

**CHINESE PAINTING IN 3D:
AN ARTISTIC STUDY OF THE USE OF THE
TRADITIONAL CHINESE PAINTING AESTHETIC IN
THREE-DIMENSIONAL COMPUTER GRAPHICS**

A Thesis

by

STEPHANIE ANN STRICKLAND

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

December 2010

Major Subject: Visualization Sciences

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Chair of Committee,
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ABSTRACT

Chinese Painting in 3D: An Artistic Study of the Use of the Traditional Chinese Painting
Aesthetic in Three-Dimensional Computer Graphics. (December 2010)

Stephanie Ann Strickland, B.E.D., Texas A&M University

Chair of Advisory Committee: R. Yauger Williams

This thesis presents a study of both traditional Chinese painting and three-dimensional (3D) digital non-photorealistic shading techniques, the results of which are used to create a short animation illustrating an environment that maintains the aesthetic of a Chinese painting while exploring a two-dimensional art style in a new way through camera movement and parallax.

Traditional Chinese painting uses alternative methods to communicate depth, such as value range, water-to-ink ratio and vertical placement of objects. In contrast, perspective and parallax are native characteristics of 3D digital technology and are easily generated using a virtual camera. When combining these two mediums to inject linear perspective into the Chinese painting style, it is equally important to maintain the integrity of the aesthetic by adhering to the stylistic and compositional rules throughout the animation. As a result, the final project may be paused at many key frames and appear to follow these rules closely.

This study also describes the methodology of translating the Chinese painting aesthetic into a 3D digital medium, which can also be used in the interpretation of other traditional art styles.

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1. INTRODUCTION

The free-spirited style of traditional Chinese painting and the controlled method of three-dimensional (3D) computer graphics, when combined, produce a unique result. It is a combination of organic and digital; traditional and technological, spontaneity and precision. Each medium has its own strengths to enhance the other as well as limitations which present challenges when one attempts to combine them.

For instance, traditional Chinese painting in the *xieyi* style (also known as “freehand” style, see Section 2) is created by single brushstrokes of ink on absorbent rice paper. Each stroke determines the placement of the next to create an improvised composition. Each stroke is finite, which means that once it is done, the artist preserves the integrity of the stroke and does not paint over or correct it. This style of Chinese painting has a spontaneous beauty and vitality that is characteristic of the tradition.

In contrast, 3D computer graphics values precise control over every attribute. Everything is created digitally and manipulated through much iteration before being finalized. While the mathematical nature of the medium inherently makes the technology possible, it also makes creating naturalistic-looking imagery more difficult.

While Chinese painting creates an image with organic vitality almost effortlessly, computer graphics must work against its mathematical foundation to produce similar results. However, in 3D computer graphics we are given both a third dimension as well as the dimension of time, which allows us to explore a two-dimensional (2D) art medium in a new

This thesis follows the style of *IEEE Transactions on Visualization and Computer Graphics*.

way.

This thesis studies both traditional Chinese painting as well as 3D computer graphics, and discusses the methodology behind combining the two to create a short animation. The goal is to create a short animation by analyzing the traditional Chinese painting aesthetic and translating it using 3D software in order to explore the medium in other dimensions through camera movement and parallax. An additional goal is to have the resulting animation follow the characteristics and compositional rules of Chinese painting so that the animation can be paused at many key frames and look like a traditional 2D painting. This thesis also discusses the results of the study and evaluates the work based on how true it is to the traditional Chinese painting aesthetic.

2. BACKGROUND

To better understand the Chinese paintings used in this research, it is important to study their origins and which characteristics and principles have prevailed over the course of China's history.

Many characteristics of traditional Chinese painting as it is known today developed over centuries of art in China. From as early as the 4th century A.D., trends such as simple line and elegant composition were characteristic of the art. By the Han Dynasty (206 B.C. – 220 A.D.), emphasis on line, especially in depicting figures, became increasingly popular.

By the Tang Dynasty (618 – 907), paintings of figures in court life were at their peak, while another subject – landscape – began its rise. Here we see two more iconic traits emerge which are the use of line (both as silhouetting and filling techniques) as well as the importance of portraying the innate nature of the object rather than its literal form [8]. The later caused the popularity of landscape painting to grow, where it peaked during the Song Dynasty (906 – 1279). These paintings were highly valued for their depiction of the artist's spirituality and the harmony between man and nature [9]. These landscapes are excellent examples of how the artists communicated depth and dimension rather than using the linear perspective that was more iconic of Western art styles of that time period. One of these methods is still very common with traditional Chinese painting, which is the use of color values (lightness or darkness) and blurriness to differentiate foreground objects from background objects (see Figure 1).



Figure 1: Landscape painting from the Song Dynasty by Wen Zhengming [8].

The Song Dynasty also fostered the development of a new art style to contrast the most popular *gongbi* style of the previous eras (*gongbi* literally translates to “the careful brush” and is a highly precise and detailed painting style done with ink on non-absorbent paper or silk). This new style called *xieyi*—the translation meaning “sketching the idea”—celebrates the freehanded stroke and spontaneous creation of a composition (see Figure 2). The abstract nature of this style was appreciated by Chinese critics since their belief was that realistic paintings of an object can never show its true nature [8].



Figure 2: Example of gongbi (left) and xieyi (right) styles [4, 7].

The intent of this study is to analyze the characteristics and features of two Chinese paintings in the *xieyi* style and to recreate the aesthetic in 3D.

3. METHODOLOGY

3.1 Artistic Intent

A visual analysis of the *xieyi* Chinese painting style is necessary to ensure that the digital work produced in 3D closely matches the aesthetic of the painting. The results of this analysis yield a list of important characteristics derived from Chinese painting principles which can be categorized as follows:

- Content
- Value
- Brushstroke color and form
- Composition

Each can be paired to a specific digital technique best suited to recreate that characteristic in a 3D environment. It should be noted that the purpose of this study is not to copy the exact paintings used in the visual analysis, but rather to combine digital techniques to create a short animation that closely resembles the style, aesthetic and compositional principles of the selected Chinese painting objects.

3.2 Visual Analysis

This study focuses on two common objects which have been popular in Chinese paintings for centuries: the plum blossom and the lotus. These iconic flora have influenced many artists and styles since as early as the Song Dynasty [11] and because they present a variety of opportunities for digital implementation, they are ideal objects for this study. The following analyses will focus on two paintings of these objects: a plum blossom painting by

Xin Qi (see Figure 3) and a lotus painting by Zhang Zhi Yue in the style of Zhang Daqian (see Figure 4) [4-5]. Both are painted in the *xieyi* style and are detailed in Section 3.2.1 and 3.2.2 respectively. The analyses will also reference other paintings for examples of variation.



Figure 3: Plum blossom painting in the *xieyi* style by Xin Qi [5].



