Original Article

Design A Virtual Reality Interface to Enhance the User Experience of Intangible Cultural Heritage Protection

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Abstract: With the continuous development of science and technology, virtual reality (VR) technology has gradually become an important tool in intangible cultural heritage protection. This paper aims to design a virtual reality interactive interface to enhance the user experience of intangible cultural heritage protection. Firstly, the design objectives and requirements are determined by analyzing intangible cultural heritage's characteristics and protection needs. Then, an interactive interface design scheme is proposed based on the principle and application of virtual reality technology. The scheme includes user interface design, interaction design, and information display design. Finally, the effect of the design scheme is evaluated through user experiments, and the user experience is analyzed and summarized. The experimental results show that the designed virtual reality interactive interface can effectively improve the user experience of intangible cultural heritage protection, immerse users in the world of intangible cultural heritage, and enhance protection awareness and participation.

Keywords: Virtual reality; Intangible cultural heritage; User experience; Interactive interface; Protection.

1. Introduction

With the continuous development of science and technology, Virtual Reality (VR) technology has gradually become the focus of attention (Akdere et al., 2021). Virtual reality technology enables users to immerse themselves in a virtual environment by simulating the sensory experience of the real world. This technology has been widely used in entertainment, education, medical care and other fields, and has also shown great potential in cultural heritage protection (Walczak & White, 2003). Intangible cultural heritage is the crystallization of human wisdom and creativity, including oral traditions, performing arts, social practices, ceremonies, festivals and so on (Skublewska-Paszkowska et al., 2022). However, due to the particularity of intangible cultural heritage, its protection and inheritance face many challenges. Traditional conservation methods mainly rely on field visits and oral inheritance, which are limited by time, space and human resources (Hou et al., 2022). In addition, due to the particularity of intangible cultural heritage,

many intangible cultural heritage projects cannot be protected on the ground, resulting in the gradual disappearance of these precious cultural heritages (Hou et al., 2022).

Virtual reality technology provides a new solution for the protection and inheritance of intangible cultural heritage. Through virtual reality technology, users can experience intangible cultural heritage in a virtual environment and feel real scenes and emotions. Virtual reality technology can bring users into an infinite virtual space, so that users can personally experience the charm of intangible cultural heritage, and can also solve the limitation of time and space (De Paolis et al., 2022). However, the application of virtual reality technology in the field of intangible cultural heritage protection is still relatively small (Walczak & White, 2003). There are some problems in the user experience of the existing virtual reality interface, such as complex operation, lack of interactivity, lack of reality, etc. (Sutcliffe et al., 2019). These problems limit users' in-depth understanding and experience of intangible cultural heritage and affect users' enthusiasm and participation in intangible cultural heritage protection (Xu et al., 2022).

Therefore, this paper aims to design a virtual reality interactive interface to enhance the user experience of intangible cultural heritage protection. By improving the design of virtual reality interactive interface, users can be more convenient and intuitive to participate in the protection and inheritance of intangible cultural heritage (Zheng & Liu, 2022). This study will explore how VR can be used to create a more realistic and immersive user experience, and how to improve user understanding and engagement with intangible cultural heritage through interaction design. Through the implementation of this research, we expect to be able to provide an innovative solution for intangible cultural heritage protection and provide certain reference and reference for the application of virtual reality technology in the field of cultural heritage protection.

2. Application of Virtual Reality Technology

2.1. Application of Virtual Reality Technology in Intangible Cultural Heritage Protection

Intangible cultural heritage refers to the cultural heritage created by human beings and passed down in the form of oral traditions, performing arts, social practices, rituals, festivals, knowledge and practice, handicrafts and skills, and knowledge of nature and the universe (Kuptsova & Sazonova, 2022). Different from material cultural heritage, intangible cultural heritage is mainly inherited through oral traditions and practices. It is the crystallization of human wisdom and creativity and represents the identity and cultural inheritance of a specific community (Lu, 2016).

2.2. The Importance of Intangible Cultural Heritage

Intangible cultural heritage has important significance and value in human society. First of all, intangible cultural heritage is an important part of human cultural diversity, representing the unique cultural characteristics of different regions, nations and communities (Arizpe, 2004). Secondly, intangible cultural heritage is the witness of human history and tradition. Through inheritance and protection, people can better understand and recognize their own cultural roots (Lu, 2016). In addition, intangible cultural heritage also carries people's emotions, memories and identities, which play an important role in the cohesion and identity of the community (Ji et al., 2021). However, the intangible cultural heritage faces many challenges and threats, such as population aging, inheritance fragmentation, environmental changes, etc. Therefore, the protection and inheritance of intangible cultural heritage has become an important task of contemporary society (Popova & Fomenko, 2022).

2.3. The Application of Virtual Reality Technology in Intangible Cultural Heritage Protection

As an emerging interactive interface technology, virtual reality technology provides new possibilities for the protection and inheritance of intangible cultural heritage. Through virtual reality technology, people can experience the intangible cultural heritage in an immersive way and feel its unique charm and value. Virtual reality technology can simulate the scene, music, dance and other elements of intangible cultural heritage, so that users can participate in it personally and enhance their understanding and identification of intangible cultural heritage (Wu, 2023). In addition, VR technology can also help solve some difficult problems in the protection of intangible cultural heritage, such as inheritance fracture and environmental change. Through virtual reality technology, intangible cultural heritage can be preserved and inherited in the form of digital, avoiding material loss and inheritance difficulties in the traditional way (Xu et al., 2022). At the same time, virtual reality technology can also simulate the original environment of intangible cultural heritage, so that people can experience the real cultural environment in the virtual space, so as to better protect and inherit intangible cultural heritage (Shen, 2021).

