

Application of Virtual Reality Technology to Display of “Maritime Silk Route” Culture

Tsung-Chih Hsiao,¹ Ran Yan,¹ Chien-Yun Chang,^{2*}
Chih-Cheng Chen,^{3,4**} and Minqi Guo⁵

¹College of Computer Science and Technology, Huaqiao University, Fujian 361021, China

²Department of Fashion Business and Merchandising, Ling Tung University, Taichung 40852, Taiwan

³Department of Aeronautical Engineering, Chaoyang University of Technology, Taichung 413310, Taiwan

⁴School of Information Engineering, Jimei University, Fujian 361021, China

⁵School of Humanities and Social Sciences, Harbin Institute of Technology, Shenzhen 518055, China

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Scenic vistas of Quanzhou are displayed in a 720° perspective as an immersive live 3D display to provide a real digitalized virtual reality experience. In this paper, we report our research on simulating and exploring the extensive scenery of the Quanzhou Maritime Silk Route to support cultural tourism. Users can access the “Maritime Silk Route” applet on their mobile phone by approaching a sensor or scanning a QR code.

1. Introduction

In this study, we built a cloud platform for virtual reality (VR) technology. Upon user authentication, this system initiates a platform service and provides suggestions based on an analysis of usage patterns. To help the perceiver obtain a realistic and vivid experience with interactive feedback, VR uses computer technology to simulate the 3D world of the human senses, including hearing, touch, and vision.⁽¹⁾ VR changes the traditional way of interacting with entities via its immersive virtual space and expands the experience from the usual cognitive range by making the most of the perceiver’s imagination in space and time.⁽²⁾

This paper describes an approach to offering a more realistic way for people to gain an understanding of the Maritime Silk Route civilization of Quanzhou. The research results provide an immersive and interactive experience in a 720° field of view via VR and augmented reality technologies. In addition, we discuss the interactive functions of phonetic explanation and various video, text, and picture-sharing features. The objective of this research is to attract the interest of more people in taking the initiative to understand the history of maritime civilization, promote the development of China’s “One Belt, One Route” initiative, and spread knowledge of China’s ancient Maritime Silk Route culture.

*Corresponding author: e-mail: chienyunchang1638@gmail.com

**Corresponding author: e-mail: 201761000018@jmu.edu.cn

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2. Literature Review

2.1 Culture of the Quanzhou Maritime Silk Route

Quanzhou is a core city in China owing to its role in connecting nearly 100 countries of diverse cultures along the Maritime Silk Route for the purpose of economic trade. The Maritime Silk Route extends from Quanzhou to the Pacific, Atlantic, Mediterranean, and Indian Oceans. The friendly exchanges between different nations have promoted the prosperity of the religious civilization in Quanzhou, where records trace its peaceful coexistence and mutual influence among the people along the route, which has inspired China's current "One Belt, One Route" initiative. To date, Quanzhou has preserved many historical sites from the Maritime Silk Route civilization, which convey its authenticity, diversity, and uniqueness.

2.2 VR technology

Compared with other virtual technology products, the advantages of VR of low-cost development, minimal hardware requirements, and easy dissemination have resulted in its wide use in all walks of life. In 2016, the BBC's Taster series launched a 360° video realistically depicting scenes and presented new VR projects at the Google I/O conference. The audience was placed at the center of the image and flashbacks were reproduced by integrating free-roaming VR with the appropriate topic selection and a narrative mode, which balanced the audience's immersive experience and generated anxiety and even panic.⁽³⁾

In addition, a panoramic human visual system was launched by China's National University of Defense Technology, which generated post-production images using a columnar projection model and achieved a full range of realistic scene viewing effects.⁽⁴⁾ The Institute of Software at the Chinese Academy of Sciences used image processing picker and stitching software to develop navigation services with simulated realistic scenes based on columnar projection.^(1,5-7)

3. Method

The method employed to create panoramic images in this study is applied to displaying the Maritime Silk Route culture. The panoramic image construction process is shown in Figs. 1 and 2.

