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Generating Method of Planting Map for Three-Dimensional Rice Field Painting Based on Fixed Point Perspective

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Abstract: *There is a certain technical threshold for transferring the design drawing of fixed-point perspective three-dimensional rice field painting to planting drawing. This threshold hinders the promotion of rice field painting in cost sensitive areas. By analyzing the imaging principle and technical difficulties of rice field painting, according to the working principle of optical and visual imaging, the process of light and shadow projection of design pattern onto the ground is simulated by computer software, and the ground projection map is calculated. The projection map can be transformed into planting map, which greatly reduces the production time and difficulty of planting map.*

Keywords: *Three-dimensional rice field painting; Fixed point perspective; Planting map; Manufacturing method*

1. Introduction

Rice field painting is a form of agricultural landscaping art that originated in Japan. With the land as the "canvas" and the rice as the "paint", planters plant different varieties and colors of rice in the rice fields to form specific patterns or words, forming a highly visually impactful leisure and tourism agricultural landscape. With the continuous promotion of rural revitalization strategy, one of the main representatives of creative agricultural cultivation is rice paddy painting, which has received more and more attention from agricultural institutions and large households around the world [1].

Rice field painting is a combination of traditional agriculture and painting that can attract many audiences with its novel form and unique creation. This art form effectively integrates the primary industry with the tertiary one and has become an effective measure to promote the transformation of agricultural areas into scenic areas, as well as a common landscape means for rural revitalization. Since 2010, rice field paintings have been introduced into China and have mushroomed all over China. Rice field painting has a positive role in promoting the development of tourism agriculture and rural tourism, and shows a rapid development trend [2].

The author noticed in the practice of rice field painting in one place that the planters are often farm workers. The problem is not the color separation planting, but the fact that the target blueprint is often difficult to translate into a planting map to guide implementation. For this problem, Wang Xiaoguang of the College of Agriculture of Yunnan University introduced a two-dimensional pattern design method that can only be applied to one point of perspective in his paper “Rice Field Painting Design and Field Production” [3], which uses the principle of large near and small far, and cannot realize the three-dimensional effect of "so realistic they jump off the paper", nor can it adapt to the design needs of multiple patterns from multiple angles. In the article "Simple Techniques for Making Rice Field Paintings", Wu Qiang suggested using the " square block " grid positioning method [4]. This method actually belongs to the grid subdivision method, in which the grower needs to draw the perspective pattern 1:1 in the subdivision grid of the rice field. This method is complicated and not very practical for complex patterns. The rest of the scholars either avoided the issue or did not talk about it in detail. This paper then explores a simple method of generating planting maps by analyzing and utilizing the imaging mechanism, taking the paradox that planting maps are difficult to design during the implementation of rice field painting as a point of breakthrough. In order to promote them and thus the popularity of rice field painting.

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2. Technical difficulties in the transformation of rice field painting planting maps

Small-scale rice field paintings are usually more than ten meters square, while large-scale rice field paintings can be several hundred meters square, such as the rice field painting patterns in the Rice field painting pattern of Park Daomengkongjian in Xinglongtai Xibo Town, Shenbei New District, Shenyang City(Figure 1)[5]. Such a huge scale requires the viewer to view it from a high altitude. At present, there are two main ways to view rice paddy paintings: one is for viewers to climb to a high platform of more than ten meters or even dozens of meters for viewing; the other is for direct viewing through human-carrying aircraft or indirect viewing through aerial photography by drones. Since the second way is not only costly and not direct, but also limited in the number and length of viewers, most organizers of rice field paintings will choose the first way to view, i.e. high platform viewing. A high platform is built at the edge of the rice field painting, and the viewer climbs up to the platform to see the painting from a high position. Since the position and height of the platform are fixed, the viewpoint is also fixed with the specific rice field painting, so it is a fixed point of view. Due to the fixed point of view, the pattern of rice field painting without perspective processing will appear to be distorted near large and far small, and the viewing effect is not good and lacks three-dimensional effect. In order to avoid such a situation, we need to pre-treat the pattern with perspective distortion, and the processed rice field painting is often referred to as three-dimensional rice field painting, where the viewer sees the pattern without perspective distortion, as if the three-dimensional pattern jumps on the rice field. The train-patterned rice field painting that appears in the last story of the 2020 hit movie "My Hometown and I" is an example of a three-dimensional rice field painting viewed from a fixed point of view.