To sum up, intangible cultural heritage, as an important part of human cultural diversity, has important significance and value. The application of virtual reality technology provides new ways and possibilities for

the protection and inheritance of intangible cultural heritage, provides users with a more immersive experience, and improves the user experience of intangible cultural heritage protection.

2.4. The Application of Virtual Reality Technology in Intangible Cultural Heritage protection

Virtual Reality (VR) technology is a computer-generated simulation environment that enables users to interact with and experience immersive experiences in a virtual world. The core of virtual reality technology is to completely immerse users in a virtual environment through head-mounted displays, gamepads, sensors and other devices to make them feel as if they are in the scene (Dudakov, 2021). The application of virtual reality technology in intangible cultural heritage protection has great potential (Shen, 2021). Firstly, VR technology can provide a highly realistic environment that enables users to personally experience the unique charm of intangible cultural heritage (Fu et al., 2023). Through virtual reality technology, users can visit traditional villages, watch traditional performances, and learn traditional crafts in a virtual environment without going to the site (Yapp & Kim, 2022).

This immersive experience can greatly improve users' understanding and appreciation of intangible cultural heritage. Secondly, virtual reality technology can realize the digital preservation and inheritance of intangible cultural heritage. Many intangible cultural heritages face the erosion of time and the loss of human resources. Virtual reality technology can preserve these intangible cultural heritages through digital means, and make more people understand and learn through the display and dissemination of virtual environment (Walczak & White, 2003). For example, through virtual reality technology, traditional folk stories, traditional music, traditional dance, etc. can be preserved in digital form, and more people can enjoy and learn through the display of virtual environments.

In addition, VR technology can also provide interactive learning and interactive experience. Traditional intangible cultural heritage protection can only be displayed by static ways such as words and pictures, while virtual reality technology can enable users to participate in it personally and interact with the characters in the virtual environment through interactive ways (Feng, 2023). This interactive learning and experience can better stimulate users' interest and participation and enhance users' awareness and participation in the protection of intangible cultural heritage (Shen, 2021). To sum up, the application of VR technology in intangible cultural heritage protection has a broad prospect. By providing immersive experience, digital preservation and inheritance, as well as interactive learning and interactive experience, virtual reality technology can greatly improve the user experience of intangible cultural heritage protection and promote the inheritance and development of intangible cultural heritage.

2.5. Advantages of virtual reality technology in intangible cultural heritage protection

Virtual reality technology has many advantages in the protection of intangible cultural heritage, which make it an effective tool to enhance user experience. The following are the main advantages of virtual reality technology in the protection of intangible cultural heritage:

1. Immersive experience: Virtual reality technology can provide immersive experience, making users feel like they are in the actual scene of intangible cultural heritage. Through virtual reality technology, users can personally experience the unique charm of intangible cultural heritage and feel its unique atmosphere and emotions (Xu et al., 2022).

2. Interactivity: Virtual reality technology can provide rich interactivity, enabling users to interact with intangible cultural heritage (Selmanović et al., 2020). Users can interact with the cultural heritage in the virtual environment through gestures, voice or other interactive means to further deepen their understanding and experience of the intangible cultural heritage (Zhu, 2022).

3. Visual presentation: Virtual reality technology can present intangible cultural heritage to users in a more intuitive and vivid way. Through virtual reality technology, users can watch performances, displays and demonstrations of traditional skills of intangible cultural heritage, as well as participate in them, so as to better understand and appreciate the unique features of intangible cultural heritage (Selmanović et al., 2020).

4. Cross-time transmission: Virtual reality technology can deliver intangible cultural heritage to users across time and space. Through virtual reality technology, users can experience intangible cultural heritage that has disappeared or cannot be experienced in person, such as ancient buildings and traditional festivals (Zhu, 2022). This transmission across time and space can help users better understand and protect intangible cultural heritage.

5. Educational: Virtual reality technology can provide educational experiences that enable users to learn and understand the history, context, and significance of intangible cultural heritage. Through virtual reality technology, users can participate in the protection and inheritance of intangible cultural heritage, thereby cultivating a sense of identity and responsibility for intangible cultural heritage (Xiao et al., 2022). To sum up, virtual reality technology has the advantages of immersive experience, interaction, visual presentation, cross-time transmission, and education in the protection of intangible cultural heritage (Zhang et al., 2023). These advantages make virtual reality technology an important tool to enhance user experience and promote the protection of intangible cultural heritage. By making full use of the advantages of virtual reality technology, intangible cultural heritage can be better protected and passed on, and users' understanding and appreciation of intangible cultural heritage can be improved (Kuptsova & Sazonova, 2022).

3. Design Principles of Virtual Reality Interactive Interfaces

User experience refers to the overall feeling and satisfaction that users feel when using a product or service (Berni & Borgianni, 2021). When designing virtual reality interface, the importance of user experience cannot be ignored. A good user experience can enhance users' participation and interest in intangible cultural heritage protection, making them more willing to actively participate in and support related activities (Zhu, 2022). Firstly, user experience directly affects the user's intention to use the virtual reality interactive interface. If users are confused, inconvenient, or dissatisfied during use, they may give up or switch to other better options. On the contrary, if users have a good experience, they will be more willing to use the VR interactive interface for a long time and improve their participation in the protection of intangible cultural heritage (Lacoche et al., 2022).