Figure 4: Lotus painting in the xieyi style by Zhang Zhi Yue [4].

3.2.1 Plum Blossom

Beginning with this painting of plum blossoms by Xin Qi, this analysis will use the categories listed in Section 3.2 as guidelines for identifying important characteristics of the painting (see Figure 5).



Figure 5: Visual analysis of a plum blossom painting by Xin Qi [5].

In this painting, Xin Qi uses two techniques to communicate depth. The first is the use of different values (the degree of lightness or darkness in a color [10]) where the artist paints the foreground objects with darker colors while receding objects are painted with lighter colors. This gives the painting a sense of atmospheric depth, an occurrence in nature where the air itself makes faraway objects appear lighter. The second technique is the use of varying ratios of ink to water in the brushstrokes. Objects in the foreground use more concentrated ink and for certain areas, a drier brush. In the background, brushstrokes contain more water which not only makes the value lighter, but also creates more bleed around the stroke. This has the effect of giving the background objects a blurry, out-of-focus appearance.

The type of brushstroke used is another important characteristic of this painting. For the branches, a brush with black and brown ink is used to create jagged rough strokes. Depending on the speed and dryness of the brush, this can leave streaks of white known as *feibai*, or “flying white” [11]. The placement of the strokes begins with the larger base of the branch and continues with smaller branches and twigs in a balanced arrangement. The younger twigs are rendered as mostly straight lines in contrast to the older branches’ twisted forms. Black dots are painted along the branches representing leaf buds, and are used to give an organic, lively quality to the painting. They also anchor the flowers to their wood base.

The artist paints the blossoms with red ink loaded onto the brush in varying degrees of saturation, creating a gradient effect when applied to the paper and adding dimension to the petals. The actual flowers are painted with up to five round strokes per flower, one for each petal. Large groups of flowers are clumped together and single blooms are scattered

along the branches. The stamens of the flowers are painted in black ink with a fine brush. It is also common to use highly saturated yellow or white paint for this style (see Figure 6).



Figure 6: Plum blossom painting by Hwa Qing demonstrating the use of yellow paint in flower stamens [6].

The overall composition maintains a liberal amount of white space. The branch starts at the edge of the painting, seeming to grow from an unseen origin into the negative space of the painting. The artist balances the composition by using bright areas of color to offset the large dark masses.

From this visual analysis of the plum blossom painting, key characteristics have been identified and are listed as follows:

- Content: plum blossoms and branches
- Color value and water-to-ink ratios to communicate depth
- Type of brushstroke used to define form and color
- Effective use of white space and balance of objects to create an appealing composition.

3.2.2 Lotus

In this visual analysis of a lotus painting by Zhang Zhi Yue, we will be looking at the same characteristic qualities as those of the plum blossom paintings (see Figure 7). This painting, like Qi's plum blossom, uses the same two methods to communicate depth: brightness value and water-to-ink ratio. The background leaves are painted with a very wet brush with a low ink concentration giving them the appearance of being far away. The foreground elements are highly saturated with ink making them more prominent.



Figure 7: Visual analysis of a lotus painting by Zhang Zhi Yue [4].

The types of brushstrokes used in this painting are varied depending on the object. Thick, sweeping strokes of black ink are used to shape the leaves (blue or green hues are often used as well). Depending on the angle and age of the leaf, the culmination of a group of strokes can take on many shapes, including semi-circles, circles, bell-shapes or more nebulous forms (see Figure 8 for more examples of leaf shapes). Small black dots are painted along the stems of both the leaves and flowers. Very dry, thin strokes are used to create tall grasses.

The lotus flower is painted using an outline method in which the silhouettes of the petals are drawn with a fine brush. The ink color of the outlines is darker than the fill color, which is gently applied in pink along the outer face of the petals. The inner face of the petals are kept white or allowed a small amount of pink bleed.

The carpellary receptacle of the flower (the center seed pod surrounded by many small stamens [12]) is obscured in this painting, however it is typically painted using the same style as the flower petals but using a yellow or green fill color. The stamens of the flower are clearly visible. Here, the artist has drawn them using a combination of deep red and yellow ink with a fine brush. For another example of how a lotus flower core can be painted, see Figure 8.

Both paintings share a characteristic that is common with many traditional Chinese paintings, which is the absence of a light source. Because of this, objects in these paintings rely on the brushstroke technique to give them dimension and shape.



Figure 8: Lotus painting by Yi Ren demonstrating different leaf and flower styles [1].

From this visual analysis of Yue's lotus painting, we can identify similar key characteristics that were found in the plum blossom painting analysis:

- Content: Lotus leaves, lotus flowers and dry grass
- Color value and water-to-ink ratios to communicate depth
- Type of stroke used to define form and color
- Balance of objects to create an appealing composition.

3.3 Implementation

Once a list of characteristics is established, the next step is determining which set of digital techniques will be needed to apply the aesthetic of our selected Chinese painting objects in 3D. The implementation process involves six steps:

- Modeling and generating geometry
- Applying shading techniques and styles
- Camera Layout
- Rendering
- Post-processing

Typically lighting is a necessary step in the production process, however due to the nature of the Chinese painting aesthetic, alternative methods to lighting are used and are detailed in the shading and post-processing sections. The majority of the final animation is constructed using Autodesk Maya [13], a program that allows the user to interactively build objects, apply shaders, animate and render a scene in 3D. Other software used in the shading,

rendering and post-processing stages include Renderman, Adobe Photoshop and Adobe After Effects [14-16].

3.3.1 Modeling and Generating Geometry

Creating models for the animation partially fulfills the formal content and composition characteristics determined by the visual analysis in Section 3.2. Two methods were used to create these models: polygons and Maya Paint Effects.

Maya's polygon modeling tools were used to create geometry for the plum branch, lotus leaves and lotus flowers. Polygon modeling involves arranging a set of connecting faces (planes made up of at least three vertices) into a desired form to which shading can be applied. Pixar Renderman's Subdivision Attributes were applied to each polygonal model to give them a smoothed appearance [14]. The Subdivision Surface Attribute, derived from the Catmull-Clark subdivision scheme, works by subdividing the polygon face recursively based on the curvature of the mesh and camera distance to approximate a completely smooth surface (known as the "limit" surface) [17]. This method, performed at render time, is very efficient for creating smooth-looking models because it uses the minimum number of subdivisions needed to approximate a smooth surface for each face based on its distance from the camera. Since areas with less curvature require fewer subdivisions, this scheme is much more efficient than a simple smooth, which divides all polygonal faces an equal number of times regardless of their curvature (see Figure 9 for a visual comparison).

