Research Article
Protection of Intangible Cultural Heritage Based on VR: Taking Xiuyan Jade Carving Craft as an Example

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Innovative exploration of the inheritance and dissemination of intangible cultural heritage can make it play an important role in national development and international social exchange. By taking the inheritance and development of Xiuyan jade carving craft as the background, in this study, the design principle, technology platform, process flow, and technology integration of virtual display technology applied to jade carving technology are elaborated, and the realization of adopting virtual reality technology to assist inheritance of Xiuyan jade carving technology is summarized, so as to form the inheritance system mode, which is suitable for the modern lifestyle. Finally, VR technology is used to explore the development of visualization platform for Xiuyan craft, which further explores the way of intangible cultural heritage protection of traditional manual technology.

1. Introduction
Intangible cultural heritage is the precious spiritual wealth created by our ancestors for thousands of years, and these folk customs and arts enrich people’s life. In the new era, it is the cornerstone of China’s advanced cultural construction [1]. However, with the formation of market economy integration, the intangible cultural heritage is facing arduous challenges, where the development of science and technology, entertainment media, radio and television, and network platform are gradually occupying every corner of life, which leads to numerous intangible cultures that cannot stand on their own functionalities [2]. At the same time, due to the development of science and technology in China, many advanced technologies for intangible cultural heritage protection have emerged, such as virtual reality (VR) technology, virtual reality interaction technology, and 3D technology. The emergence of virtual reality technology provides more possibilities for the protection of intangible cultural heritage and transfers the traditional protection mode [3]. At present, virtual reality technology is attracting worldwide attention, which seems to be a new concept and new trend of cultural heritage under the digital background. But for now, the research based on VR in the field of culture mostly focuses on historical sites or cultural heritage, while the research on digital protection and visual presentation of traditional handicrafts is less. Many projects at home and abroad tend to export cultural achievements, mostly for display, presentation, and performance, while ignoring cultural mobility, while the formation and process of traditional skills are ignored. In the process of digital protection, most research studies not only highlight the uniqueness of the culture but also lack of extensive significance, which cause that the research results have poor extension and popularization.

Therefore, this study attempts to take VR technology as the main technical path, Xiuyan jade carving craft as the research subject, and the visualization platform as the media to explore the feasibility and necessity of digital technology in intangible cultural heritage protection. VR technology is used to reproduce the jade craft of intangible cultural heritage, so that users can experience the traditional technological process in an immersive way, and explore the new mode of intangible cultural heritage.
2. Application of VR Technology in Intangible Cultural Heritage Protection

2.1. Overview of VR Technology. From the functional point of view, VR technology can be defined as a simulation system, which uses the creation of a virtual world to simulate and generate a three-dimensional dynamic environment close to the real world, so that the user’s sensory system can get a pleasant experience in this environment. Therefore, this technology is also known as the spirit environment [4].

VR can superimpose the virtual and the real to ensure the consistency of object lighting, geometry, motion, etc., to achieve augmented reality effects [5–7].

In the mobile augmented reality system, the integration of virtual and reality is realized by three methods [8]: 3D model reading and rendering, pixel operation, and texture rendering. The main principle of texture rendering is to take the real image as the texture data and then make the texture as the unit to draw the real image on the surface perpendicular to the virtual camera. Then, a virtual object is generated between its plane and the camera. The basic principle of pixel operation is to use pixel function to read the data of real image into cache and draw virtual object [9]; 3D model reading and drawing are mainly through reading the format of the 3D model and then reading the data of the 3D model (vertex and face of the model), and furthermore, openGL can draw objects through these data and materials.

2.2. Feasibility Analysis. Words, images, images, and other traditional recording methods can play a certain role in the protection of intangible cultural heritage, but they cannot fully present the rich and colorful forms of intangible cultural heritage [10]. The essence of intangible cultural heritage protection based on virtual reality technology is as follows: through all-round, three-dimensional vivid records and complete preservation to realize the inheritance and dissemination of intangible cultural heritage.

(1) In the reconstructed virtual environment, users can browse and interact with each other according to their subjective wishes. They can understand the craftsmanship of thousands of years across the historical development and personally experience the dissemination of information. The use of virtual reality to protect intangible culture makes people ignore the factors of time and space, and accurately understand the unique charm of traditional culture.

(2) The application of VR technology in the field of intangible cultural heritage can maximize the representation of the form and details of intangible cultural heritage. Digital technology can make historical scenes, cultural heritage, and so on into a fully realistic three-dimensional model, so that people can feel the reality in the virtual space.

