Development and Application of an Interactive Exhibition Platform for Intangible Cultural Heritage Creative Products in the VR Technology Context

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Abstract. The digital display of intangible cultural heritage is becoming increasingly important. The purpose of this study is to construct an immersive exhibition platform for intangible cultural heritage creative products using VR technology. The research utilizes methods such as virtual scene modeling and interaction design, and develops an immersive virtual exhibition hall using the example of Nanyang Duini dyeing and printing. The results show that VR technology can achieve scene reproduction and interactive experiences, effectively enhancing the sense of immersion and interactivity in exhibitions. The study demonstrates that VR is an important means for the digital display of intangible cultural heritage, providing insights for future applications. The innovation of this study lies in exploring the application of VR's immersive interactive mode in the field of cultural and creative industries.

Keywords: virtual reality technology, intangible cultural heritage, digital display

1 Introduction

Virtual reality technology opens up new possibilities for the digital display of intangible cultural heritage. Existing research primarily focuses on the faithful reproduction of virtual museums, with limited consideration for interactive experience design. This study explores the application of VR in intangible cultural heritage exhibitions from a user experience perspective. Current research rarely addresses how to leverage the interactive advantages of VR to enhance the sense of immersion in intangible heritage displays. This study centers on scene reconstruction and interaction mode optimization to design immersive virtual intangible heritage exhibition halls. To analyze how VR technology enriches the intangible heritage exhibition experience, this study takes Nanyang Duini dyeing and printing as an example and designs a targeted virtual display platform. The article first outlines the research background, then describes the system design concept and implementation, and finally demonstrates the advantages of VR technology in enhancing the sense of immersion in intangible heritage exhibitions through examples[1].

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2 Overview of VR Technology Features and Cultural Heritage Applications

2.1 Overview of VR Technology

Virtual reality technology is the technology that simulates the real world using computer-generated interactive three-dimensional environments. Its core lies in providing users with an immersive experience through visual, auditory, tactile, and other forms, making them feel like they are part of the virtual world. Key technologies of virtual reality include image generation, sensor tracking, and scene rendering. With the improvement of computer processing power and the development of display devices, virtual reality technology can achieve more realistic interactive effects[2].

2.2 Advantages of VR Technology in Cultural Heritage Conservation

Compared to traditional physical exhibitions, VR-based cultural heritage conservation applications have unique advantages. VR can break through spatial limitations, recreate large and difficult-to-display scenes, and better present cultural content. VR can achieve time-spanning, reconstructing scenes from different historical periods, providing in-depth explanations of historical changes. VR supports a variety of interaction methods, allowing users to virtually manipulate artifacts and experience immersion. VR can personalize scenes based on user needs, enabling self-guided tours and immersive learning. Overall, VR technology can create a more three-dimensional, dynamic, and immersive cultural heritage conservation environment, facilitating the perception, understanding, and dissemination of traditional culture[3].As shown in Tab 1.

Table 1 Advantages of VR technology in cultural inheritance

advantage	Description
Break space limits	VR can restore huge scenes, overcome the space limitations of traditional physical displays, and better present cultural connotations.
Time crossing	VR can reconstruct scenes from different historical periods, help explain historical changes in depth, and realize cultural inheritance across time.
Multiple interaction modes	VR supports a variety of interactive ways, and users can virtually operate cultural relics and get an immersive experience.
Personalized scene	VR allows the creation of personalized scenes based on user needs, enabling self-guided Tours and immersive learning.
Three-dimensional, dynamic, immersive experience	VR technology creates a more three-dimensional, dynamic and immersive cultural inheritance environment, which helps to more deeply perceive, understand and disseminate traditional culture.

3 VR-Based Exhibition Platform for Intangible Cultural Heritage Creative Products

3.1 Platform Design Concept

To fully leverage the advantages of VR technology and create an immersive exhibition platform for intangible cultural heritage creative products, we have designed a virtual exhibition hall that simulates real-world scenes and environments. The platform aims to achieve three-dimensional reconstruction of various types of intangible cultural heritage creative products, allowing users to browse and experience different heritage items within a virtual setting. Additionally, the platform needs to incorporate interactive modes that enable users to naturally explore exhibits and access information using VR devices. Striking a balance between exhibition effectiveness and interactive experience, the platform aims to provide users with a direct and immersive understanding of intangible cultural heritage within a virtual environment[4].As shown in Fig 1.