Secondly, user experience also plays an important role in improving users' understanding and cognition of intangible cultural heritage. By designing an intuitive and easy to understand interactive interface, users can more easily browse and understand the relevant information of intangible cultural heritage (Hulusic et al., 2023). For example, by using VR technology, users can visit the making process of traditional handicrafts in an immersive way to gain an in-depth understanding of the cultural connotation behind them. This immersive experience can enhance users' cognition and understanding of intangible cultural heritage. In addition, UX can also improve user satisfaction and loyalty to the VR interactive interface. Users are more likely to recommend it to others and continue to use the interface if they are pleasurable and satisfied with it. Such word-of-mouth communication and user loyalty are of great significance for the promotion and inheritance of intangible cultural heritage protection (Wilson et al., 2022).

In summary, user experience plays a crucial role in designing VR interactive interfaces. By focusing on user experience and providing intuitive, easy-to-use and immersive interface design, users can enhance their participation and interest in intangible cultural heritage protection, enhance their cognition and understanding of cultural heritage, and improve user satisfaction and loyalty (Wu, 2023). Therefore, user experience should be put in the primary position when designing virtual reality interactive interfaces to ensure that users can obtain the best use experience. The basic principles of virtual reality interactive interface design refer to some basic guidelines and principles that should be followed when designing virtual reality interactive interfaces to improve user experience and achieve the goal of intangible cultural heritage protection. Here are the basic principles of virtual reality interface design:

Learnability means that users can quickly learn and master the operation mode and function of the virtual reality interactive interface. In the design of virtual reality interactive interface, the cognitive burden of the user should be reduced as much as possible, and the interface layout and operation mode should be intuitive, concise, and consistent (Liccardo & Bonavolontà, 2022). For example, common ICONS and symbols are adopted to provide clear instructions and prompts to help users quickly understand and master the functions and operation methods of the interface.

Feedback refers to the ability of the virtual reality interactive interface to provide users with operation results and status information in a timely and accurate manner. When designing the VR interactive interface, feedback should be provided to the user through various ways, such as visual and auditory, to help the user understand whether his operation is successful, as well as the current state and progress of the system. For example, the results of the operation and the reaction of the system are shown to the user through animation effects and sound prompts, so as to enhance the user's sense of participation and satisfaction (Raswan et al., 2023).

Consistency means that all parts of the virtual reality interactive interface are consistent in function, operation mode, and interface style and so on. In the design of virtual reality interactive interface, we should try to follow the uniform design specification and style, so that users can quickly switch and adapt

between different interfaces and functions (Su et al., 2013). For example, maintaining similar button styles and layouts, consistent color and font styles, and consistent interaction logic and actions can improve user experience and efficiency.

Controllability refers to the ability of users to independently select and control the functions and operation modes of the virtual reality interactive interface. In the design of virtual reality interactive interface, flexible setting options and personalized customization functions should be provided to meet the needs and preferences of different users (Huang et al., 2012). For example, it provides adjustable interface brightness and volume, customized keyboard shortcuts and gesture operations, and personalized interface layout and theme styles to enhance user engagement and satisfaction.

Reliability means that the VR interactive interface can operate and respond to user actions stably and reliably. When designing the virtual reality interactive interface, the stability and performance of the system should be considered to avoid the problems such as crash and stagnation, to ensure the normal use and experience of users. For example, performing adequate testing and optimization to ensure interface fluency and responsiveness, as well as providing reliable error handling and recovery mechanisms to enhance user trust and satisfaction (Sun & Li, 2023).

By following the above basic principles, the design of virtual reality interactive interface can improve the learning efficiency, operation convenience and satisfaction of users, so as to improve the user experience of intangible cultural heritage protection. The design of virtual reality interactive interfaces faces some challenges in improving the user experience of intangible cultural heritage protection. These challenges include technical, human-computer interaction, and user experience aspects (Liu, 2022). Firstly, technical challenges are important factors that must be considered when designing VR interactive interfaces. Although the development of virtual reality technology has made great progress, there are still some technical limitations. For example, the high cost of virtual reality devices limits user penetration; The volume of virtual reality equipment is large, which is inconvenient to carry. The resolution and frame rate of virtual reality devices have a certain impact on the user experience (Schleussinger, 2022). Therefore, these technical limitations should be fully considered when designing VR interactive interfaces to provide a better user experience. Secondly, human-computer interaction challenges are one of the issues to be addressed when designing VR interactive interfaces. Virtual reality interactive interfaces need to interact effectively with the user to provide an immersive experience.