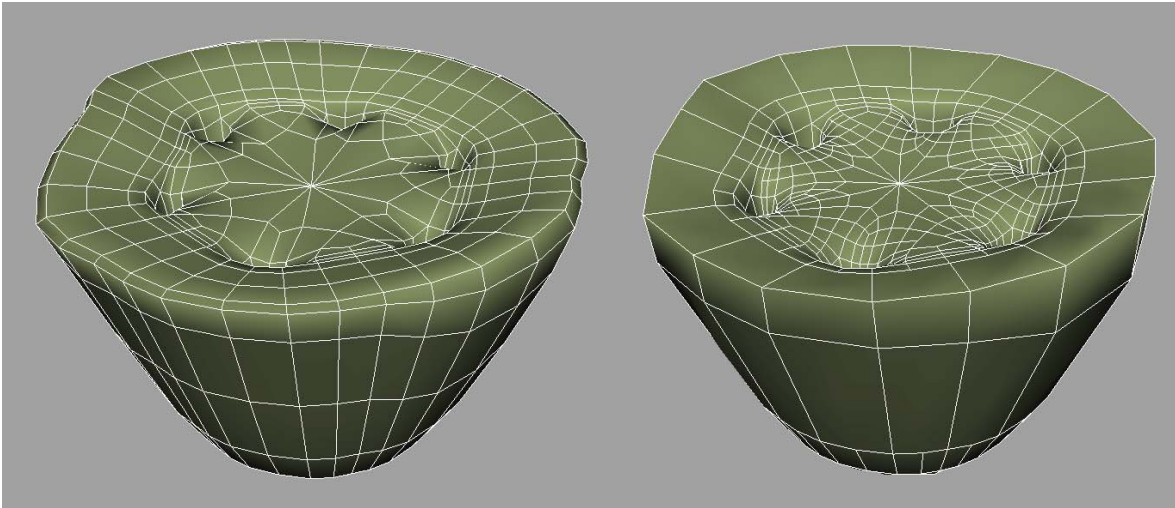


Figure 9: Visual representation of a smoothing scheme (left) and a subdivision scheme (right) applied to a polygon model.

Figure 10 shows the models that were constructed using polygonal modeling tools. The model of the plum branch consists of several cylindrical-based shapes varying in width and length and grouped together in an organic formation. The lotus leaves are composed of a series of panels in order to give more flexibility and variety when duplicated. The lotus flower was modeled starting with a thin petal, which was duplicated and arranged in an array around the carpellary receptacle, which is modeled as a single piece in the center.



Figure 10: Polygon models of the plum branch (top), lotus leaf (left) and lotus flower (right).

To generate the plum blossoms, lotus flower stamen, grass, and black dots on both the plum branches and the lotus stems, Maya Paint Effects was used. This tool contains a series of scripts written in Maya Embedded Language (MEL) and is highly customizable [13]. The tool allows for the creation of both 2D painted surfaces and 3D geometry. In this study, the 3D tool was used. The tool works by allowing the user to drag a brush along a surface creating a path from which “tubes” will be generated. Tubes are 3D geometry that sprout from the painted curve into 3D space and whose shape can be defined by five

different growth patterns. These patterns are branches, twigs, leaves, flowers and buds (see Figure 11). For the plum blossoms, twigs, flowers and buds were used to create five-petal flowers with a circular array of stamen. The stamens of the lotus were created using branches and buds with varying degrees of twist. The grasses were shaped using very thin branches and twigs with wide variations in height. The black dots were created without any added growth patterns, and were simply defined as very short black tubes. Before being shaded, the Paint Effects must be converted into polygons in order to apply necessary subdivision schemes and to facilitate texture mapping (detailed in Section 3.3.2).

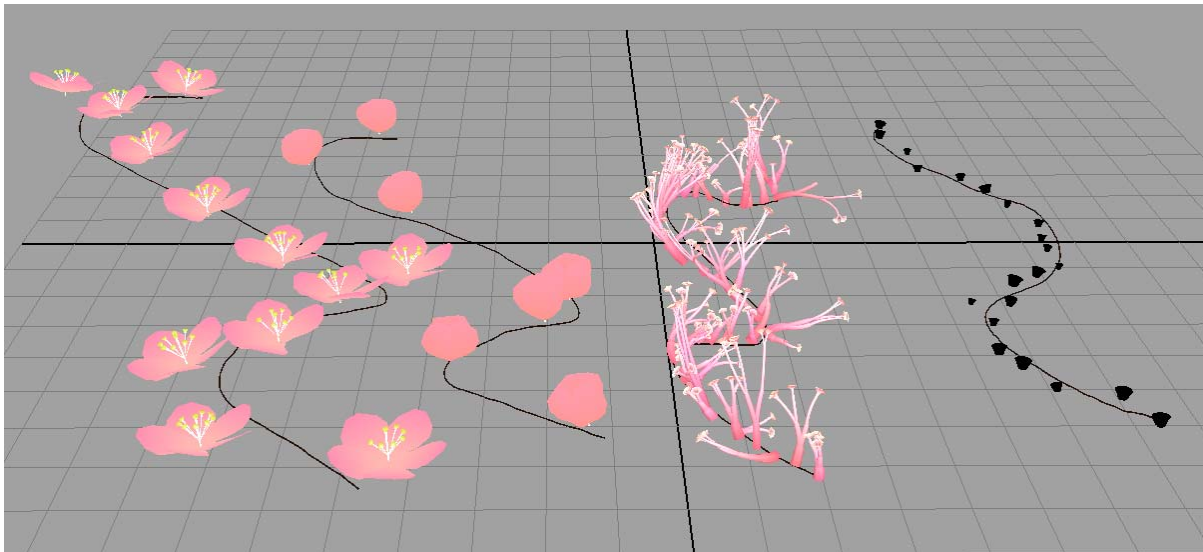


Figure 11: Screenshot of plum blossom, lotus flower stamen and black dot Paint Effects tools (curve drawn in black).

3.3.2 Shading Techniques and Styles

The appearance of a surface and how it reacts to light is defined by its “shading”, and how light is absorbed, reflected or emitted is determined in computer graphics by a “shader” [18]. A basic shader may have attributes such as diffuse color, transparency, incandescence or specularly (reflected light that creates highlights). Based on the brushstroke characteristics identified in the visual analysis of the plum blossom and lotus paintings, this is the best method for employing the aesthetic of those characteristics because of the image mapping versatility that shading offers. In this study, two shading methods were used for the objects in the scene: texture mapping and procedural coding.

The basic principle behind texture mapping is using 2D image files to determine the values of the attributes they are assigned to. A simplified way of visualizing texture mapping is applying a decal to the surface of an object [19].

