Design and Implementation of Ceramic Virtual Display System

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Abstract: Using virtual reality technology to achieve the three-dimensional digitalization of ceramic artworks and accessing these 3D digital models through a web browser can provide a new approach for the promotion and dissemination of traditional ceramic culture. This paper aims to preserve traditional ceramic culture and craftsmanship as intangible cultural heritage, enhancing public understanding of traditional ceramic culture. Taking Jingdezhen ceramics as an example, various ceramics are three-dimensionally modeled using modeling software. A virtual exhibition hall is created in Unity3D, where the ceramic models are placed and interactive features are built, enabling functionalities such as virtual tours of the ceramic exhibition, ceramic viewing, and ceramic making. By leveraging WebGL, users can access the virtual exhibition system through a web browser. The virtual exhibition system promotes public understanding of ceramic culture and virtual reality technology, revitalizing traditional artifacts and promoting the inheritance and digital preservation of ceramic culture.

Keywords: Virtual Reality; Ceramic; 3D Modeling; Unity3D; WebGL

1. Introduction

Virtual reality technology provides a new form for the digital protection of cultural heritage. Utilizing virtual reality technology can vividly showcase cultural heritage objects, promoting their preservation and transmission[1]. Virtual reality technology enables visitors to immerse themselves in cultural heritage tours and browsing from the comfort of their homes[2], allowing them to interact with nearly authentic virtual cultural heritage objects[3]. Technologies such as virtual reality, augmented reality, and mixed reality make user-centered presentations possible, enabling digital access to cultural heritage when physical visits are restricted[4]. Immersive virtual reality devices are increasingly popular in the field of cultural heritage[5]. In the digital protection of cultural heritage, virtual exhibitions have become an important form. Aiello et al. designed and implemented a virtual museum called the Eternal Museum, which integrates gaming and education, receiving positive feedback from users. The study shows that virtual reality technology has the capability to bridge the gap between people and distant environments, allowing those without travel experience to enjoy extraordinary experiences of cultural heritage[6]. Kamariotou et al. explored the development strategies for digital museums, indicating that using technology to provide visitors with a more enjoyable virtual experience is an interesting research direction[7].

Ceramics, as a form of cultural heritage, hold significant historical and cultural value globally. The evolution of ceramic craftsmanship reflects the technological innovations and aesthetic changes of different periods, serving as a window into the development of human civilization. In recent years, research on the digital preservation and transmission of ceramic culture using virtual reality technology has become a hot topic. Yue Ming et al. conducted a systematic review of the application of virtual reality technology in ancient ceramics, analyzing the progress in visualization, usability, and interactivity of virtual reality in ceramic restoration, and established a virtual reality-based ceramic restoration platform[8]. Yue Bai systematically

analyzed the innovation and development of ceramic art in virtual museums, discussing the application of Internet of Things technology in ceramic virtual museums[9]. Xueting Wu et al. applied CAD technology, virtual reality technology, and convolutional neural networks (CNN) to 3D modeling of ceramic products and optimized the design effect[10]. Yong Kang Peng et al. studied virtual exhibitions of ceramic products based on static image sets and 3D virtual reality displays of ceramic products based on WebGL[11]. Wenyan Zhao et al. explored innovative measures for digital heritage education from multiple perspectives, studying diverse dissemination methods and approaches for the digital heritage education of Jingdezhen ceramics[12]. This paper will research the 3D modeling of Jingdezhen ceramics, create virtual exhibition halls in Unity3D, and implement functions such as exhibition hall roaming, ceramic viewing, and ceramic creation, with access to the virtual exhibition system via WebGL in a web browser.

2. Requirements Analysis

The ceramic virtual exhibition system is based on WebGL technology, displaying scenes created in Unity3D in a web browser, allowing users to easily enter the virtual exhibition hall from any location without any additional software. The system not only improves the convenience and accessibility of exhibitions but also provides users with an immersive experience of ceramic art, appreciating the charm of traditional culture.

2.1 User Requirements Analysis

The analysis of user Requirements is as follows:

(1) Target Audience Requirements: The target audience for the ceramic virtual exhibition system consists of people who love traditional ceramic culture and wish to gain a deeper understanding of it. Therefore, the system design Requirements to simplify the operation steps. For example, users should not be required to register an account or enter a username and password; instead, they can directly access and use the ceramic exhibition system through a public URL.

(2) Ceramic Viewing Requirements: To satisfy users' Requirements for detailed and free viewing of ceramics, the system should include zooming and rotating functions. Users can switch between interfaces and scenes through buttons, enabling them to view ceramics from all angles.