Source: Figure 1 is cited from reference [5]

Figure 1: Rice field painting pattern of Park Daomengkongjian in Xinglongtai Xibo Town, Shenbei New District, Shenyang City[5]

At present, the design and implementation of three-dimensional rice field painting with a fixed point of view requires basic steps such as pattern design, design drawing to planting drawing, vectorized pointing and staking out and manual coloring. The two steps of the implementation stage, vector legal pointing and staking out the lines and manual coloring, can be done by ordinary villagers with simple training, and Wu Qiang has described the planting method of rice field painting in detail in his article [4]. The two steps of the design phase, pattern design and design drawing to planting drawing, require the use of perspective principles and the necessary 3D technology in order to achieve. Due to the complexity of the technology and the need for operators to have a basic knowledge of geometry and spatial mapping, the design and implementation of similar rice field paintings are currently mainly done by commercial companies that possess the relevant technology. Due to the technology, the participation of villagers who grow rice is low, which in turn leads to high costs and is not conducive to the popularity and development of rice field painting.

To solve this technical problem, it is necessary to explore a simple method of making a three-dimensional rice field painting planting map based on a fixed point of view to fill the gap in the method level at this application point.

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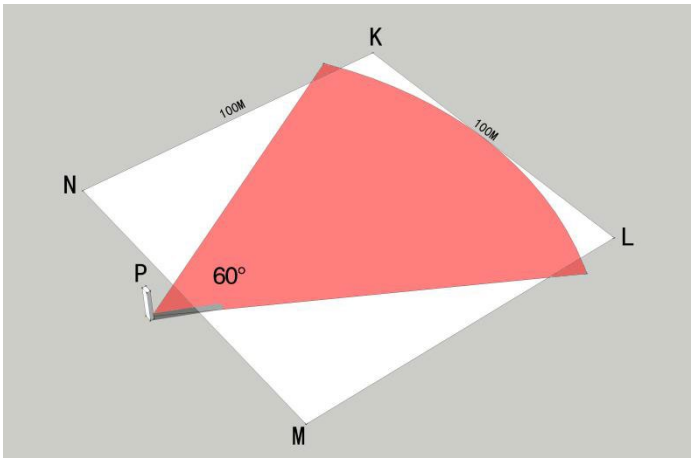
3. The imaging principle of rice field painting

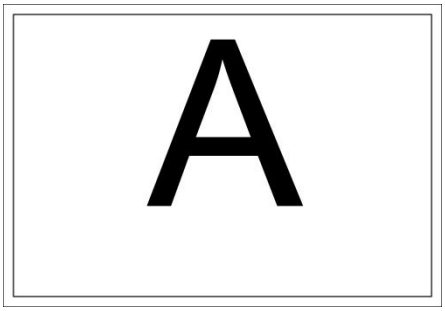
First, we need to analyze the imaging principle of rice field painting. In order to illustrate the imaging principle, we first abstract the scene of fixed-point one-way observation of rice field painting as a simple space environment for simulation. Outside the midpoint of the NM side of a 100mx100m square field KLMN, a 10m high observation point P is set up, and the sector-shaped area in the figure illustrates the 60-degree view range directly in front of the observer. The square field is equivalent to the rice field planting surface, and point P is equivalent to the observation point on the high platform. The viewer is on a single side of the rice paddy painting, which is one of the simplest viewing modes of rice field painting (Figure 2).



Source: Figures 2 is self-photographed or self-drawn by the authors.

Figure 2: Computer simulation scene of fixed-point observation of rice field painting

In order to simplify the simulation, we set a "letter A" as the content of the rice paddy image, and the font of the "letter A" is "Arial", which comes with the Microsoft computer operating system. ". We then set the goal for the observer to see the actual paddy field image as the "letter A" without perspective distortion as shown in Figure 3.



Source: Figures 3 is self-photographed or self-drawn by the authors.

Figure 3: Set a "letter A" as the image content of rice field painting

In order to allow the observer at point P to see the image on the high platform as in Figure 3, according to the principle of perspective, the corresponding image on the field should be the pattern shown in Figure 4. It can be seen that the "letter A" on the field has been deformed because it has to offset the perspective deformation of large near and small far. The height of "letter A" in the original image is d and the top width is a. The height of "letter A" after deformation is 7d and the top width becomes 3.6a, while the bottom width remains the same. This means that the pattern is not only stretched several times in the direction of the line of sight, but also widened in the horizontal direction. The farther the distance from the observer, the greater the width is.