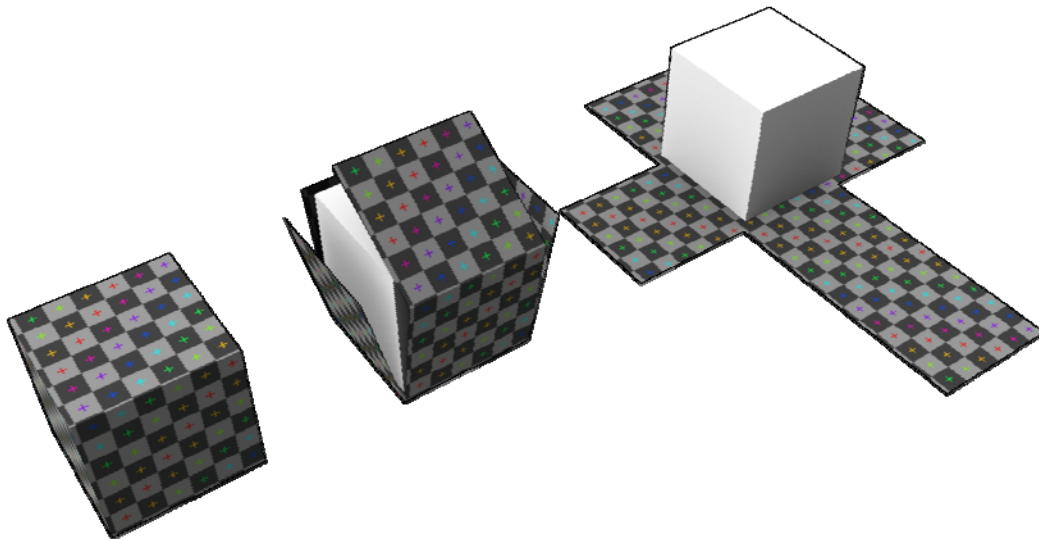


Figure 12: Visual representation of the UV unwrapping process [2].

To facilitate texture mapping, we must begin with a process called UV unwrapping, which is the process of projecting the surface of a 3D model into a 2D space (see Figure 12) [2]. Once a 2D representation of the model's surface is created, it can be exported as an image and brought into an imaging software such as Adobe Photoshop [15]. Here, it can be used as reference to create texture maps that can then be projected back onto the model in 3D space.

Maya's UV mapping tools as well as a script called "Pelting tools" were used to unwrap the objects created during the modeling process [20]. Each object's UV coordinates were exported for reference as an image file (see Figure 13 for an example of exported UV coordinates). This step is crucial to the success of the texture mapping process; if it is not done properly, the map will be difficult to create and might not align to the model in a reliable way.

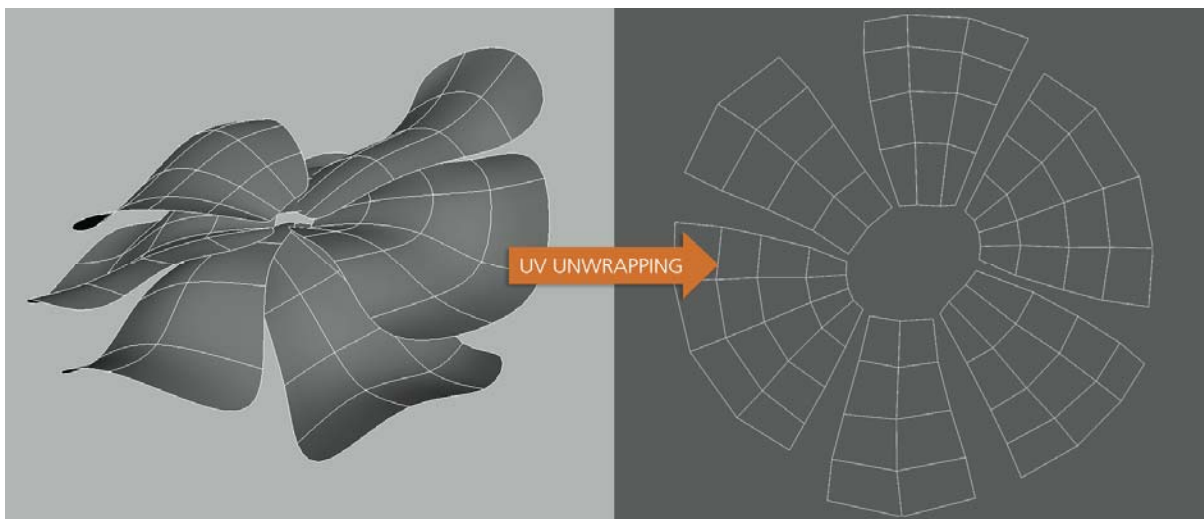


Figure 13: Exported image as a result of the UV unwrapping process applied to the lotus leaf model.

Three types of texture maps were created for each object in the scene: color, transparency and displacement maps. To create the color maps, hand-painted brushstrokes created with ink on rice paper were imported digitally using a flatbed scanner and brought into Photoshop (see Figure 14). Using the exported UV coordinates as a guide, the brushstrokes were transformed, warped and arranged within the bounds of the unwrapped polygons (see Figure 15). Photoshop can also be employed for a variety of functions useful to the texture map-creation process such as changing color hues, increasing contrast, desaturating and adding blur.



Figure 14: Scanned digital image of hand-painted lotus leaf brushstrokes created with ink on rice paper.

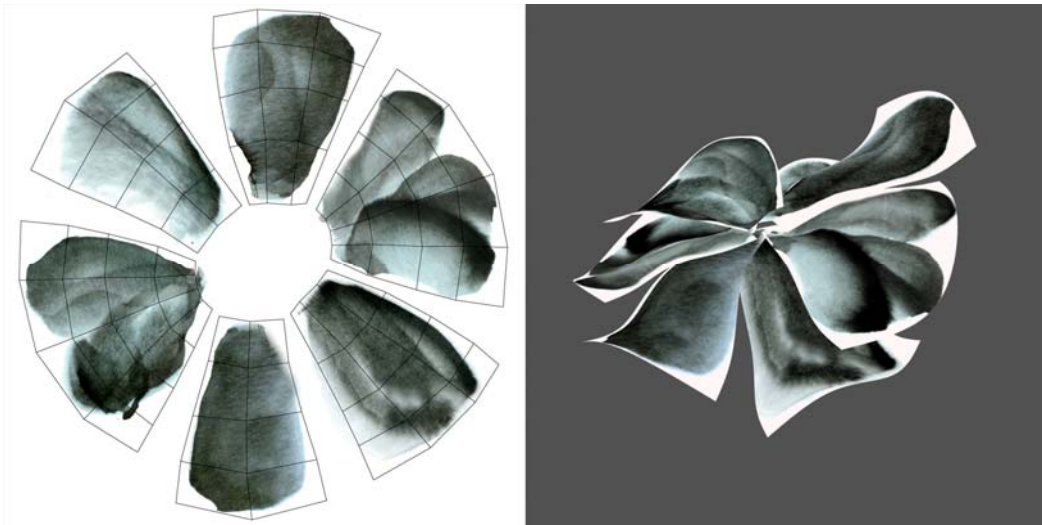


Figure 15: Lotus leaf color map created using scanned images. Texture map with UV coordinates overlaid as a guide (left). Color map mapped onto lotus leaf model (right).