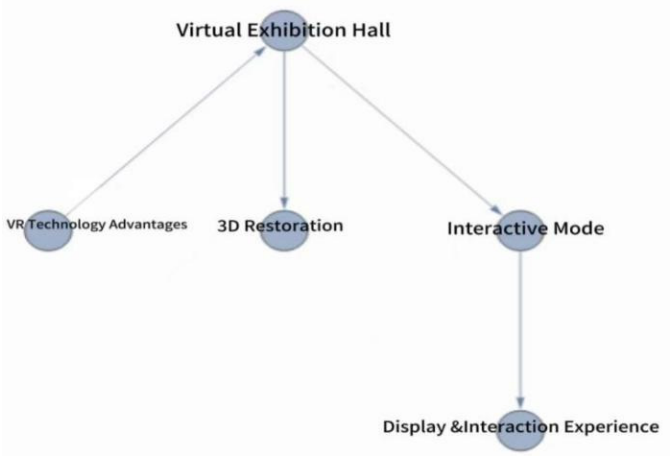

Figure 1: Application of VR Technology in the Exhibition Platform for Intangible Cultural Heritage Creative Products

3.2 Scene Construction

Scene construction forms the foundation of the platform. We employ a method involving 3D scanning and model creation to digitally recreate real intangible cultural heritage products. Considering exhibition space and experience, we design a versatile virtual exhibition hall with well-organized layouts and ample lighting. This hall incorporates virtual display elements such as stands and information boards. The texture and detail of the models within the scene directly influence user immersion. Therefore, meticulous craftsmanship is required to simulate different material objects and achieve a realistic rendering effect. Simultaneously, appropriate lighting sources are strategically placed to create sufficiently realistic lighting effects[5].

In the construction of virtual scenes, 3D models serve as the basis. Object models within the scene can be represented as polygon meshes composed of triangular faces:

V = {v1, v2, ..., vn} // Vertex set

F = {f1, f2, ..., fm} // Face set

Where vi represents the three-dimensional coordinates (x, y, z) of the ith vertex, and fj represents the jth face composed of vertex indices.

Lighting effects play a crucial role in enhancing scene realism. We utilize the Phong lighting model to render the lighting effects of various virtual objects:

$$I = k_a \cdot I_a + k_d \cdot I_d \cdot (N \cdot L) + k_s \cdot I_s \cdot (R \cdot V)^n \quad (1)$$

In this context, Ia, Id, and Is represent the intensities of ambient light, diffuse light, and specular highlights, respectively. The coefficients ka, kd, and ks denote the reflection coefficients, where N represents the normal vector, L stands for the light source direction, R represents the reflected light direction, V represents the viewing direction, and n represents the specular exponent[6].

3.3 Interaction Mode Design

Within the virtual scene, users need natural interaction methods to explore exhibits and access information. We have designed various interaction modes tailored to different types of exhibits, including voice prompts, button clicks, and direct hand operations. Voice interaction can provide users with explanations about the exhibits, button interaction allows for opening and closing display cases to view internal items, and hand interaction enables users to directly manipulate exhibits, such as grabbing and rotating, to experience multi-angle views. The integration of different interaction modes creates an immersive and comfortable interactive experience.