However, due to the particularity of virtual reality technology, traditional human-computer interaction methods may not be fully applicable to virtual reality environments (Nandy et al., 2023). For example, the traditional way of mouse and keyboard interaction may not be intuitive and natural enough in a VR environment. Therefore, it is necessary to explore new human-computer interaction methods when designing virtual reality interactive interfaces to provide better user experience. Finally, user experience challenges are important issues to be concerned with when designing VR interactive interfaces. The design of the virtual reality interactive interface should be able to meet the needs of users and provide a good user experience. However, since each user has different needs and experience preferences, designing a VR interaction interface that can adapt to all users is a challenging task. Therefore, it is necessary to conduct user studies to understand the needs and experience preferences of users when designing virtual reality interactive interfaces, and to design interfaces based on this information to provide personalized user experiences. In summary, VR interactive interface design faces challenges in terms of technology, human-computer interaction, and user experience in enhancing user experience of intangible cultural heritage protection. Overcoming these challenges requires designers to constantly explore innovations that combine user needs and technological developments to provide a better user experience.

4. Virtual Reality Interactive Interface Design Methods
4.1. User Demand Analysis

Before designing the virtual reality interactive interface to enhance the user experience of intangible cultural heritage protection, the user needs analysis should be carried out first. User requirements analysis is to understand the expectations, needs and preferences of users in order to meet their expectations and provide a better user experience during the design process (Qiu et al., 2023). First, you need to identify the target user group. Intangible cultural heritage protection involves people of all ages, different cultural backgrounds, and interests (Guo & Wang, 2022). Therefore, we need to divide the user population into different subgroups to better meet their needs. Through questionnaires, interviews or focus group discussions, users' expectations and needs for intangible cultural heritage protection were collected.

These needs may include the understanding of cultural heritage, interactive participation, learning experience and so on. Through research, users' expectations and requirements for virtual reality interactive

interfaces can be obtained, which provides a basis for subsequent design (Yeh et al., 2022). By observing the behavior of users in intangible cultural heritage protection activities, their behavior patterns and habits are analyzed. This helps to understand the expectations and needs of users when using VR interactive interfaces, as well as the problems and challenges they may encounter. User behavior analysis can provide guidance for interface design to make it more in line with user habits and expectations (Zhu, 2022).

4.2. Interactive Design Prototyping

Interaction design prototyping is one of the important steps in designing virtual reality interface. By making the interactive design prototype, the function and interaction mode of the virtual reality interactive interface can be better displayed, and the content of intangible cultural heritage protection can be better understood and experienced by users (Freitas et al., 2020). Experience prototyping studies in VR have been conducted to understand user experience (UX) and expectations. These studies have revealed design recommendations to answer user concerns and expectations, including the provision of enough margin of error in gestural manipulations, prevention of driver and passenger distractions, keeping up with the technology within the car's life cycle, involvement in the journey, collaboration with the driver, and relatedness to social networks (Sen & Sener, 2020). When prototyping an interaction design, it is first necessary to clarify the function and interaction requirements of the virtual reality interaction interface.

According to the characteristics of intangible cultural heritage protection and user needs, the elements that need to be displayed in the interface and the interaction mode are determined. For example, it can include multimedia content such as pictures, videos, and audios that display intangible cultural heritage, and ways for users to interact with the virtual environment, such as gesture recognition and head tracking (Bach et al., 2019). Next, based on the functional and interaction requirements, interaction design tools are used to make an interaction design prototype. One can choose to use professional interaction design software such as Axure, Sketch, etc., or use online interaction design tools such as Figma, In Vision, etc. With these tools, static and dynamic effects of the virtual reality interactive interface can be created to simulate the interaction process between the user and the interface (Sayara et al., 2023).When prototyping an interaction design, the following points should be noted.

Firstly, the layout of the interface and the arrangement of elements should be in line with the user's habits and intuition, so that the user can quickly understand and use the interface (Jing et al., 2023). Secondly, the interaction mode should be simple and clear to avoid too many operation steps and complex interaction process, to improve the efficiency and experience of users. In addition, it is necessary to consider the limitations and characteristics of VR devices to ensure the feasibility and usability of interaction design prototypes in VR environments (Freitas et al., 2020). Through interaction design prototyping, it can help designers and users better understand and evaluate the design options of virtual reality interactive interfaces. Designers can find and solve problems in design in time through prototype production and improve the quality and effect of design.

By interacting with the interaction design prototype, users can feel the use experience of the virtual reality interaction interface in advance, and make suggestions and opinions for improvement, so as to better meet the needs and expectations of users (Stöcklein et al., 2010). In short, interaction design prototyping is an important part of designing virtual reality interactive interfaces. Through prototyping, the functions and interaction modes of virtual reality interactive interfaces can be better displayed, and the user experience of intangible cultural heritage protection can be improved.

5. A Case Study of Virtual Reality Interactive Interface Design

This chapter will discuss how to improve the user experience of intangible cultural heritage protection by designing virtual reality interactive interfaces through two case studies of virtual reality interactive interface design. VR Interface in ITB Electric Car's Virtual Exhibition: This case study focuses on the virtual reality user interface (VRUI) from ITB electric car's virtual exhibition. The research aimed to understand the ideal experience of VRUI from the user's perspective and needs, thus enabling designers and developers to develop the VRUI based on these factors (Nadia, 2018).

SCeVE - A Component-based Framework to Author Mixed Reality Tours: This case study presents SCeVE, a component-based framework that supports flexible design and authoring of interactive mixed reality (MR) tours. It offers ease of access to design choices such as synchronization, collaborative exploration, visualization, and evaluation. The framework empowers authors to focus only on the design of the required virtual environments, enabling the creation of diverse collaborative MR tours (Vellingiri et al., 2020).