3.1 Image acquisition

The rule for panoramic image acquisition is that more than 30% of the contents collected should have overlapping areas for use in identifying similar feature points and performing

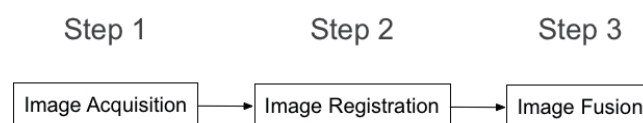


Fig. 1. Panoramic image construction process.

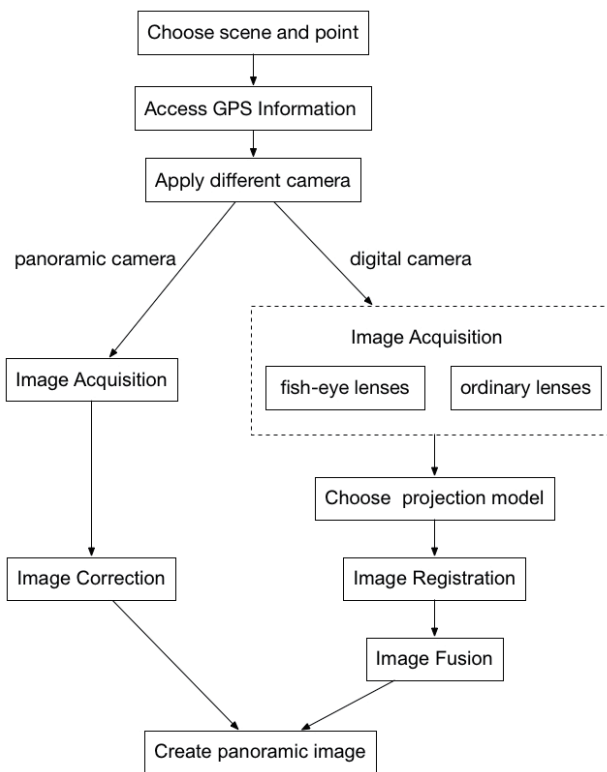


Fig. 2. Flowchart of the process of creating a panoramic image.

image fusion to generate a 3D panorama. The equipment used to collect panoramic images includes a 360° camera that integrates light and shadow with multiple lenses in combination with a tripod head and tripod.^(8–10)

The principle of panoramic camera conversion involves translation, rotation, and scaling in the horizontal and vertical directions, as shown in Fig. 3.

To simulate a reduction screen in the fixed visual direction, the generated panoramic image transformation requires that the camera be fixed in the vertical direction with no panning or zooming. The center of the camera is considered to be the human eye. By translation and rotation of the camera, human head action can be simulated, such as looking up and down, shaking the head, and moving the head around, which creates an all-round 720° perspective experience. Figures 4 and 5 respectively show the principles of rotation about a central axis point and on a plane.

Models for projecting panoramic images include those for a 3D cylinder, sphere, and cube. The projection model for a cylinder conveniently acquires images and generates only a small amount of data. As shooting is only carried out in the horizontal direction, without any up or down vertical movement, the resulting image mosaic does not provide an all-round panoramic experience.⁽¹¹⁾ The projection principle is shown in Fig. 6.

To achieve a 3D effect, the second model for projecting a sphere requires a 720° panoramic camera that captures the surrounding environment.⁽¹²⁾ To do this, the model implements a

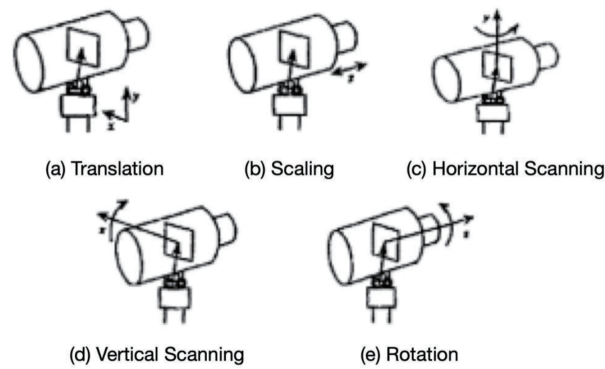


Fig. 3. Camera transformations.