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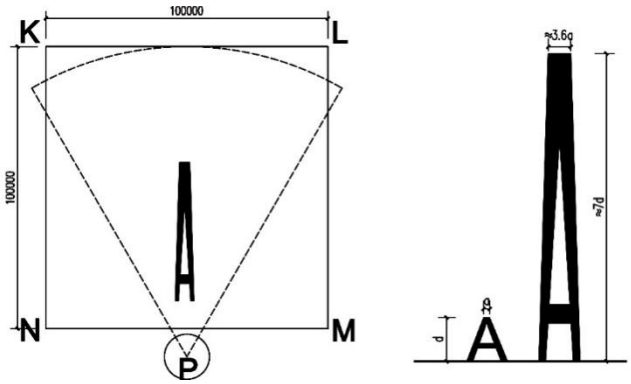

Source: Figures 4 is self-photographed or self-drawn by the authors.

Figure 4: The change of plane form of "letter a" and deformation comparison

In the above scene, the height of the view point is 10m, and the height difference between the seen image and the actual image on the site is up to 7 times. The comparison of this abstract scene reveals that there is a certain amount of distortion between the design pattern and the actual pattern planted on the site because of perspective. It is easy to imagine that this amount of distortion is related to the height of the viewer, the higher the height, the smaller the amount of distortion, and conversely, the larger the amount. The "letter A" in the scene without deformation is equivalent to the design, and the "letter A" after elongation and deformation is equivalent to the planting. The deformation caused by the perspective not only exists in the direction of the line of sight, but also in the direction of the vertical line of sight, resulting in an arc deformation. This is a complex deformation of perspective in both directions, which is difficult to draw by hand. Therefore, the core difficulty of the design to planting diagram is precisely the process of calculating the deformation pattern to offset the perspective.

4. A simple generating method

According to the conventional method, the design drawing to planting drawing needs to be found by using geometric drawing method for cartography. In the case where the observer is located in the center of the rice paddy, there is also the problem of distortion of the curved perspective. This mapping process is very complex and can be quite difficult even for trained professionals. Therefore, it is essential to find a simple way to convert the design drawing to a planting drawing.

According to the basic optics and the working principle of visual imaging, the humans see the rice field paintings because the daylight reflected from the ear of rice enters the eye during the day and forms an image on the retina. If this physical process is modeled in reverse, it can be understood that the rice field painting is a projection of light from the humans' eyes, formed on the ground through the visible pattern. Therefore, the deformed ground pattern can be obtained by projection. Theoretically, it is possible to project the outline of the pattern directly on the ground at the observer's position, using the light source and the design pattern, through the contrast of light and shadow on the earth. However, in the real world, the illumination projected onto the ground by ordinary light sources may be so weak that it is difficult to distinguish its boundaries, even at night, due to the large size of the paddy field drawing, which is not practically operable. Therefore, it is not realistic to perform the above operation 1:1 in reality. Therefore, we chose to use software simulation to calculate the light and shadow boundaries, and then further create a two-dimensional deformation pattern, and finally form a construction drawing to guide the implementation of rice field painting. The grower can then plant according to this drawing.

Nowadays, there are many software that can perform spatial and light simulation, and the author used Google Sketchup 2016, V-Ray for SketchUp 3.40.02 and AotuCad 2014. The specific operation is as follows, continuing the simulation analysis using the previous scenes.

Step 1: Scene modeling. Simplify and restore the scene of the rice field painting in Google Sketchup 2016 software environment. The content of the scene to be restored contains to the flat size of the rice field painting, the height of the observation height platform and other information. The white bottom surface simulates the extent of the rice field, and the observation platform is located on the side of the rice field (Figure 5-1).

Step 2: Masking surface setting. Use the design pattern as the masking surface. The pattern used to make the shading surface should preferably be clear and concise in outline. The author makes the