(3) Ceramic Creation Requirements: The system should meet users' desires to create their own ceramics. Users should be able to design and display their ceramic works using the tools and resources provided by the system, experiencing the joy of creation.

(4) Ceramic Information Display Requirements: Users need to obtain detailed information about the ceramics in the exhibition hall. Therefore, the system should provide video introductions and text information display functions, allowing users to comprehensively understand the background, history, and craftsmanship of the exhibits through convenient button interactions.

2.2 User Requirements Analysis

The analysis of user Requirements is as follows:

(1) Main Interface and Function Selection: Users should be able to enter the function selection interface from the main interface. This process should be simple and efficient, allowing users to quickly access the desired function modules.

(2) Virtual Exhibition Hall Scene: The virtual exhibition hall scene should be created using Unity3D. The design of the exhibition hall should align with the cultural requirements of ceramics, using traditional wooden materials for texture mapping, and replicating the appearance of the Forbidden City Museum to ensure a cultural and historical atmosphere.

(3) Exhibition Hall Roaming: Users should be able to roam the exhibition hall in the first-person perspective, using the mouse for interactive operations. The directional keys control the movement of the viewpoint, and the mouse controls the rotation of the field of view, allowing users to freely explore every corner of the exhibition hall for an immersive experience.

(4) Ceramic Viewing: Users should be able to view ceramics in detail using zoom and 360-degree rotation functions. Users can enter the viewing interface from the function selection interface or by clicking on the ceramic buttons, and double-click the ceramics they want to explore to obtain detailed information and interactive experience.

(5) Ceramic Creation: The system should provide various creation options, including selecting types of ceramics and replacing parts of the ceramics (such as shape, surface color, glaze type, etc.). Users can design and combine ceramics freely through the displayed patterns, experiencing the joy and sense of accomplishment in creation. The system function module diagram is shown in Figure 1.

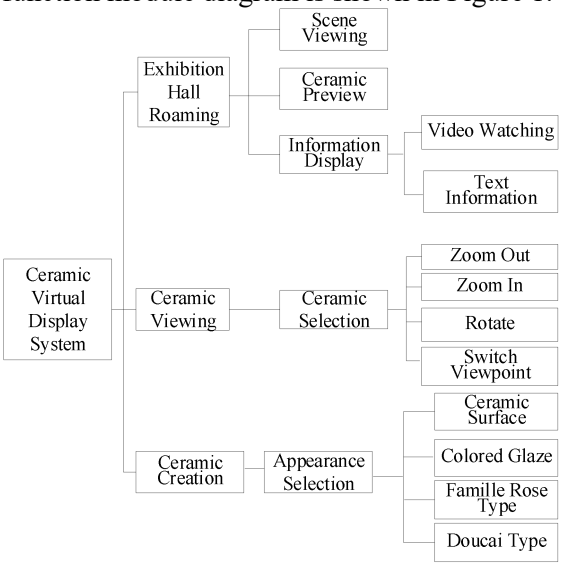

Figure 1. System Function Module Diagram

3. System Design and Implementation

3.1 Ceramic Modeling

The most famous traditional Chinese ceramic culture is that of Jingdezhen ceramics. Jingdezhen has produced a large number of artistic, utilitarian, and decorative ceramics, with over three thousand types. Some of the most renowned types include blue and white porcelain, doucai, colored glazes, and famille rose. Using 3Ds Max software, the selected ceramics are modeled and then imported into Unity3D, where they are placed in the designed virtual exhibition hall scene. The general steps for ceramic modeling are as follows:

(1) Creating the Outer Wireframe of the Ceramic: Establish a plane in the front view and attach a material frame to outline the appearance of the ceramic using points. In the modifier settings, select Bezier corner points to change the curvature of the lines, making the ceramic's outer frame smoother. Continuously adjust until the vertical section of the ceramic is displayed.

(2) Creating the Ceramic Model: Add the Lathe modifier in the modifier settings and move along the horizontal axis to ensure that the wireframe style matches the chosen model, ultimately forming a complete 3D ceramic model.

(3) Adding Ceramic Material: Open the "Material/Map Browser" option in the material editor and select the VRayMtl material type.

(4) Displaying the Ceramic Material: Select the created ceramic model, open the material editor, and click to assign the selected material to the corresponding ceramic model, making it present a realistic material effect.

Figure 2 shows the effects of some completed ceramic models.