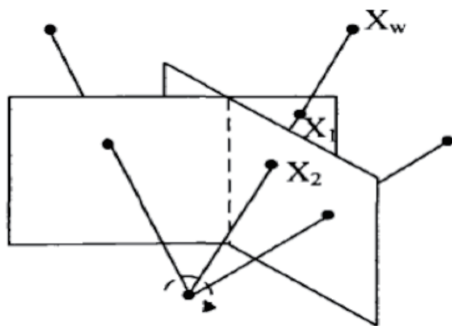


Fig. 4. Arbitrary rotation about a core point.

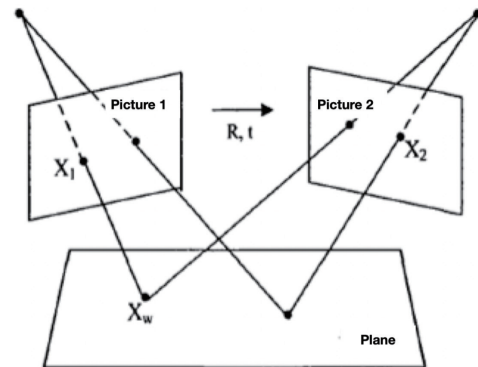


Fig. 5. Arbitrary rotation on a plane.

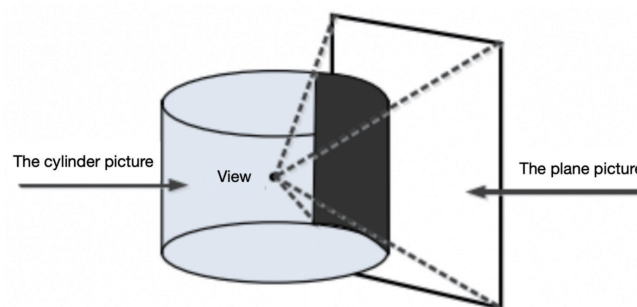


Fig. 6. (Color online) Cylinder projection model.

comprehensive perspective by importing a 3D roaming system rather than projecting directly onto a 2D plane, as shown in Fig. 7.

The model for projecting a 3D cube generates the third type of computer graphics mentioned above. On the basis of the construction of a cube, six local panoramic images are obtained to match the six sides of the cube, the projection principle of which is shown in Fig. 8.

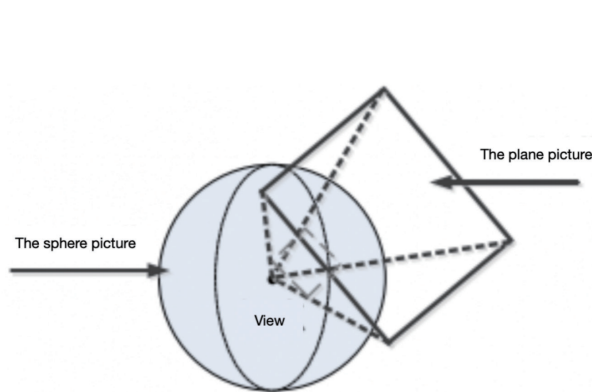


Fig. 7. (Color online) Sphere projection model.

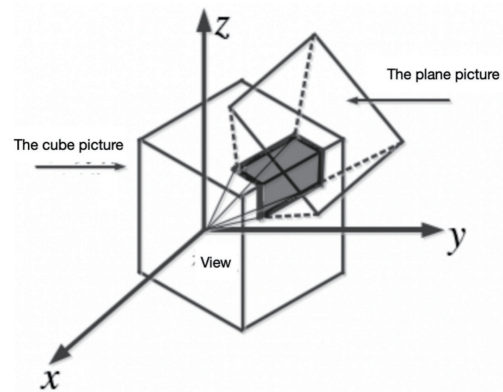


Fig. 8. Cube projection model.

3.2 Image registration

An important step in the collection of panoramic images is panoramic image registration, which is a key determinant of the final effect. From the region, frequency, and feature points, image registration can identify and register overlapping content in local images, thereby obtaining greater associated similarity among the images. The principle of feature point matching, one of the most popular approaches used in image processing, is to identify the feature points of a real panoramic image with unique characteristics, such as edges and lines.⁽¹³⁾ Commonly used feature point matching algorithms include the Harris and scale-invariant feature transform algorithms, which are shown in Figs. 9 and 10, respectively.