A Novel Augmented Reality-based Interface for Robot Path Planning: This study presents a novel augmented reality-based interface for robot path planning. It explores the use of augmented reality in the

context of robot path planning, demonstrating the potential for innovative interfaces in this domain (Fang et al., 2014). The CRC Handbook of Computer Science and Engineering comprehensively covers a wide range of topics, encompassing the evolution of computing paradigms, models of interaction, software engineering, artificial intelligence, open systems, object-oriented design principles, multiple interface models, technologies for interoperability and design patterns. Additionally, it delves into coordination mechanisms and agent-oriented programming. The handbook also presents case studies on virtual reality and data information systems to showcase the inherent effectiveness of interactive models in computer graphics applications and more broadly in empirical computer science research (Wegner, 1998).

6. User experience evaluation and improvement

6.1. User Experience Evaluation Survey Methodology

In order to evaluate the user experience of the VR interactive interface in intangible cultural heritage protection, we used two methods: supervisor user testing and questionnaire survey. Evaluating the user experience of VR interactive interfaces in intangible cultural heritage protection involves assessing various aspects such as usability, immersion, interaction, and user satisfaction. Two methods commonly used for this purpose are supervisor user testing and questionnaire surveys. In supervisor user testing, the user's interaction with the VR interface is observed and analyzed by a supervisor or researcher. This method allows for real-time feedback and the ability to identify issues that may not be apparent to the user. For instance, the study "in VR Note: Design, Creation and Evaluation of an Interactive Note-Taking Interface for Study and Reflection in VR Learning Environments" used supervisor user testing to evaluate the pedagogical benefits of a novel interactive note-taking interface in VR (Chen et al., 2019).

Questionnaire surveys, on the other hand, are used to gather user feedback after interacting with the VR interface. This method can provide valuable insights into the user's subjective experience and satisfaction. For example, the study "The Influence of in-VR Questionnaire Design on the User Experience" used questionnaire surveys to assess user experience, the effect on presence, duration of completing the questionnaires, and users' preferences (Safikhani et al., 2021). An effective way to evaluate the user experience is to observe the user's actions on the VR interface and record their reactions and behaviors. We invited 25 volunteers as test users, who were more suitable to evaluate the interface we designed due to their interest in intangible cultural heritage protection. During the test, we recorded the user's operation path on the interface, the operation time, and the user's feelings and feedback.

We designed a questionnaire that integrated multiple aspects to evaluate user feedback on the VR interactive interface in terms of satisfaction, ease of use, and user engagement. We distributed this questionnaire to the test users and performed statistics and analysis on their response results. Based on the supervisor user test and questionnaire data, we conducted exhaustive statistics and analysis of the user's operation path, operation time and feedback. Through these analysis results, we found some problems and shortcomings. Based on the analysis of user operation path and operation time, we noticed that some users encountered confusion or inconvenience when using the VR interactive interface. For example, when searching for specific intangible cultural heritage information, some users need to go through multiple steps and spend a long time.

Others are confused when interacting and need prompts and guidance to complete tasks. These issues directly affect the user experience. According to the feedback from the testers, they are generally satisfied with the virtual reality interface: the interface design is beautiful, the interaction style is unique, and the experience is realistic. However, a small number of testers mentioned several areas of improvement, such as the slow responsiveness of the interface and the lack of intuitive operation of some features.

6.2. User Experience Improvement Strategies

On the basis of the analysis of the user experience evaluation results, we adopt the following improvement strategies to enhance the user experience of the virtual reality interactive interface. In order to solve the problem that users need to go through multiple steps when searching for information, we will simplify the operation path and optimize the way of searching and presenting information, so that users can obtain the intangible cultural heritage information they need more quickly and conveniently.

Adaptive Clustering of Search Results: This approach involves reorganizing search results based on user actions, such as reran king documents based on a selected cluster or a viewed document, merging unselected clusters, and promoting "near-miss" documents. This can help users find relevant information more quickly (Shen et al., 2009). In order to solve the confusion of users in the interactive operation, we will add clear operation guidelines to the design of the interface, and provide tips and help functions, so that users can more conveniently and quickly complete a variety of interactive operations.

Understanding User Cognition: Research suggests that understanding the general cognitive model of people in visual information search can help in designing interfaces that conform to the user's cognitive model. This involves analyzing each step of the user interaction process and understanding the user's cognitive law under the guidance of different interfaces (Wu, 2021).

Affordance Design Approach: This approach focuses on improving the affordances of user interfaces. Affordances are properties of an object that show the possible actions users can take with it, thereby suggesting how they can interact with the interface. This approach can help make e-learning and other interactive operations effortless (Park & Song, 2015). In order to solve the problem of slow interface response speed mentioned in user feedback, we will optimize the program code to improve the operating efficiency of the system and ensure that the response speed of the interface meets the user's expectation. Through the implementation of user experience evaluation and improvement measures, we expect to provide better virtual reality interactive interfaces and enhance users' experience and sense of participation in intangible cultural heritage protection. At the same time, we are aware that user experience is a long-term process, and further improvement and optimization of VR interaction interfaces are needed in future research to meet evolving user requirements.