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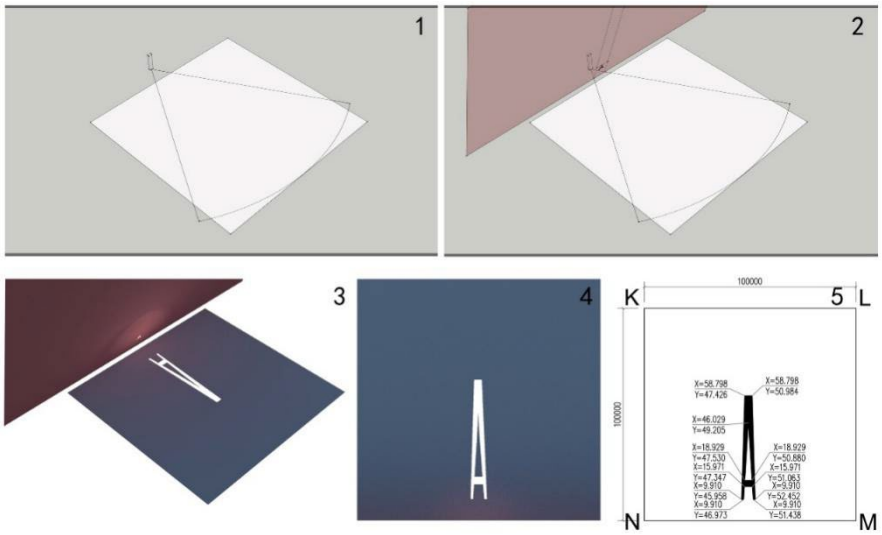
masking surface by making the pattern that needs to be displayed as a skeleton face in the model scene made by Google Sketchup 2016 software. If the pattern is more complex, the production of skeleton surface is more time-consuming, you can use a picture format with a transparent channel (such as PNG format) as a masking surface, the design pattern part made of transparent material, can be transparent to light. In this case, a hollow surface is used to block the front of the observation platform. Since the observer's line of sight is tilted downward, the scene also tilts the masking surface downward by about 30° to simulate a view plane perpendicular to the main line of sight of the human eye (Figure 5-2).

Step 3: Generating the projection. There are many ways to generate the projection. The scene is simulated with V-Ray for SketchUp 3.40.02 software for light and shadow, a projection light is set at the observer's eye, and the brightness of the light and other parameters are adjusted as needed to obtain a complete and clear projection (Figure 5-3).

Step 4: Getting the projection map. After the calculation of the software, the projection pattern on the bottom surface can be obtained, and the top-view projection map of the projection is output and saved for backup by the software (Figure 5-4).

Step 5: Drawing the planting map. Import the generated top-view projection into the mapping software AotuCad2014, scale the picture to the actual size, set a corner of the site as the coordinate origin (0,0) to establish a two-dimensional plane coordinate system, and accordingly mark the relative coordinates of the key points of the planting map pattern to form a planting map with relative positioning coordinate points, on which the grower can base the positioning of the planting boundary (Figure 5-5).



Source: Figures 5 is self-photographed or self-drawn by the authors.

Figure 5: Diagram of five steps in the production process

The above scenario demonstrates a method of making a simple pattern planting map viewed in a single direction. The same method can be used to generate relatively complex patterns. In the actual case, some of the rice field paintings are arranged in a circular shape around a high platform, so that the rice field paintings can be seen by the observer in a 360° range. The method described above can also generate this kind of 360° rice field painting. Only a design and projection diagram of a 360° encircled observation high platform pattern is shown here (Figure 6), and the imaging principle is basically the same as that of unilateral imaging. The difference is that in the second step of masking surface setting stage, the masking surface needs to be designed as a 360° surround surface as well, and the pattern is hollowed out on that masking surface (Figure 7). The pattern in the design is "Beautiful Country - Hope for China", and the pattern is deformed in all directions in the projection. By the above method, the planting map can be obtained quickly and accurately to guide the work of planting patterns.

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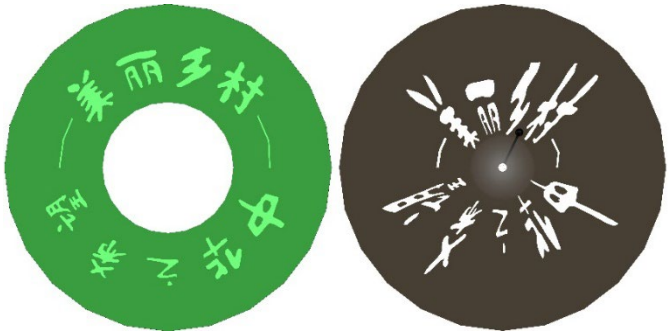

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Figure 6: Design drawing (left) and projection drawing (right) of a rice field painting that 360 degree around high platform

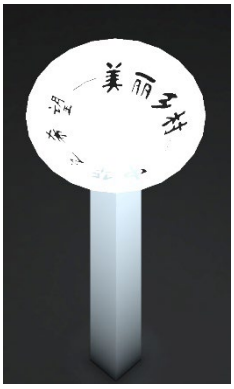

Figure 7: Occlusion face settings in 360 ° scenes

5. Conclusion

The thriving rice field painting art should not become difficult to promote because it is limited by a certain technical link. The simplification of planting map drawing technology has effectively broken through its technical difficulties, making planting maps no longer an obstacle to rice field painting design and turning rice field painting into an art form that everyone can participate in.

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