3.3 Image fusion

There are two image synthesis algorithms, the linear fusion and fade-in/fade-out algorithms.⁽¹⁴⁾ By using different camera focal lengths, the projection parameters provide a relative response, as shown in Fig. 11. The mathematical function of the fade-in/fade-out algorithm is shown in Eq. (1), where I refers to the image and d is the distance between overlapping regions.

$$I_3 = d \times I_1 + (1 - d) \times I_2. \quad (1)$$

3.4 Image correction

To improve the color saturation and exposure of the panoramic images, the image correction step provides image enhancement to make panoramic images more closely resemble real scenes. The aim of image correction is to improve the overall quality of panoramic images to provide a better user experience.

Image enhancement uses the image clarity, the grey coefficient, and image contrast to reflect the information contained in the image data. The camera imaging process is described by Eq. (2) for camera response function CRF, exposure time t , and natural scene S .

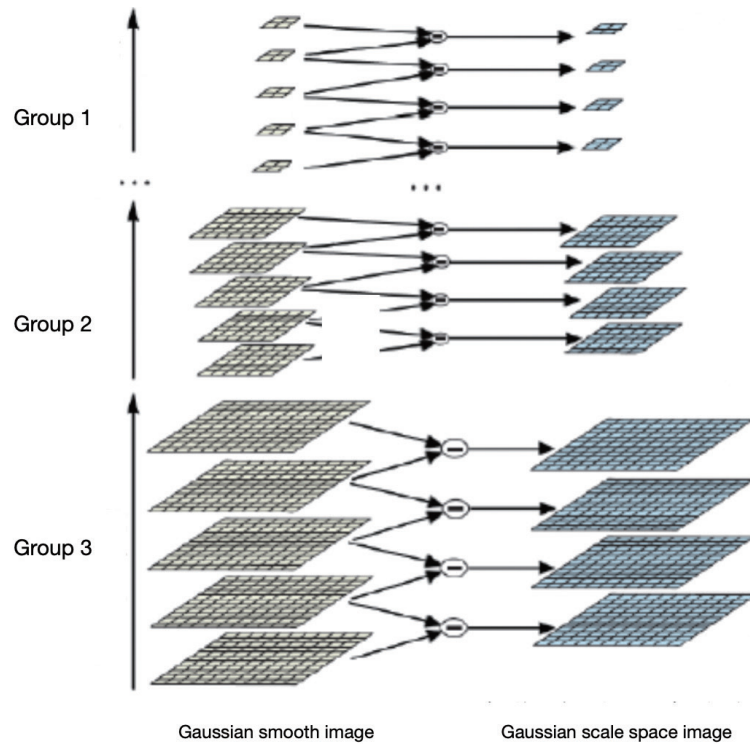


Fig. 9. (Color online) Difference of Gaussian spaces.

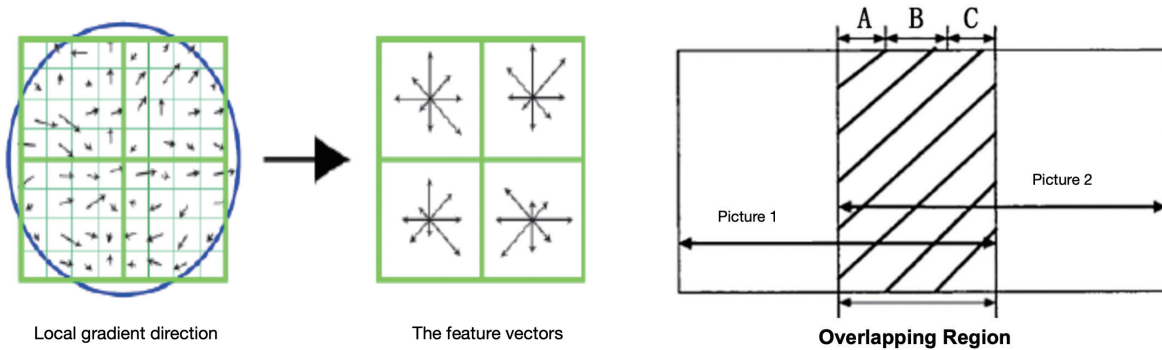


Fig. 10. (Color online) Feature description generated by scale-invariant feature transform algorithm.