7. Conclusions

This study aims to design virtual reality interactive interfaces to enhance the user experience of intangible cultural heritage protection. Based on the analysis of existing intangible cultural heritage protection methods and research on virtual reality technology, we designed an interactive interface that aims to provide users with a more immersive and interactive experience. We evaluated the designed interactive interface by implementing user surveys and experiments. The results show that the interface has achieved significant results in improving the user experience. Users expressed a high degree of satisfaction with the application of virtual reality technology and believed that the interface could better display the characteristics and value of intangible cultural heritage. The main contributions of this study include the following aspects are firstly, we design an interactive interface based on virtual reality technology, which provides a new display way for intangible cultural heritage protection.

The interface enables users to understand and experience intangible cultural heritage more deeply through immersive experience and interactive design. Secondly, we verify the effectiveness of the designed interactive interface in improving user experience through user research and experiments. The improvement of user satisfaction and experience for the interface proves the potential of virtual reality technology in the protection of intangible cultural heritage. Finally, this study provides some perspectives for further research. There is still a lot of room for the development of virtual reality technology in the protection of intangible cultural heritage. Future research can further explore how to combine other technologies, such as artificial intelligence and augmented reality, to enhance the effect of intangible cultural heritage protection. In addition, user needs and experiences for different types of intangible cultural heritage can be further studied to better meet the needs of users.

References

Akdere, M., Acheson, K., & Jiang, Y. (2021). Retracted: An examination of the effectiveness of virtual reality technology for intercultural competence development. *International Journal of Intercultural Relations*, *82*(5), 109–120. https://doi.org/10.1016/j.ijintrel.2021.03.009

Arizpe, L. (2004). Intangible Cultural Heritage, Diversity and Coherence. *Museum International*, *56*(1–2), 130–136. https://doi.org/10.1111/j.1350-0775.2004.00467.x

Bach, B., Cordeil, M., Engelke, U., Ens, B., Serrano, M., & Willett, W. (2019). Interaction Design & Prototyping for Immersive Analytics. *Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems*, 1–8. https://doi.org/10.1145/3290607.3299019

Berni, A., & Borgianni, Y. (2021). From The Definition Of User Experience To A Framework To Classify Its Applications In Design. *Proceedings of the Design Society*, *1*(7), 1627–1636. https://doi.org/10.1017/pds.2021.424

Chen, Y.-T., Hsu, C.-H., Chung, C.-H., Wang, Y.-S., & Babu, S. V. (2019). iVRNote: Design, Creation and Evaluation of an Interactive Note-Taking Interface for Study and Reflection in VR Learning Environments. *2019 IEEE Conference on Virtual Reality and 3D User Interfaces (VR)*, 172–180. https://doi.org/10.1109/VR.2019.8798338

De Paolis, L. T., Chiarello, S., Gatto, C., Liaci, S., & De Luca, V. (2022). Virtual reality for the enhancement of cultural tangible and intangible heritage: The case study of the Castle of Corsano. *Digital Applications in Archaeology and Cultural Heritage*, *27*(12), e00238. https://doi.org/10.1016/j.daach.2022.e00238

Dudakov, N. (2021). Research of immersion in virtual reality technology for the stage of information systems design. *Графикон-Конференции По Компьютерной Графике и Зрению*, *31*, 1125–1130.

Fang, H. C., Ong, S. K., & Nee, A. Y. C. (2014). A novel augmented reality-based interface for robot path planning. *International Journal on Interactive Design and Manufacturing (IJIDeM)*, *8*(1), 33–42. https://doi.org/10.1007/s12008-013-0191-2

Feng, F. (2023). Research on the Protection System of Tangka Intangible Cultural Heritage Based on VR Technology. *Academic Journal of Science and Technology*, *7*(2), 178–182. https://doi.org/10.54097/ajst.v7i2.12265

Freitas, F., Oliveira, H., Winkler, I., & Gomes, M. (2020). Virtual Reality on Product Usability Testing: A Systematic Literature Review. *2020 22nd Symposium on Virtual and Augmented Reality (SVR)*, 67–73. https://doi.org/10.1109/SVR51698.2020.00025

Fu, K., Sharudin, S. A., Wang, Y., & Huang, Z. (2023). Virtual Reality in Ancient Village Cultural Heritage Protection: Zhen Shan Village Case Study. *Journal of Sociology and Ethnology*, *5*(9), 22–26. https://doi.org/10.23977/jsoce.2023.050904

Guo, L., & Wang, J. (2022). Research on the Protection and Inheritance of Intangible Cultural Heritage Based on Digital Technology. In *The Frontiers of Society, Science and Technology* (Vol. 3, Issue 8, pp. 677–683). Francis Academic Press. https://doi.org/10.3233/ATDE221084

Hou, Y., Kenderdine, S., Picca, D., Egloff, M., & Adamou, A. (2022). Digitizing Intangible Cultural Heritage Embodied: State of the Art. *Journal on Computing and Cultural Heritage*, *15*(3), 1–20. https://doi.org/10.1145/3494837

Huang, S.-H., Yang, Y.-I., & Chu, C.-H. (2012). Human-centric design personalization of 3D glasses frame in markerless augmented reality. *Advanced Engineering Informatics*, *26*(1), 35–45. https://doi.org/10.1016/j.aei.2011.07.008

Hulusic, V., Gusia, L., Luci, N., & Smith, M. (2023). Tangible User Interfaces for Enhancing User Experience of Virtual Reality Cultural Heritage Applications for Utilization in Educational Environment. *Journal on Computing and Cultural Heritage*, *16*(2), 1–24. https://doi.org/10.1145/3593429

