design strategies and tactics were applied to improve the user experience of the three-dimensional painting.

5.1 Research Design

The investigation of the above objectives was conducted through the practice-based methodology in which the knowledge and expertise of researchers were key to research outcomes. In line with the principles of practice-based research, the processes, procedures, and content of the creative processes generated knowledge and improvements to virtual environments of paintings within virtual museums. The practice-based research methodology enabled the researcher to maximize personal experience and motivations towards the generation of the insights presented below. As noted earlier, the primary strategies employed here include the design of two-dimensional characters, the exploration on methods to ensure the authenticity of the three-dimensional prototype, the design of interaction, the design of soundtracks and
the application of interpretive material. With these techniques and design strategies, in compare with displaying the two-dimensional painting conventionally, the abundant storylines and connotations of the painting could be delivering to audiences much easier. Additionally, a novel and fanciful experience is provided for audiences, which enhances the engagement of the audiences.

5.2 Summary

In conclusion, this thesis has demonstrated the importance of applying specific strategies and techniques during the development of virtual environments for virtual museums. When working on a three-dimensional animated Chinese painting, animators could derive quality images from the original painting for use in creating two-dimensional designs to preserve the details as well as aesthetic and cultural value of the original painting. Additionally, the authenticity of the three-dimensional prototype not only depends on using similar three-dimensional models and objects, but also depends on the representation of the style and crucial features of the original painting. Finally, the design of interaction and the application of interpretive material could be specialized in different cases to focus on solving the most crucial problems that impede message delivering and emotion conveying.

The study has established that photo-editing software and three-dimensional game engines are effective tools museum professionals could apply in the digitalization of physical museums and the design of virtual museums. In this case study, Adobe
Photoshop and Unity3D game engine successfully transformed the two-dimensional still painting into a three-dimensional animated painting, effectively favoring the achievement of the goals of the study.

Further, the incorporation of gamification elements enhanced the interactivity of the 3D painting. Gamification has been identified as the addition of game-like features within non-game contexts to increase engagement (Dopker et al., 2013). The involvement of viewers was an essential consideration of this research. The animators demonstrated the role of gamification in painting animation by incorporating a glow intended to direct the attention of viewers while interacting with the media. After engaging with different objects and characters in the virtual environment, audiences can unlock subsequent scenes by following the glow’s lead. Rather than a static animation video, gamification effectively transformed the three-dimensional animated prototype into a sort of puzzle game requiring the input of viewers. Gamification also contributes to psychological need satisfaction of viewers through increased interaction with media (Sailer et al., 2017). Thus, gamification is recommended for animating paintings.

Background music, interpretive material, and narrative voice formed additional critical components of this study. The virtual environment was customized to accommodate viewers proficient in both English and Chinese languages. English is incorporated in the form of interpretive texts drawn from the original Ode of the Goddess of the River Luo by Cao Zhi. Viewers who are proficient in English can interact with the
media through the animation and English subtitles on the screen. Chinese assumed a much more prominent role in this project due to the cultural and historical value of Kazhi’s painting of *The Goddess of the Luo*. Chinese culture and painterly technique are evidenced in the appearance of the characters and objects, as well as background music. Chinese language is incorporated through the narration of selected lines from the original poem. While interacting with the painting within the virtual environment, viewers can perceive and appreciate Chinese culture, music, and language, while enjoying the advantage of English interpretive text. The outlined elements contribute significantly to the creation of an immersive world and can be used as a model for similar inventions in the virtual museum context.

This project has considerable room for further improvement and development, and the future possibilities incorporates enhancing the interactivity by providing users more options in the dialogue system, as well as developing the three-dimensional project into the VR version. The destination of this case study is being applied to the physical museum as a supplement to interpret the original painting more effectively, as well as being displayed on the official website of the museum to be a part of the virtual museum.

The design strategies and techniques experimented in this project could also be applied to the three-dimensional animation of other famous Chinese paintings. My methods are best suited for being applied to the animation of the Chinese paintings
which have abundant storylines and scenes, such as the painting of "Along the River during the Tomb-sweeping Festival" by Zeduan Zhang, which is also a national treasure collected in the Palace Museum. Similar to the painting of "The Goddess of the Luo", this painting also has a long scroll format and depicts the daily life of people of all walks of life in the Northern Song Dynasty. This painting not only witnesses the prosperity of the capital city Bianjing, but also reveals some social problems at that time. Therefore, my methods could be applied to create a three-dimensional animated painting of "Along the River during the Tomb-sweeping Festival", providing the audiences a journey among different life scenes which help them understand the customs of the Northern Song Dynasty and the connotation behind the painting.
Appendix A

The Original Painting of The Goddess of the Luo by Gu Kaizhi. (In order to display it, the painting is cropped to three sections here.)
References


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