(3) Most of the intangible cultural skills are taught by oral transmission, and there is no standard to speak of, whose inheritance is limited and slowly spread. Through digital technology, we can realize the further integration of culture, maximize the sharing of resources, and improve the efficiency of intangible cultural heritage protection.

2.2.1. Applying Rules. The application of VR technology in the protection of intangible cultural heritage makes the protection and inheritance of intangible cultural heritage more modern and systematic. In practice, users should pay attention to its principle.

(1) The integration of technology and culture: traditional culture needs to find technology through the integration of modern technology. The balance point of the combination of art and culture should be based on the particularity and nature of intangible cultural heritage. The only way to understand the inheritor’s skills and pay attention to the history, folk customs, and regional culture of intangible cultural heritage is to protect the crafts of inheritors [11].

(2) The protection of intangible cultural heritage is not only to preserve and inherit the original appearance as far as possible, but also to promote it to modern life through scientific protection, through eliminating the rough and extracting the essence, and making use of advanced technology, and the intangible cultural heritage can be better extended to modern life.

(3) In the process of intangible cultural heritage protection, it is difficult for researchers to comprehensively investigate different regional cultures. In the process of collection, recording, and output, researchers may have subjective feelings, but these are not the most original characteristics and expressions of intangible cultural heritage. Therefore, in the protection of intangible cultural heritage, special attention should be paid to regional characteristics and cultural connotations.

2.2.2. Core Technologies. Virtual reality is a brand-new interdisciplinary technology. It needs a variety of core technologies to simulate the inherent ecological environment and material carrier of intangible cultural heritage and to show its original ecological characteristics.

(1) Virtual environment modeling technology
   According to the requirements of intangible cultural heritage display content, three-dimensional data in the actual environment are obtained, and the corresponding virtual model is established according to the three-dimensional data. Only by constructing the “reality” model of the research object can the final presentation be more credible.

(2) Real-time 3D imaging technology
   It takes enough time as the premise to establish an accurate model and generate accurate images of various objects according to different lighting conditions. Because it is real time, image updating needs
2.2.3. Technology Platform. Applying virtual reality technology to intangible cultural heritage needs the effective support of computer technology.

(1) Adobe Photoshop, referred to as PS for short, is one of the most famous image processing software of Adobe Company. It has shown powerful functions and good performance in image scanning, editing and modification, image production, advertising creativity, graphic processing, etc., and is well received by graphic designers.

(2) Maya software is one of the most famous 3D software developed by Autodesk. It was first developed by the American company Alias Wavefront. Once launched, it was widely concerned by animation and film industry with its powerful functions, friendly interface, and rich impressive effects, and quickly became the top-level 3D animation software. It is applied to model making, character animation, film and television advertising, and special effects [14]. Its perfect function, simple operation, efficient production, and realistic rendering have made it become the first choice for the production of high-end film.

(3) The birth of ZBrush subverts the traditional 3D modeling. With powerful functions and intuitive processes, virtual objects can be modeled and textured in a real-time environment. ZBrush has a simple interface and smooth operation, which can carve models with more than 1 billion faces through a tablet or mouse, and hand over complicated problems such as topology and network distribution to the background for automatic processing. It is the first design tool in the world that allows artists to create freely. Images and tiny details in the mind can be easily carved by stereo brushes. The exported normal maps and low-resolution models can be recognized by all large-scale 3D software, and it has become an important modeling material assistant tool recognized in the field of professional animation production [15].

(4) Unity3D game engine and integrated development environment are perfectly combined. This tight integration enables the editor to do whatever it does to publish the game. These features of simplicity, visibility, intuition, and editor make building games more interesting. It supports many aspects, and there is a very powerful editor to integrate all these. It was a game development kit for Mac, Windows, and Linux, which can be deployed on iPhone and Wii or on the web later [16]. The language of Unity3D is a scripting language. This is rare in game engines. Another example is that Second Life also uses Mono as the scripting engine and C# as the scripting language [17].

3. The Realization of VR Technology in the Protection of Intangible Cultural Heritage

Xiuyan jade carving, which appeared in the Hongshan culture in northeast China, has a long history with simple and elegant shape, and exquisite technique. It can be called both form and spirit, endowed with vitality, and it is a nonrenewable precious resource given to mankind by nature. Based on this background, this study’s design, 3D model, and virtual technology demonstrate Xiuyan jade by virtual reality technology to reproduce the manufacturing process of Xiuyan jade.