A transparency map was also created using the color map. The purpose of a transparency map in a shader is to define the amount of transparency on a surface based on the gray values of the map [21]. For instance, a gray value of 100% (black) would be completely transparent, while a value of 0% (white) would be opaque. These maps are useful for giving objects an exactly defined outline; in this case it is the edge of the brushstrokes on the lotus leaves. By using middle-gray colors, the map can also give the edges a fuzzy appearance, causing it to resemble an ink bleed (see Figure 16).

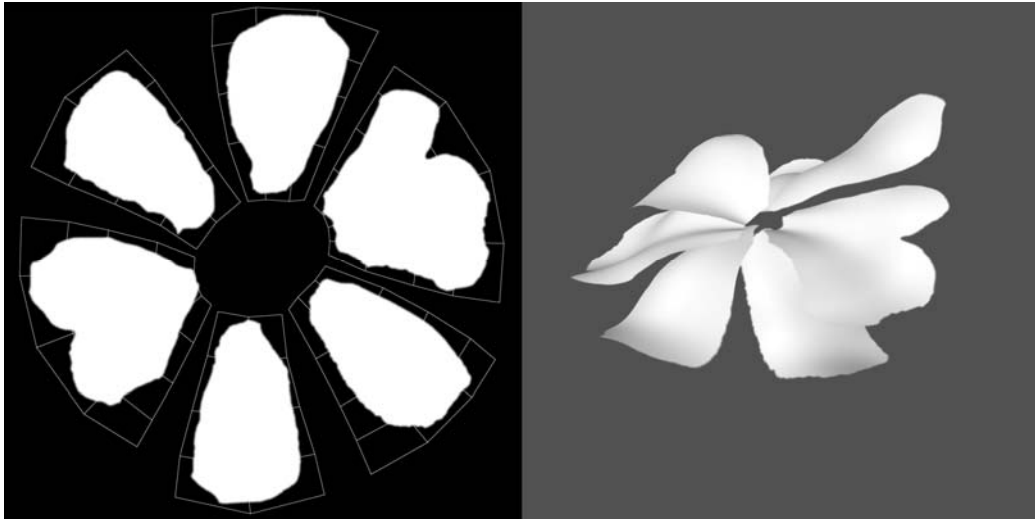


Figure 16: Lotus leaf transparency map (left). White areas will be opaque while black areas will be transparent. UV coordinates are overlaid on map as a guide. Transparency map mapped onto lotus leaf model (right).

The third type of map used in this process is a displacement map, which is a map that modifies the surface of the object and is useful for adding fine detail [21]. Like the transparency map, it is composed of gray values that move the geometry in a positive or negative direction. In the case of displacement maps, 50% gray causes no displacement while a higher percentage causes a negative displacement and a lower percentage results in a positive displacement. The effect of a displacement map is most obvious with some type of lighting in the scene, however because this study does not use any lighting, the purpose of the displacement map is to give extra shape and dimension to the shaded objects (see Figure 17).

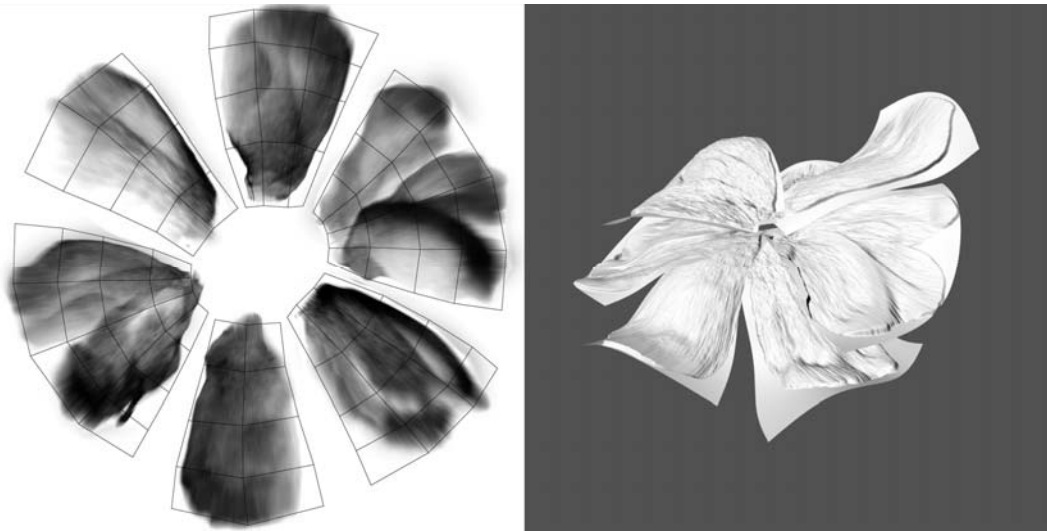


Figure 17: Lotus leaf displacement map (left). White areas will displace in the positive direction while black areas will displace in the negative direction. UV coordinates are overlaid on map as a guide. Displacement map mapped on to lotus leaf model (right).

Once the appropriate texture maps have been created, Renderman's shader network-building program called "Slim" is used to compile them into a working shader that can be applied to objects in the scene [14]. To begin, a "Delux" node is used to add transparency, and incandescent attributes to the shader. By inputting the color maps created earlier into the incandescent attributes (rather than a diffuse color attribute, which is most common), we create a shader that emits light in the pattern of the color map rather than receiving and reflecting light. The reason for using this technique is to emulate the aesthetic of a Chinese painting by using purely the brushstroke images to shape and shade the models in the scene, thus eliminated the need for a light source.

A Displacement node is also added to the network, into which the displacement map is inputted. In this node we can control the overall displacement as well as the positive and

negative displacement amounts. Once the Delux and Displacement nodes are combined into an Ensemble node, they can be added to the scene and applied to the models. This network structure was used to create shaders for all models in the scene with the exception of the lotus flower petals, which were shaded using a procedural shader. Figure 18 shows an example of the shading network constructed in Slim.

