

The people of the Central Plains who migrated southward to escape the war brought the advanced culture of the Central Plains to Fujian and integrated with the local aborigines, gradually forming a native architectural style that reflects the Confucian ideal of living in the heart of a large family and includes a defensive function. Tulou are structured in a variety of ways, and the design of the internal space takes into account the factor of livability, reflecting the harmony between human beings and nature. The development of digital technology has provided new ways for the protection and dissemination of cultural heritage, such as the digital display project of the Forbidden City. However, existing studies have insufficiently explored the combination of Hakka clan culture and digital technology, especially at the philosophical level.

1.2 Research Significance

The significance of this study lies in exploring how to effectively inherit and disseminate Hakka clan culture in the digital age, particularly its philosophical ideas. By analyzing the philosophical connotations of Hakka culture and the application of digital technology, this study aims to provide new perspectives and methods for the protection and dissemination of traditional culture. This is crucial for engaging the younger generation in Hakka culture and for promoting and preserving this unique cultural heritage globally. Additionally, this study will offer valuable references for the digital inheritance of traditional culture in other regions.

1.3 Literature Review

1.3.1 Hakka Culture and Traditional Folk Houses

In the 1980s, Japanese scholar Shizuo Asakawa initiated the study of traditional folk dwellings from a genealogical perspective by classifying building types based on dialects. Academician Changqing inherited and developed this viewpoint, proposing the method of dividing the genealogy of terroir architecture based on the dialects of ethnic and folk families, and examining the five matrix features: village morphology, plan form, building materials, building structure, and building decoration (Chang, 2016). Zhiyao categorised the architectural genealogy using the dialect as a clue (Zhiyao, 2014). Yizhi clarified the subordination of the terroir system in Fujian region and explored the matrix characteristics of the terroir architectural genealogy in the core area of the Min system (Yizhi, 2019).

Huang Hanmin's 1988 Examination of Round Buildings in Fujian shows more comprehensively the apparent evolution of round buildings in Zhangzhou from castles to castles to round buildings (HanMin, 1988). In 2012, he published a book entitled Fujian Tulou Architecture, in which he argued that 'Tulou' originated from the coastal area of Zhangzhou from the perspective of both historical data and existing cultural relics, thus creating a new understanding of the formation of Tulou (HanMin, & Limu, 2012). More recent scholars have used new technologies to produce data combining dwellings and villages with cultural geography, arguing that there is no inevitable relationship between the three places in terms of transmission and origin. *Translated with DeepL.com (free version)*

1.3.2 The Application of Digital Technology in the Conservation and Dissemination of Hakka Traditional Houses

Under the background of information technology and intelligence, the protection and development of traditional houses face new requirements and the research horizon needs to be expanded. The application of digital technology in the protection and dissemination of cultural heritage is becoming increasingly widespread. At present, the domestic digital protection projects for tangible cultural heritage have made some achievements that have attracted global attention. For example, the 'Digital Dunhuang' project of the State Key Laboratory of CAD & CG of Zhejiang University. As can be seen in the digital conservation cases of the Jingjiang King's Tomb mausoleum site and the Yungang Grottoes, digital technology has formed a relatively perfect system (Wang, 2019). The digital technology for ancient architectural sites and collections of cultural relics has further visualised information and established information system, which is conducive to the all-round management of the specifics of ancient architecture (Ran Kongkong, 2021). Through the establishment of three-dimensional virtual technology models, the information management of cultural relics buildings has been realised, which further promotes the maintenance of cultural relics buildings. Three-dimensional virtual technology has more advantages in protecting ancient buildings compared with the traditional methods.

The medium on which Tulou culture depends has shifted from architectural forms to digital media, reaching a wider audience and realising a shift towards 'spatial bias' (WeiJian, & Jun, 2023). Cases of digital

design applications in Tulou include the ‘Hakka Tulou Trilogy’, which showcases the cultural elements of Tulou, i.e., the symphonic music ‘Echoes of Tulou’, the large-scale original song and dance drama ‘Tulou Charm’, the opera ‘Tulou’, the animated film ‘Big Fish - Begonia’ and other Tulou cultural derivatives. However, the problems of insufficient excavation of the cultural connotation of Tulou and insufficient integration of communication resources (WeiJian, & Jun, 2023) still remain.

1.3.3 Global Applications of Virtual Reality (VR) / Augmented Reality (AR) in Cultural Heritage Preservation

In recent years, virtual reality (VR) and augmented reality (AR) technologies have been widely applied in the field of cultural heritage preservation globally. For instance, Pompeii in Italy has utilized VR technology to recreate the ancient city’s prosperity, allowing visitors to immerse themselves in the charm of ancient civilizations. The Sydney Opera House in Australia employs AR technology to provide visitors with detailed information about the internal structure and historical background of the building, enhancing the visitor experience. These projects not only demonstrate the potential of digital technology in cultural heritage preservation but also offer valuable references for this study.

2. Objectives

The primary objective of this study is to conduct an in-depth analysis of the philosophical connotations of Hakka culture, explore the application mechanisms of digital technology in the inheritance of Hakka clan culture, and propose feasible digital design solutions. The specific objectives include:

- 1) Analyzing the philosophical connotations of Hakka culture, especially the impact of Taoist “unity of heaven and mankind” and Confucian “people-oriented” concepts on Tulou culture.
- 2) Investigating the application mechanisms of digital technology in the inheritance of Hakka clan culture, with a focus on virtual reality (VR) and augmented reality (AR) technologies.
- 3) Developing specific digital design solutions, including 3D modeling, VR, and AR technologies, to enhance tourists’ cultural experiences and the interest of the younger generation in Hakka culture.
- 4) Evaluating the effectiveness of the proposed digital design solutions, including user feedback and technical performance assessments.