Ji, Y., Zhong, S., Zhang, B., & Sean, C. (2021). Constructing Embodied Interaction of Intangible Cultural Heritage Course through Immersive Virtual Reality. *The Ninth International Symposium of Chinese CHI*, 133–138. https://doi.org/10.1145/3490355.3490373

Jing, X., Patel, V. L., Cimino, J. J., Shubrook, J. H., Zhou, Y., Draghi, B. N., Ernst, M. A., Liu, C., & De Lacalle, S. (2023). A Visual Analytic Tool (VIADS) to Assist the Hypothesis Generation Process in Clinical Research: Mixed Methods Usability Study. *JMIR Human Factors*, *10*(1), 44–644. https://doi.org/10.2196/44644

Kuptsova, I. A., & Sazonova, V. A. (2022). Intangible Cultural Heritage: Conceptual Approaches to the Phenomenon Definition. *Observatory of Culture*, *19*(1), 56–64. https://doi.org/10.25281/2072-3156-2022-19-1-56-64

Lacoche, J., Villain, E., & Foulonneau, A. (2022). Evaluating Usability and User Experience of AR Applications in VR Simulation. *Frontiers in Virtual Reality*, *3*, 881318. https://doi.org/10.3389/frvir.2022.881318

Liccardo, A., & Bonavolontà, F. (2022). VR, AR, and 3-D User Interfaces for Measurement and Control. *Future Internet*, *15*(1), 1–18. https://doi.org/10.3390/fi15010018

Liu, H. (2022). Digital Interactive Technology of Intangible Cultural Heritage Based on Virtual Reality Technology. *2022 2nd International Conference on Networking, Communications and Information Technology (NetCIT)*, 298–302. https://doi.org/10.1109/NetCIT57419.2022.00077

Lu, T. L.-D. (2016). The Routledge Companion to Intangible Cultural Heritage. In M. Stefano & P. Davis (Eds.), *The Routledge companion to intangible cultural heritage*. Routledge. https://doi.org/10.4324/9781315716404

Nadia, Z. (2018). Expectations and Ideal VRUI from User's Perspective, Case Studies: VR Interface in ITB Electric Car's (Molina) Virtual Exhibition. *Journal of Computers*, *13*(6), 721–732. https://doi.org/10.17706/jcp.13.6.721-732

Nandy, A., Smith, J., Jennings, N., Kuniavsky, M., Hartmann, B., & Goucher-Lambert, K. (2023). Vr Or Not? Investigating Interface Type And User Strategies For Interactive Design Space Exploration. *Proceedings of the Design Society*, *3*(7), 3851–3860. https://doi.org/10.1017/pds.2023.386

Park, H., & Song, H.-D. (2015). Make e-learning effortless! Impact of a redesigned user interface on usability through the application of an affordance design approach. *Journal of Educational Technology & Society*, *18*(3), 185–196.

Popova, A., & Fomenko, E. (2022). The Place of Intangible Cultural Heritage in the State Policy of China. *Культура и Искусство*, *11*, 42–53. https://doi.org/10.7256/2454-0625.2022.11.38835

Qiu, B., Zheng, C., Wang, Z., Cheng Xie, L., Zhan, X., Zeng, Y., & Zhang, X. (2023). Innovative Strategies for Generative Art in the NFT Market: A Case Study of the Art Blocks. *Ergonomics In Design*, *77*, 129–138. https://doi.org/10.54941/ahfe1003370

Raswan, M., Kay, T., Camarillo-Abad, H. M., Cibrian, F. L., & Qi, T. Di. (2023). Guess the Gesture: Uncovering an Intuitive Gesture-based User Interface for 3D Content Interaction in Virtual Reality. *Creativity and Cognition*, 361–364. https://doi.org/10.1145/3591196.3596610

Safikhani, S., Holly, M., Kainz, A., & Pirker, J. (2021). The Influence of in-VR Questionnaire Design on the User Experience. *Proceedings of the 27th ACM Symposium on Virtual Reality Software and Technology*, 1–8. https://doi.org/10.1145/3489849.3489884

Sayara, A., Chen, E. L., Nguyen, C., Xiao, R., & Yoon, D. (2023). GestureCanvas: A Programming by Demonstration System for Prototyping Compound Freehand Interaction in VR. *Proceedings of the 36th Annual ACM Symposium on User Interface Software and Technology*, 1–17. https://doi.org/10.1145/3586183.3606736

Schleussinger, M. (2022). *Towards the ultimate search interface-A research plan* (pp. 1–11).

Selmanović, E., Rizvic, S., Harvey, C., Boskovic, D., Hulusic, V., Chahin, M., & Sljivo, S. (2020). Improving Accessibility to Intangible Cultural Heritage Preservation Using Virtual Reality. *Journal on Computing and Cultural Heritage*, *13*(2), 1–19. https://doi.org/10.1145/3377143

Sen, G., & Sener, B. (2020). Design for Luxury Front-Seat Passenger Infotainment Systems with Experience Prototyping through VR. *International Journal of Human–Computer Interaction*, *36*(18), 1714–1733. https://doi.org/10.1080/10447318.2020.1785150

Shen, X., Zhai, C., & Belkin, N. J. (2009). *Adaptive Clustering of Search Results* (pp. 447–453). Technical report. https://doi.org/10.1007/978-3-642-02247-0_51