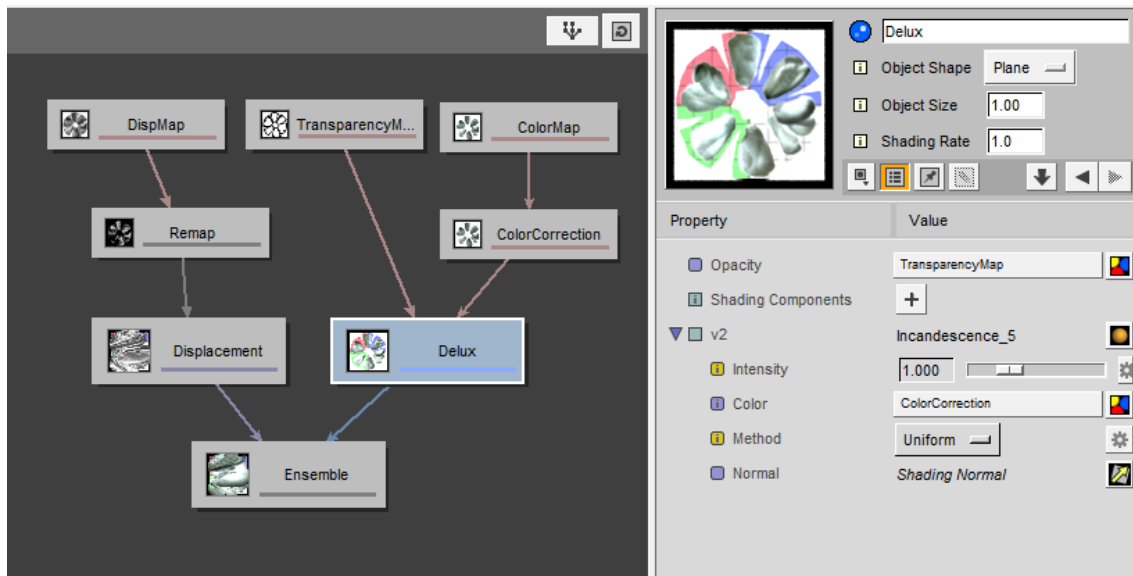


Figure 18: Slim shading network for a lotus leaf (left). Attributes for Delux node (right).

The objects created using Paint Effects had Maya's default shading applied, however it was not suitable for the Chinese painting style being recreated. By converting them into polygons, modifying the UV coordinates slightly, and applying texture maps, the desired look was achieved (see Figure 19).

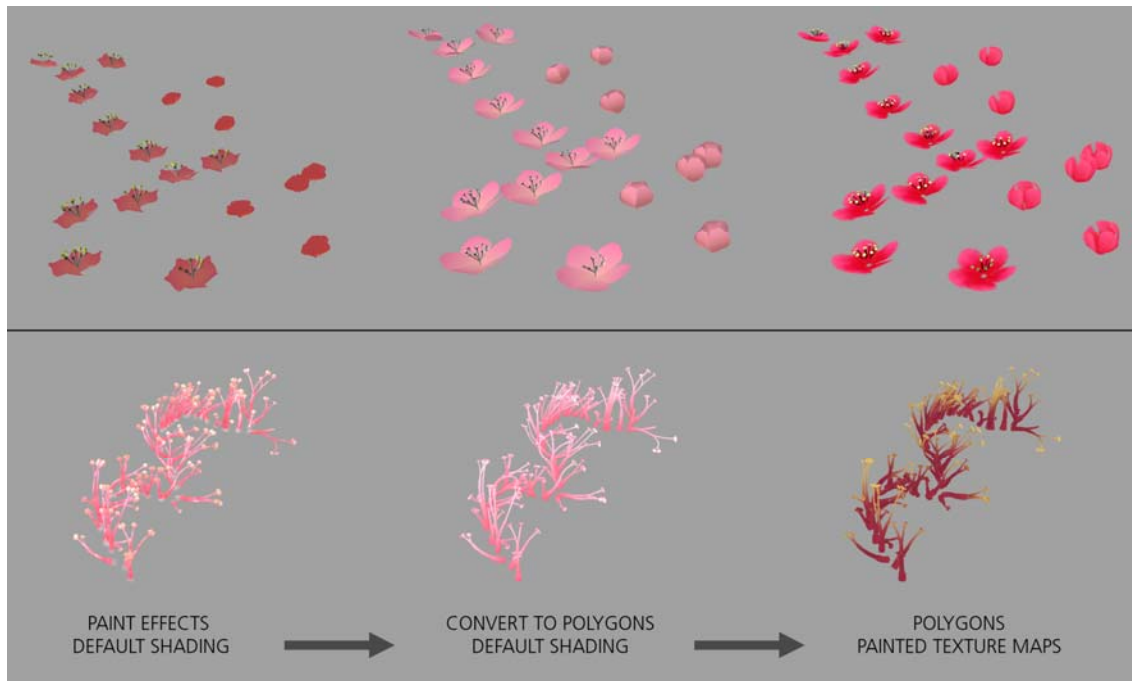


Figure 19: Process for shading objects created with Paint Effects. Plum blossom flowers (top) and lotus flower stamen (bottom).

The procedural shader was written in a C-based programming code called Renderman Shading Language (RSL), and is used to create the outline style of the lotus flower petals [22]. This shader is based on a non-photorealistic (NPR) cel-shader (also known as a “toon” shader) created by Larry Gritz, which is used to give 3D objects the look of a 2D cel-painted animation [19]. It does this by reducing the object’s color range and creating outlines around its edges (see Figure 20).

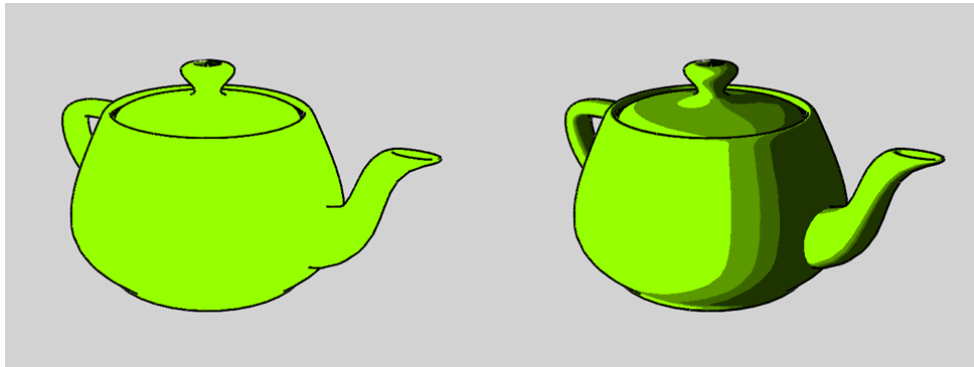


Figure 20: Two examples of NPR cel-shading applied to teapot models: single color (left) and four-color (right) [3].

Beginning with the input variables, the shader created for the lotus petals in this study allows the user to define a color map, transparency map, map flip direction, outline thickness, outline color, outline transparency, outline edge fuzz (noise) and amount of blend between the outline and texture maps. Using the concept of the outline formula from Gritz's cel shader, an outline was created for the lotus petals by calculating the angle between the camera and each face normal and drawing a line where that angle fell within the range of an angle defined by the variable "outlinethickness". This angle is passed into a filterwidth() function which reduces any antialiasing (also called "jaggies") that might occur on the edges [22]. The outline edge is softened and given a more organic look by adding a noise filter which is applied in the range between the non-outlined angle and outlined angle.