Figure 2. Ceramic Modeling Effect

3.2 Function Selection Interface Construction

The function selection interface, as shown in Figure 3, consists of three parts.

(1) Upper Part: Displays the title of the interface to clarify the current interface's theme and functions.

(2) Middle Part: Contains three buttons that lead to different scenes of the ceramic virtual display system. The specific functions are as follows:

•Exhibition Tour Button: The corresponding code is attached to this button. Clicking the button will navigate to the "Exhibition Tour" interface. Users can freely roam the virtual exhibition hall, experiencing an immersive environment.

•Ceramic Viewing Button: The corresponding code is attached to this button. Clicking the button will navigate to the "Ceramic Viewing" interface. Users can closely observe various ceramic pieces, using zoom in, zoom out, and 360-degree rotation functions to examine every

detail.

•Ceramic Creation Button: The corresponding code is attached to this button. Clicking the button will navigate to the "Ceramic Creation" interface. Users can choose and design their ceramic works, experiencing the joy of creation.

(3) Lower Right Part: Contains a "Back" button. The corresponding code is attached to this button. Clicking the button will navigate back to the "Start" interface. This button provides a convenient navigation option, ensuring that users can easily return to the main menu for other operations.

The key code for implementing the function selection interface is as follows:

```
public class Tiaozhuan1: MonoBehaviour
    {
        public void Skip0()
        {SceneManager.LoadScene(0);}
        public void Skip2()
        {SceneManager.LoadScene(2);}
        public void Skip3()
        {SceneManager.LoadScene(3);}
        public void Skip4()
        {SceneManager.LoadScene(4);}
}
```

Figure 3. Function Selection Interface

3.3 Construction of the Ceramic Viewing Scene

The ceramic viewing interface is shown in Figure 4.

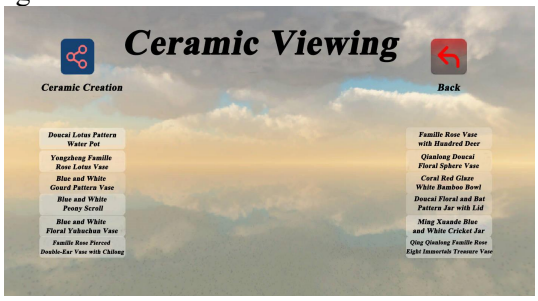

Figure 4. Ceramic Viewing Interface

The layout and functional design of the interface are as follows:

(1) Upper Part: Includes an image with the title "Ceramic Viewing System" and two buttons:

•Ceramic Creation Button: Clicking this button navigates to the ceramic creation interface, allowing users to experience and participate in the creation process of ceramics.

•Back Button: Clicking this button navigates back to the "Function Selection" interface, providing users with an easy way to return to the main menu for other options.

(2) Middle Part: Using the "Famille Rose Vase with Hundred Deer" as an example, users can display the vase by double-clicking the button after entering the scene. Specific interactive operations are as follows:

•Left Mouse Button: Controls the rotation of the ceramic piece, allowing users to view the details from different angles.

•Mouse Wheel: Controls the scaling of the ceramic piece, enabling users to zoom in for detailed viewing or zoom out for an overall view.

The corresponding code is attached to the "Famille Rose Vase with White Deer" button, implementing the function of displaying the vase upon double-clicking. Users can control the rotation and scaling of the object through mouse operations, as shown in Figure 5 and Figure 6.