Shen, Y. (2021). Study on the Protection and Product Development of Intangible Cultural Heritage with Computer Virtual Reality Technology. In *Data Science: 7th International Conference of Pioneering Computer Scientists, Engineers and Educators, ICPCSEE 2021, Taiyuan, China, September 17–20, 2021, Proceedings, Part I 7* (pp. 515–527). Springer. https://doi.org/10.1007/978-981-16-5940-9_39

Skublewska-Paszkowska, M., Milosz, M., Powroznik, P., & Lukasik, E. (2022). 3D technologies for intangible cultural heritage preservation—literature review for selected databases. *Heritage Science*, *10*(1), 1–24. https://doi.org/10.1186/s40494-021-00633-x

Stöcklein, J., Pogscheba, P., Geiger, C., & Paelke, V. (2010). MiReAS. *Proceedings of the 7th International Conference on Computer Graphics, Virtual Reality, Visualisation and Interaction in Africa*, 27–36. https://doi.org/10.1145/1811158.1811164

Su, K. W., Wang, H. Y., Wu, Y. Y., & Kuo, N. H. (2013). The Interface Design and Usability Evaluation of Interactive Virtual Reality Navigation System. *Applied Mechanics and Materials*, *302*, 635–639. https://doi.org/10.4028/www.scientific.net/AMM.302.635

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Sun, Y., & Li, J. (2023). User Interface Design and Interactive Experience Based on Virtual Reality. *Computer-Aided Design and Applications*, 184–195. https://doi.org/10.14733/cadaps.2023.S13.184-195

Sutcliffe, A. G., Poullis, C., Gregoriades, A., Katsouri, I., Tzanavari, A., & Herakleous, K. (2019). Reflecting on the Design Process for Virtual Reality Applications. *International Journal of Human–Computer Interaction*, *35*(2), 168–179. https://doi.org/10.1080/10447318.2018.1443898

Vellingiri, S., McMahan, R. P., & Prabhakaran, B. (2020). SCeVE: A component-based framework to author mixed reality tours. *ACM Transactions on Multimedia Computing, Communications, and Applications*, *16*(2), 1–23. https://doi.org/10.1145/3377353

Walczak, K., & White, M. (2003). Cultural heritage applications of virtual reality. *Proceedings of the Eighth International Conference on 3D Web Technology*, 182–183. https://doi.org/10.1145/636593.636623

Wegner, P. (1998). Interactive foundations of computing. *Theoretical Computer Science*, *192*(2), 315–351. https://doi.org/10.1016/S0304-3975(97)00154-0

Wilson, B., Hull, J., & Schofield, D. (2022). An Evaluation of the use of Audio Guidance in Augmented Reality Systems Implemented at Sites of Cultural Heritage. *The International Journal of Multimedia & Its Applications*, *14*(02), 1–23. https://doi.org/10.5121/ijma.2022.14201

Wu, F. (2021). Research on User Operation of High-density Entity Interactive Target Quantitative Simulation Interface. *Journal of Physics: Conference Series*, *1952*(3), 032031. https://doi.org/10.1088/1742-6596/1952/3/032031

Wu, X. (2023). Application of Virtual Reality Technology in the Digital Inheritance of Intangible Cultural Heritage. *2023 International Conference on Distributed Computing and Electrical Circuits and Electronics (ICDCECE)*, 1–6. https://doi.org/10.1109/ICDCECE57866.2023.10151329

Xiao, J., Guo, S., & Zhou, T. (2022). Research on Virtual Reality Technology in Traditional Architecture Protection. *2021 International Conference on Culture, Design and Social Development (CDSD 2021)*, 242–245. https://doi.org/10.2991/assehr.k.220109.049

Xu, W., Sun, X., & Pan, S. (2022). Visual Dissemination of Intangible Cultural Heritage Information Based on 3D Scanning and Virtual Reality Technology. *Scanning*, *10*(9), 1–7. https://doi.org/10.1155/2022/8762504

Yapp, A., & Kim, L. C. (2022). The Development of an Immersive Malay Village Virtual Reality Experience. *Asian Journal of Arts, Culture and Tourism*, *4*(1), 42–51.

Yeh, S.-C., Wu, E. H.-K., Lee, Y.-R., Vaitheeshwari, R., & Chang, C.-W. (2022). User Experience of Virtual-Reality Interactive Interfaces: A Comparison between Hand Gesture Recognition and Joystick Control for XRSPACE MANOVA. *Applied Sciences*, *12*(23), 12–230. https://doi.org/10.3390/app122312230

Zhang, L., Wang, Y., Tang, Z., Liu, X., & Zhang, M. (2023). A Virtual Experience System of Bamboo Weaving for Sustainable Research on Intangible Cultural Heritage Based on VR Technology. *Sustainability*, *15*(4), 31–34. https://doi.org/10.3390/su15043134

Zheng, Y., & Liu, X. (2022). Discussion on Two Intangible Cultural Heritage Inheritance Patterns: A Case Study of Dunhuang Painted Sculpture. *Journal of Humanities and Social Sciences Studies*, *4*(3), 254–259. https://doi.org/10.32996/jhsss.2022.4.3.28

Zhu, L. (2022). Optimization of Digital Media Product Interface Design Based on Multidimensional Heterogeneous Emotion Analysis of Users. *Mathematical Problems in Engineering*, *2022*, 1–8. https://doi.org/10.1155/2022/6944909