3.1. Interactive Mode. The core process of realization in virtual jade carving is to develop a VR interactive system based on the PC platform. Developers can realize the simulation effect through personal computers or workstations, influence the senses of eyes and bodies through computer input and output devices, and put users in a virtual three-dimensional simulation system. The virtual space can change with the change in the subject so that users can feel immersive, as shown in Figure 1.
3.2. Implementation Mode. The VR design includes five parts: design, cutting, carving, polishing, and output of the scanned model. First of all, the scanned jade is analyzed from multiple angles, and the model is designed by two-dimensional graphics software. The convenient tools such as copying and mirroring can be used to assist the drawing of artwork, and the matching degree between graphics and jade can be repeatedly adjusted. Then, the cutting tool is used to cut the jade prototype; various brushes in ZBrush are used to carve the details of the jade model in the fine carving part; and the subdivision level is increased to achieve the polishing effect. Finally, the manufactured model is imported into Unity3D, and the man-machine interaction interface of its displacement, rotation, scaling, and other editable operations are further set. The steps are shown in Figure 3.

3.2.1. Three-Dimensional Scanning Data Sampling. Through three-dimensional scanning, the image of material is converted into a format that can be read by computer, stored, and edited by later software. Sampling data reproduce the jade material by means of cloud points, which makes the outline features virtual. Cloud point collection can directly generate the surface, section lines, and so on of jade, which makes the construction of a 3D model more accurate and convenient, and switch entities into the management mode of computer digitization [21].

3.2.2. 2D Graphic Design. Based on 3D scanning, the computer converts the jade in virtual space into digital graphics and obtains the drawing object of 2D graphics, which makes the design targeted. The two-dimensional editing software uses another digital expression to express the outline image of the design figure. In the two-dimensional design software, the design image is drawn at the two-dimensional coordinate position of the model through the pressure-sensitive pen of the hand-drawn board. We maximize the use of the whole jade material to create and finally present two-dimensional visual expression graphic information on the computer.

3.2.3. Virtual Cutting and Matching. In order to avoid stretching after mapping, it is necessary to expand the UV line of the jade model in 3D software in advance. According to the line draft on the stone, the model is cut and extruded; the point, line, and surface of the model are further manipulated by three-dimensional algorithms such as stretching, rotating, and scaling in three views; and symmetrical objects are mirrored and copied. Finally, the three-dimensional digital display in the design drawing is constructed. It is necessary to combine both 2D drawings and 3D scanning data, and modify constantly in the most reasonable interactive way to achieve the ideal result.

3.2.4. Carving of 3D Model. After completing the above steps, the computer has already stored the basic model parameters of jade, but it is still a rough model designed according to the drawings, and the relief and texture in jade need to be further refined. In the engraving software ZBrush, abundant engraving brushes are used to simulate the effects of various kinds of drills in the jade-making process. After making the model, it needs to increase the subdivision level to achieve the polishing effect.

3.2.5. VR Display. We import the completed jade model into Unity3D for an all-round virtual immersive display.

3.3. Construction of Visual Platform. By using the virtual engine Unity3D, the design in PS, the cutting in Maya, and the carving in ZBrush are integrated to build a new visual platform, which can keep the creative function of the original software to achieve the immersive experience of the whole process, as shown in Figure 4.

According to the above research on the VR process, the virtual jade carving can be obtained. However, the main body of the Xiuyan jade carving process of intangible culture is skills and forms of expression, which is the main part of intangible culture [22]. Therefore, the display of the jade carving process and the recording of processing must be completed in the virtual reality software Unity3D.

The most important step in the virtual jade processing platform is jade carving. The commonly used tools have different sizes and types, which can be divided into cutting pieces and various grinding heads. Virtual jade processing can use the brush function of ZBrush software to simulate the carving effect that real carving tools can achieve. As shown in Figure 5, every brush has Draw Size to adjust the brush size, and Z Intensity to adjust the brush intensity. When holding down the Alt key during engraving and drawing, the intensity becomes negative to realize reverse engraving, while holding down the Shift key to switch to the Smooth brush, which can replace the polishing effect. Moreover, the adjustment of the brush size can replace the switch of the real tool [23, 24].

The core idea of the development is equivalent to realizing virtual ZBrush sculpture in Unity3D. We import digital models and production tools into Unity3D as materials, and then control and combine the materials through coding and scripts to achieve the final effect. Therefore, the
innovative platform comprehensively develops the functions of plane, 3D, and engraving software based on ZBrush. Finally, with the virtual engine Unity3D as the medium, it is transformed into the virtual process of real jade carving processing.