We have also incorporated a voice interaction understanding module that utilizes natural language processing techniques to recognize user query intentions and access a backend knowledge base to provide corresponding responses[7].

```
# Speech interaction understanding
def getUserIntent(speechInput):
  intent = nlpModule.analyze(speechInput)
  if intent == "ASK_INFO":
    return fetchInfoResponse(speechInput)
  elif intent == "NEXT_ITEM":
    return switchItem()
  # And so on
```

Add visual feedback for button interactions:

```
# Button interaction
def onButtonClick(button):
  button.setDown(True)
```

```
    button.render() # Refresh visual effects
      # Execute corresponding logic
      button.setDown(False)
    button.render()
```

The palm-motion tracking is added to grasp judgment to carry out dynamic correction and improve robustness：

```
  # Grab decision
  lastPalmPose = None
  while True:
    palmPose = getPalmPose()
    if lastPalmPose:
      refineByMotion(palmPose, lastPalmPose) # Dynamic correction
    grabDetection(palmPose, object)
      lastPalmPose = palmPose
```

After capture, the captured object movement simulation and scene element feedback are added：

```
  # Grab feedback
  if grabSuccess:
    heldObject.setGrasped(True)
    heldObject.simulatePhysics() # Run a physical simulation
     updateSceneLight() # Scene lighting change
    playSound(grabSound)
```

Achieve smooth conversion between modes and manage the interaction process：

```
  # Interactive management
  actionMode = VOICE
  while True:
    if actionMode == VOICE:
      runVoiceInteraction()
    elif actionMode == BUTTON:
      runButtonInteraction()
    elif actionMode == GRAB:
      runGrabInteraction()
```

```
actionMode = decideModeTransition() # Judgment switch
```

4 System Implementation

4.1 Development Environment

The development of virtual reality scenes is carried out using the Unity3D engine (version 2019.3.0f6), which offers comprehensive 3D content creation tools and supports deployment on multiple platforms, including PC, mobile, VR/AR devices, and more. To support mainstream VR headsets, Oculus Integration and SteamVR plugins were imported, allowing access to hardware capabilities such as tracking cameras and controller inputs for devices like Rift, Quest, and Vive through their respective SDKs. C# serves as the primary programming language for developing interaction logic. When creating script components, inheritance from OVR/SteamVR interfaces like OVRCameraRig and SteamVR_Behaviour is utilized to obtain tracking status and controller input information. Development within the VR environment requires attention to specific characteristics, including background audio quality, lighting optimization, and user-friendly interaction. When writing C# scripts, optimization techniques such as asynchronous processing and object pool reuse are considered. Unity's support for multiple platforms facilitates testing and optimization of interaction logic on both PC and headset devices, supporting quality control for the final virtual reality experience[8].

4.2 Functional Modules

1)Scene Module: Virtual scene models are created using 3D modeling software to establish virtual environments such as exhibition halls and exhibit items. After importing into Unity, lighting and materials are configured, and scene details and visual effects are optimized. 2)Interaction Module: Based on VR SDK, device statuses are acquired and interaction inputs are processed. Various interaction methods are implemented, including voice recognition, gesture tracking, button clicks, and more. 3)UI System: uGUI is used to build menu and prompt interface elements, optimizing readability and visual effects. 4)Data Interface: A connection to the MySQL database is established to retrieve content related to intangible cultural heritage knowledge. Network requests are handled, and data is parsed to support voice interaction queries[9].

5 Application Example

Using the intangible cultural heritage craft of "Nanyang Duini dyeing and printing" as an example, the virtual exhibition hall showcases tools, materials, and products related to the printing and dyeing process. Users, when wearing VR devices, find themselves immersed in the virtual environment. Users can obtain details about specific exhibits through voice commands and explore them from different angles through hand gestures. This immersive interactive experience deepens users' understanding and appreciation of the intangible cultural heritage craft[10].

6 Conclusion

With the development of virtual reality technology, digital displays have become an essential means of cultural preservation. This study aimed to explore the application of VR technology in the exhibition of intangible cultural heritage creative products. Through scene construction and interaction design, an immersive virtual exhibition hall was developed. The research demonstrates that VR technology can enhance the experiential and interactive aspects of intangible cultural heritage exhibitions. This study provides insights into the application of VR in the cultural and creative industries. The innovation of this research lies in the exploration of VR's immersive interaction mode. However, further applications in various intangible cultural heritage fields are needed. Future improvements can be made in hardware devices and content production. In summary, VR technology holds significant potential in creating immersive digital displays for intangible cultural heritage creative products.

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