Additionally, outline opacity determined by the user is calculated and mixed with the color of the outline, which is then mixed with the color and transparency maps. Illumination loops (functions that calculate how the surface reacts to light) were not used in this shader since, by excluding them, the shader takes on default shading properties similar to incandescence. Figure 21 shows the final shader on a sphere and the lotus flower model.



Figure 21: Final procedural RSL lotus flower shader applied to sphere (left) and lotus flower model (right).

3.3.3 Camera Motion and Depth of Field

An essential digital tool used to represent the compositional elements of Chinese paintings is the camera. In this study, a perspective camera is used as the “frame” for composing the elements in the scene and by carefully doing so, the final animation can be paused at key points and appear to follow the characteristics of *xieyi* Chinese painting composition. In other words, the resulting still image should look like a 2D painting.

Implementing depth of field (DOF) in the camera addresses one of the characteristics from the visual analyses in Section 3.2, which is the use of watery brushstrokes to depict background objects. DOF in Maya is similar to depth of field used in traditional photography. By setting a smaller f-stop (or aperture), objects in front or behind the focal distance appear blurrier. This is a good way to imitate the “bleed” effect created from watery brushstrokes used in Chinese painting background elements (see Figure 22).

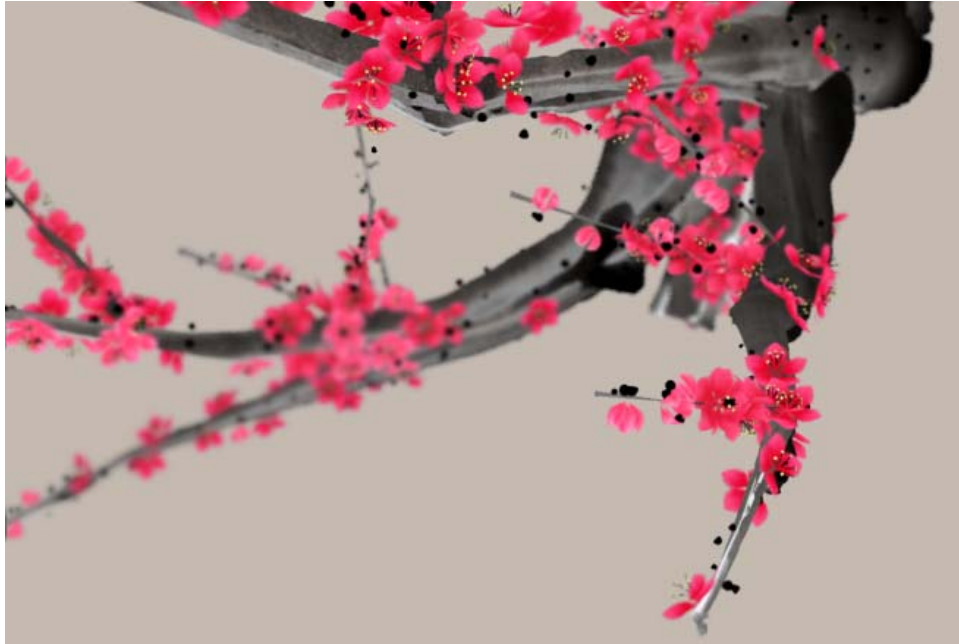


Figure 22: A still frame from the final animation demonstrating depth of field.

In addition to using the camera's DOF, this study also takes advantage of a characteristic of 3D cameras not found in traditional Chinese paintings: parallax through camera motion. The purpose of including this feature is to marry the traditional Chinese painting method of communicating depth with a common digital 3D method. In this study, the camera is animated in 3D space around the stationary objects in the scene. This adds parallax, which occurs when a line of sight is in motion causing foreground objects to appear to move faster than background objects [23]. This is a natural way for viewers to perceive depth and judge the spatial distances of objects from one another. Including an animated camera clearly highlights the richness of the constructed scene from many points of view and further unites the traditional and digital mediums.

3.3.4 Rendering

Once the camera motion is established, rendering processes all of the models, shaders, lighting, and motion into a 2D image file. For this study, Pixar's Renderman software is used to create an image sequence that will later be composited into a final video. For this particular study, Renderman handles the subdivision schemes, shading compilation, depth of field and motion blur at render time.

The rendering stage is also the appropriate time to create a z-depth pass, which is a grayscale map that shades the objects in the scene depending on their distance from the camera. To do this, a MEL script by Bohdon Sayre was used to create new shaders in the scene that would change color based on their z-depth [24]. This script is especially useful because it preserves the displacement maps used with each shader and is compatible with Renderman (transparency maps did have to be reapplied, however). Figure 23 shows a z-

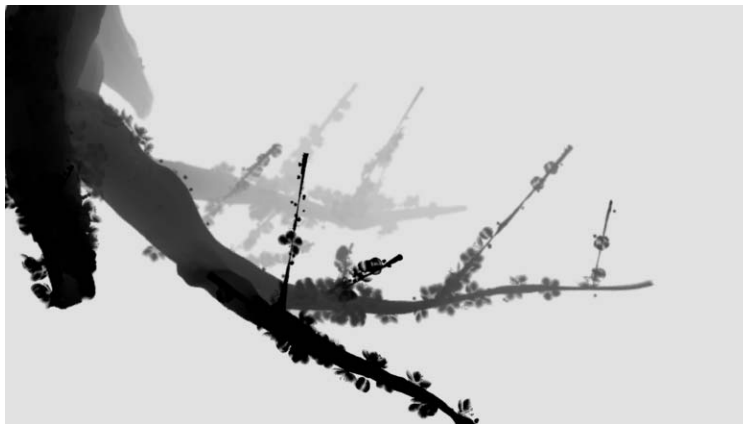


Figure 23: Example of a z-depth pass that will be used as a mask in post-processing.

depth pass of the plum blossoms. The same camera used to render the color pass is also used to render the z-depth pass as an image sequence for use in the post-processing stage. The

purpose of this pass is to create the illusion of volumetric fog in the scene, giving it an even greater sense of depth (details of this process are given in Section 3.3.5). When applied as a mask, objects in the background will appear to have a lighter value while objects in the foreground remain darker. This fulfills the value characteristic of Chinese paintings used to signify depth, which was established in the visual analysis.

3.3.5 Post-Processing

This stage deals with the raw images produced by Maya and Renderman and combines them to create the final animation. In this study, the post-processing stage involves paint-fix, blending modes, color correction and adding volumetric fog.

When rendering texture maps with Renderman, it is inevitable that small artifacts will occur on random frames. In order to correct these anomalies, rendered frames are taken into Photoshop and painted to match adjacent frames in a process called “paint-fix” (see Figure 24). Though the process can be tedious, it is necessary to ensure that no distracting flickering occurs during the animation. In this study, the renderer proved to have the most difficulty with the plum blossom branches due to the large amount of displacement applied to their surfaces.