3.4. Data Collection and Modeling

3.4.1. Digital Data Collection. In order to get more detailed information about Xiuyan jade, on-the-spot investigation on processing technology and collection of relevant information have been made, which include the following: collection of processing design patterns about Xiuyan jade; collection of the traditional processing tools of Xiuyan jade; and digital model for scanning and collecting jade. After the investigation, the materials such as pictures and patterns are further classified, screened and processed, and transformed into digital files needed for VR design.

3.4.2. Digital Pattern Processing. The evolution of Xiuyan jade design is innovated from simple patterns in primitive society to rough patterns in slave society, to exquisite patterns of flowers, birds, fish, insects, birds, animals, and auspicious patterns in the unique esthetics of each period. In the interactive design, the platform will provide users with the traditional Chinese jade carving patterns and the shapes of furnace or bottle. The collected
3.4.3. Construction of Digital Model. Digital modeling mainly includes two categories: one is Xiuyan experience, and only the arm operation appears in the virtual interface; and the other is Xiuyan carving tools. Many carving tools of jade will be used in the scene, such as flat knitting machines, electronic pens, saw blades of various styles, grinding heads, grinding needles, drill bits, and so on. The model of this link needs to achieve four basic principles [25]: accurate size, number optimization, surface optimization, and map optimization. Because the quality of the model will directly affect the fidelity of the virtual scene, the optimization will improve the running speed of the virtual scene [26]. Polygon modeling in Autodesk Maya can be completed, and the diamond sand drill bit needs to be added with metal effect and concave-convex parameters [27]. The experimenter’s arm needs to be modeled realistically. First, Autodesk Maya is used to make a simple polygon model of the hand. Then, the OBJ format is exported and imported into ZBrush, and the model is carefully carved by hand drawing board, as shown in Figure 6. Finally, the model is UV mapped and drawn to achieve visual realism. Figure 7 shows color map, bump normal map, and highlight map, respectively.

4. Systematic Development of Visual Platform

In the VR space, users’ behaviors and basic interactions belong to common technologies. This implementation can be developed through the default scenes, scripts, shader, preforms, and materials provided by the SteamVR plugin. The API script library built in the SteamVR plugin can realize handle interaction, space jump, ray detection, key control, vibration feedback, helmet positioning, stereo display, and other functions [28].

The virtual experience of the jade craft visualization platform is designed and developed by Unity2020. In the virtual processing experience, the jade is processed by the user’s arm control tool. In order to make users experience the machining process more truly, physical simulation is carried out on the process of operating tools in the Unity3D engine [29, 30]: for example, cutting grinders, carving tools, and masonry powder will rotate when they are exposed to
jade, which will be visually transmitted to users. At the same time, the virtual arm will send vibration feedback to remind users of the current operating state.

The core technology of VR is the pattern drawing, cutting, and carving of jade. The “design” experience of jade is realized by normal mapping technology in Unity3D space. The experience of “carving” of jade requires cutting and reconstruction of polygonal stones at the triangular level [31].

After the development, the system is published on PC, as shown in Figure 8. Figure 9 shows the implementation effect of the visual platform.

From the actual effect, the immersion, interaction, and imagination of virtual machining technology can make users feel virtual. When experiencing the processing technology of Xiuyan jade, users can get a sense of realism, presence, and participation. This form of personal experience plays a crucial role in the protection and inheritance of intangible cultural heritage. In the future, VR technology will provide more possibilities and greater development space for the digital protection of intangible culture.

5. Conclusions

Taking the intangible cultural heritage of Xiuyan jade carving technology as an example, the permanent preservation of traditional manual craft was realized. It can have effective image data, 3D model database, and resources of simulated spatial structure at the same time, and can preserve endangered traditional handicrafts in real time, scientifically and accurately, which is also an innovative model of digital protection for intangible cultural heritage. In addition, a visual interactive system with the perfect combination of knowledge and technology is constructed, which makes the traditional jade carving and virtual jade carving perfectly integrated; and through vivid means, tools, and carriers, a virtual process of jade carving is constructed. Finally, through digital media and digital platform, the intangible cultural heritage is displayed and disseminated, and the protection of intangible cultural heritage in digital space is further realized.

Data Availability

The dataset can be accessed upon request.
Conflicts of Interest

The authors declare that they have no conflicts of interest.

References