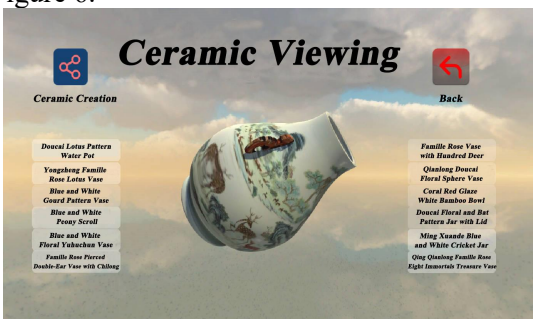

Figure 5. Ceramic Viewing Interface

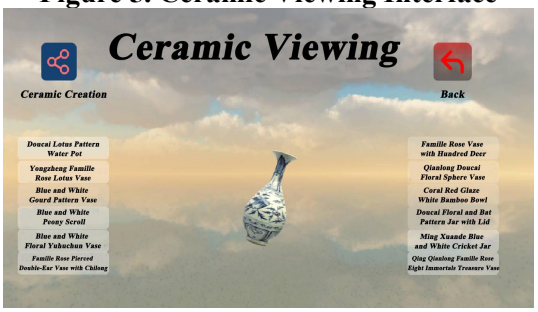

Figure 6. Ceramic Viewing Interface

The key code for implementing ceramic rotation and scaling is as follows:

```
public class Xuanzhuan : MonoBehaviour
{
    float rotSpeed = 20;
```

```
    float scale = 0.2f;
    void OnMouseDrag()
    {
        //Control the rotation of the object with the left mouse button
        float rotX = Input.GetAxis("Mouse X") * rotSpeed * Mathf.Deg2Rad;
        float rotY = Input.GetAxis("Mouse Y") * rotSpeed * Mathf.Deg2Rad;
        transform.RotateAround(Vector3.up, -rotX);
        transform.RotateAround(Vector3.right, rotY);
    }
    void Update()
    {
        //Control the scaling of the object with the mouse wheel
        if (Input.GetAxis("Mouse ScrollWheel") > 0)
        {
            transform.localScale += new Vector3(1 * scale, 1 * scale, 1 * scale);
        }
        else if (Input.GetAxis("Mouse ScrollWheel") < 0)
        {
            transform.localScale -= new Vector3(1 * scale, 1 * scale, 1 * scale);
        }
    }
}
```

3.4 Construction of the Ceramic Creation Scene

The ceramic creation interface is shown in Figure 7.

On the left side are selection buttons for different types of ceramic patterns, with each button corresponding to a type of ceramic. Clicking a button will display or hide the ceramic model. The middle part displays the ceramic model, and the right side includes selections for the four major types of ceramic appearances: colored glaze, blue and white porcelain, famille rose, and doucai.

Figure 7. Ceramic Viewing Interface

4. WebGL Platform Publishing

This system exports files and related resources that can be deployed on the server side through WebGL technology, and the client can remotely access the virtual ceramic display system through the browser.

4.1 Publishing Settings

Figure 8 shows the Build Settings in Unity for publishing the project, where you can set the sequence of different Scenes files and choose the export platform, such as PC, Apple, or Android. Here, WebGL is selected. Figure 9 shows the Publishing Settings in the Player Settings.

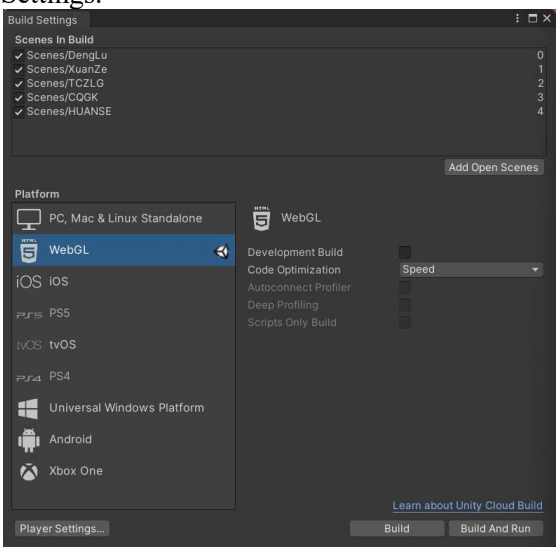

Figure 8. Export Platform Selection

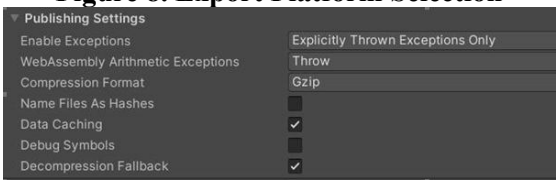

Figure 9. Publishing Settings

4.2 Effect Display

After publishing to WebGL, the display effects of ceramic viewing and ceramic creation in the browser are shown in Figure 10 and Figure 11, respectively.

Figure 10 shows the observed results after selecting the corresponding type of ceramic in the ceramic viewing interface and then zooming and rotating it. This allows a 360-degree all-around view of the ceramic. Figure 11 displays the results of ceramic creation after entering the ceramic creation interface, based on the selected ceramic type, appearance color, and glaze type. By experiencing ceramic

creation, one can enjoy the fun of the creative process.