Once all of the color and z-depth frames have been paint-fixed, they are imported into Adobe After Effects, a motion graphics and compositing software [16]. Here, the frames are sequenced together to create a continuous animation. In traditional Chinese painting, rice paper is typically pure white and has a very fine fibrous texture. For this study, a paper-like background is placed behind the frames to emulate this texture, but



Figure 24: Example of a paint-fix done in Photoshop to eliminate rendering artifacts. Before (left) and after (right).

because the medium is digital rather than tangible, the fibrous nature and color of the image is exaggerated to symbolize the physical medium.

A blending mode called “multiply” was applied to the color image sequence. This function blends the image sequence with background by multiplying the two numerical color values together, giving the illusion of paint being applied directly to paper (see Figure 25).



Figure 25: Normal mode (left) and multiply blending mode (right).

Volumetric fog is added using the z-depth pass that was rendered in the previous step. To do this, a single color layer is added on top of the existing color render (this is the color of the “fog”). The z-depth pass is then applied to the layer as a mask. This means that the darker areas of the mask block out the color in the single color layer, while the brighter areas of the mask allow more color to show. The resulting image shows foreground elements with their normal value, while receding elements become increasingly obscured by the color layer (see Figure 26). This process is done to emulate the technique used in Chinese painting of representing depth through change in values.



Figure 26: Z-depth pass applied as a mask to a gray color on top of a color render. Color render only (left), color render with z-depth mask (right).

4. CONCLUSION

4.1 Results

The results of this research include a short 55-second animation that combines two different mediums: Chinese painting and 3D computer graphics. The animation shows imagery of both the plum blossom as well as the lotus, both of which are derived from the *xieyi* Chinese painting aesthetic. By recreating this art style in 3D, we are able to explore Chinese painting in a third dimension as well as the fourth dimension of time. We can also introduce different methods of portraying depth through camera movement and parallax provided by the native 3D camera. Figures 27 through 30 show still frames from the final animation. Accompanying this thesis is a movie file (file name: FINAL_lores_h264.mov) that contains the 55-second animation described above as well as title cards at the beginning and end of the sequence giving the title and author of this thesis.



Figure 27: Frame number 190 from the final animation.



Figure 28: Frame number 644 from the final animation.

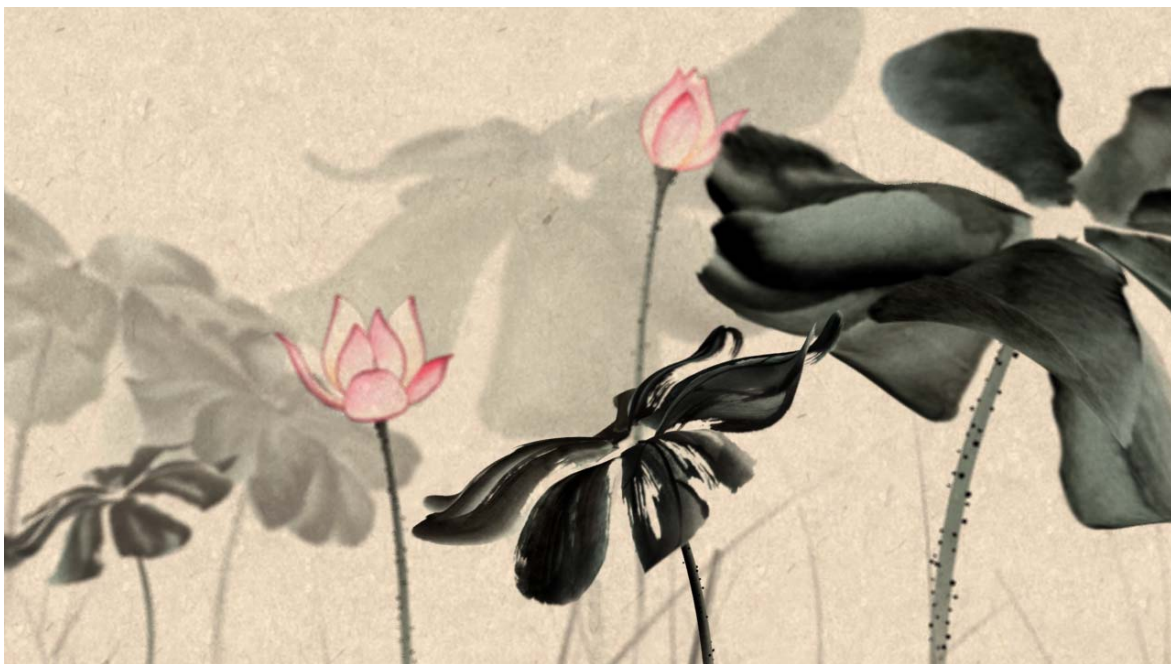


Figure 29: Frame number 825 from the final animation.



Figure 30: Frame number 1160 from the final animation.

4.2 Evaluation

Judging from paintings used as reference in this research as well as the results of the visual analysis, the results of the short animation are very good. The imagery has many qualities of the Chinese painting aesthetic which is explored in the third and fourth dimensions. The content is recognizable, the brushstrokes are natural and painterly, the composition is appealing, and depth is achieved not only through changes in value, but also through the use of another dimension.

Because of the limitations of the 3D medium, the animation seems to lack some of the spontaneity and vitality that is at the heart of the Chinese painting tradition. The reason for this may be that the forms created by the brushstrokes—when painted in 2D—leave

much to the imagination of the viewer. However when the view is moved around the objects, the forms are much more literal and rigid, and do not allow for much interpretation.

4.3 Future Work

The previous section discussed the lack of spontaneity and vitality in the final animation. A solution to this might be to implement an animation simulation where the objects in the scene interact with a natural force such as wind or water. One could also explore the use of animated characters in a similar scene with an emphasis on their realistic and natural movement appropriate to the Chinese painting aesthetic.

The methodology in this research provides a versatile approach to combining a 2D medium with a 3D medium. This can be used on any number of art genres in order to be able to explore them in a new dimension. The element of time also provides an interesting aspect to work with as far as expanding the 2D subjects into more than a single scene frozen in a moment.

The notion of “accidentalism” is unique when it comes to 3D computer graphics. With a medium such as Chinese painting, accidentalism can refer to the bleed of the ink, random ink spots, or the *fei ba* effect created by a fast-moving brush. These are incidents over which the artist has little or no control, but which are welcome occurrences that add to the painting rather than detract from it. However, while in 3D computer graphics accidents are rarely (and more likely never) desired, there are many accidents in this medium which would make interesting artistic studies if they were accepted and emphasized, such as jitter, rendering artifacts, and simulations gone awry. By capitalizing on the defects that occur while using

3D computer graphic tools, perhaps a new art medium can emerge from what is primarily considered a mathematical tool.

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