Fig. 11. Fade-in/fade-out algorithm.

$$I = f_{CRF}(S \times \Delta t). \tag{2}$$

4. Experiment

To simulate and explore the all-around real scenery of the Quanzhou Maritime Silk Route to boost cultural tourism, we obtained panoramic images via image acquisition and image registration.^(15,16) To provide a better immersive experience, the panoramic images were applied in a 3D panoramic virtual tour system.

4.1 3D panoramic virtual tour system

In contrast to the complex VR technology based on computer 3D modeling, a 3D panoramic virtual tour system utilizes realistic scene shooting. The advantages of this technology, shown in Figs. 12 and 13, include its wide application, strong authenticity, small amount of data, and easy expansion.

4.2 Panoramic virtual tour display terminal

We designed 18 hand-painted drawings in a consistent classical style as entries on the Maritime Silk Route culture. The results of this study achieved four key objectives: provision of an immersive experience using panoramic images, sharing information about the Maritime Silk Route culture, providing a realistic experience, and interaction with others, as shown in Fig. 14.

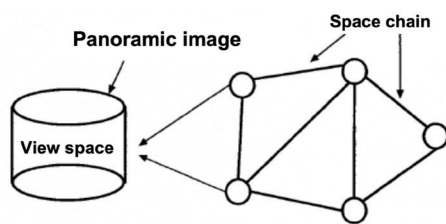


Fig. 12. View space.

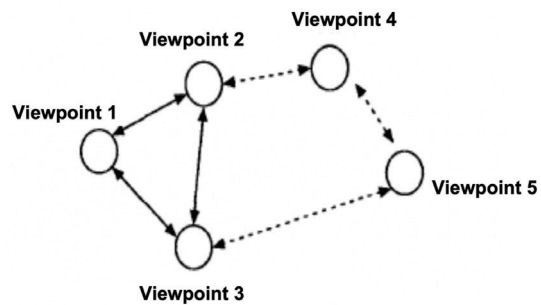


Fig. 13. Multi-viewpoint connection.



Fig. 14. (Color online) Places of historic interest in Quanzhou shown as part of panoramic experience.

5. Conclusion

In this study, we developed the overall design of a 3D panoramic virtual tour system and organized a range of linked image-based scenes for the system. Panoramic images above the ground were obtained by acquiring images with fixed viewpoints. After previewing the panoramic effect, a complete panoramic image was generated in JPG format with a width-to-height ratio of 2:1, and we confirmed the absence of errors in the resulting panoramic images.

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About the Authors



Tsung-Chih Hsiao received his Ph.D. degree from the Department of Computer Science and Engineering, National Chung Hsing University, Taiwan. He is currently an associate professor at the College of Computer Science and Technology, Huaqiao University, China. His research fields include information security, cryptography, and network security. (hsiaotc@gmail.com)



Ran Yan is currently an undergraduate student at the College of Computer Science and Technology, Huaqiao University. Her research fields include VR and multimedia creative art. (yanran97@hotmail.com)



Chien-Yun Chang received his B.S. degree from National Kaohsiung University of Science and Technology, Taiwan, in 2001 and his M.S. and Ph.D. degrees from National Kaohsiung University of Science and Technology in 2003 and 2008, respectively. From 2005 to 2009, he was an assistant professor at Hsiuping University, Taiwan. Since 2010, he has been an associate professor at Hsiuping University. His research interests are in finance, marketing, and research methods. (chienyunchang1638@gmail.com)



Chih-Cheng Chen received his M.S. and Ph.D. degrees from the Department of Mechatronics Engineering, National Changhua University of Education, in 2006 and 2011, respectively. Furthermore, he has served as an assistant professor at National Chin-Yi University of Technology, Chung Shan Medical University, and Chaoyang University of Technology. He has been an associate professor with the School of Information Engineering of Jimei University, China since 2017 and a professor there since 2020. He is a member of the IEEE. His recent research interests include the Internet of Things, AIOT technology, machine learning, information security, and intelligent RFID systems. (201761000018@jmu.edu.cn)



Minqi Guo received her B.S. degree from Huaqiao University, China, in 2018. She is currently a graduate student at the School of Humanities and Social Sciences, Harbin Institute of Technology. (18s059502@stu.hit.edu.cn)