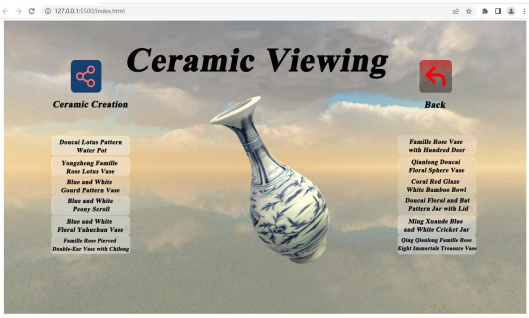

Figure 10. Ceramic Viewing

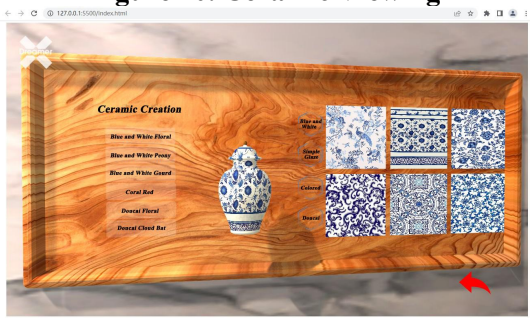

Figure 11. Ceramic Creation

5. Conclusion

Converting ceramic works into digital collectibles leverages the permanent fidelity of computer data to achieve the long-term preservation and transmission of ceramics. Although some people may think that digital collectibles are significantly different from real ceramic works and lack good transaction value, in the long run, digital collectibles can hold the same value in terms of dissemination and cultural significance as physical items. Virtual exhibitions can enhance visitors' understanding of cultural relics, promote interaction between visitors and artifacts, thereby increasing visitor satisfaction, and improving the reputation and foot traffic of museums. Virtual exhibition systems provide an innovative and attractive auxiliary display form for museums and other exhibition venues, making the presentation of items more diverse and modern. This form not only offers visitors a rich experience but also reshapes the image of museums to some extent. Through virtual reality technology and digital means, traditional culture can be revitalized in modern society, attracting more attention and opening new avenues for the protection and dissemination of cultural heritage.

Acknowledgments

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References

[1] Zhong, H., Wang, L., & Zhang, H. The application of virtual reality technology in the digital preservation of cultural heritage. Computer Science and Information Systems, 18(2), 535-551.

[2] Pagano A, Palombini A, Bozzelli G, Cerato I, Ricciardi S. ArkaeVision VR game: user experience research between real and virtual paestum. Appl Sci 10(9): 3182

[3] Kyriakou P, Hermon S. Can I touch this? Using natural interaction in a museum augmented reality system. Digital Appl Archaeol Cult Heritage 12: e00088. https://doi.org/10.1016/j.daach.2018.e00088

[4] Bekele, M. K., Pierdicca, R., Frontoni, E., Malinverni, E. S., & Gain, J. A survey of augmented, virtual, and mixed reality for cultural heritage. Journal on Computing and Cultural Heritage (JOCCH), 11(2), 1-36.

[5] Rodriguez-Garcia, B., Guillen-Sanz, H., Checa, D., & Bustillo, A. A systematic review of virtual 3D reconstructions of Cultural Heritage in immersive Virtual Reality. Multimedia Tools and Applications, 1-51.

[6] Aiello, D., Fai, S., & Santagati, C. Virtual museums as a means for promotion and enhancement of cultural heritage. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 42, 33-40.

[7] Kamariotou, Vassiliki, Maria Kamariotou, and Fotis Kitsios. "Strategic planning for virtual exhibitions and visitors' experience: A multidisciplinary approach for museums in the digital age." Digital Applications in Archaeology and Cultural Heritage 21 (2021): e00183.

[8] Ming, Y., Me, R. C., Chen, J. K., & Rahmat, R. W. O. A systematic review on virtual reality technology for ancient ceramic restoration. Applied Sciences, 13(15), 8991.

[9] Bai, Y. Application Research of Ceramic Exhibits and VR User Experience Based on Deep Learning Method Based on Nonlinear Random Matrix Combined with Internet of Things Technology and Visualization System. Mathematical Problems in Engineering, 2022.

[10] Wu, X., & Song, J. 3D Modeling and Design Effect Optimization of Ceramics Using Virtual Reality. Computer-Aided Design and Applications, 21(S12), 34-48.

[11] Peng, Y. K., Zhang, Y. L., Zhao, S. D., Cheng, X. E., Li, Y. C., & Liu, X. (2018, July). WebGL-Based Virtual Exhibition of Ceramic. In 2018 International Conference on Audio, Language and Image Processing (ICALIP) (pp. 288-291). IEEE.

[12] Zhao, W., Li, S., & Huang, Q. Research on the digital inheritance education of Jingdezhen Ceramic Culture from the perspective of. Journal of Sociology and Ethnology, 4(10), 23-28.