3. Materials and Methods

3.1 Extraction of Hakka Cultural Elements from Shen Yuan Tulou

3.1.1 Historical and Cultural Background: The Manifestation of Clan Culture in the Spatial Layout and Ritual Activities of Shen Yuan Tulou

ShenYuan Tulou, as the case study object of this paper, is located in Jintou, Guzhu Village, Guzhu Township, and is a typical Hakka inner-passageway-type round earth building. With a diameter of 81 metres, it is the largest earth building in the current measurement data, with four concentric circles. The outer circle is four storeys high, with 54 openings. It was once inhabited by more than 90 households and 500 people. Its architectural form, humanistic connotation, preservation, and development are representative of research. Hakka people pay attention to the harmonious coexistence with nature, Taoism’s ‘unity of heaven and man’ (Table 1) thought is reflected in Hakka culture, especially obvious in the site selection and architectural layout of the ShenYuan Tulou. The Tulou buildings are built alongside the mountains and the water, and are skilfully integrated into the natural environment. It has formed a unique landscape interdependence with the surrounding mountains and water systems, which has formed a unique philosophical connotation.

The Confucian concept of ‘people-oriented’ (Table 2) permeates all aspects of Hakka society, emphasising family unity and harmony, which is fully reflected in the form of Tulou settlement and clan cultural activities. The broad central floor of ShenYuan Tulou, which has been in existence for more than a hundred years, is the main venue for the residents’ red and white ceremonies as well as living and leisure activities. The internal spatial layout has the ancestral hall as the core (Figure 2), followed by the ancestral hall, the perimeter corridors, and the outermost ring for the clan members to reside in. Emphasis is placed on close ties and mutual support among family members, reflecting the importance placed on family and social order in Confucian culture. This custom of gathering clans and living together fully reflects the strong family ethical system of the Hakka people, as well as their identification with the traditional culture of the Central Plains.

Table 1 Taoist Philosophy in Tulou Culture




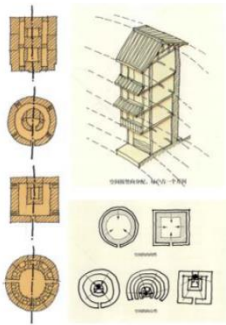
Traditional Philosophy	Philosophical Thought	Specific Manifestation	Photos
Taoism	Harmony with Nature	Layout adapted to the functional and ecological requirements of housing	
	Sublimation from “Objective” to “Situation” to “Context”	Tulou settlements along the mountains and rivers are staggered and echoed as a landscape.	

Table 2 Confucian Philosophy in Tulou Culture

Traditional Philosophy	Philosophical Thought	Specific Manifestation	Photos
Confucianism	Family Ethics	The Human Ecology of Clustering: Single-Storey Clustering of Large Families	
	Doctrine of the Mean	<p>Symmetrical layout: a central axis running through the gate and the ancestral hall, left-right symmetry</p> <hr/> <p>Equal distribution system: Vertical allocation, with essentially the same number, size and orientation of rooms, without hierarchical distinction</p> <hr/> <p>The encircling core layout of “dots and lines” symbolises the unity of the clan.</p>	

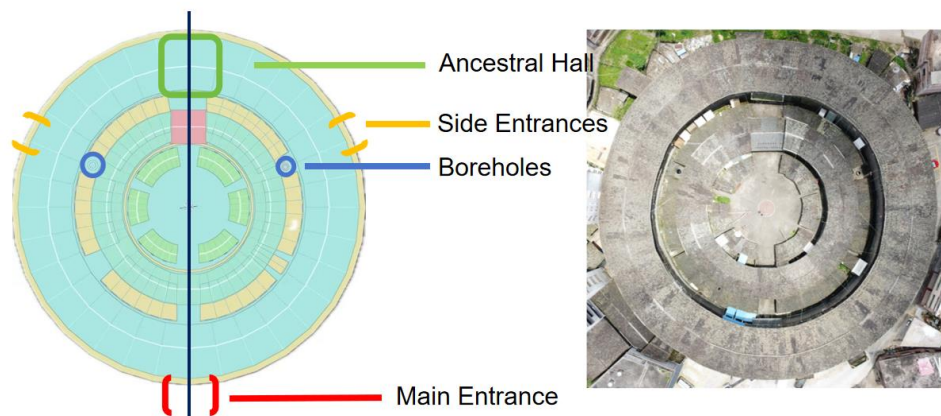


Figure 2 Layout of Shen Yuan Tulou

3.1.2 Cultural Value: The Role of Shen Yuan Tulou in Strengthening Clan Cohesion and Cultural Identity

Genealogy, as an important carrier of Hakka culture, records the harmonious history of the Hakka folk lineage. The Hakka people pay special attention to the genealogy of their own lineage, which is the most prominent cultural feature of the Hakka folklore. For example, the Sioux family, which lives in a remote earthen building, also has a complete genealogy of its family (Figure 3). Among them, the Su family rules (Figure 4), which are an important part of the family culture, embody the Hakka people's moral concepts and code of conduct. The family rules cover filial piety to parents, respect for elders, solidarity with brothers, and diligence and thrift, and are an important basis for Hakka family education and inheritance. The most distinctive feature in the Su family tree is the Su family song (Figure 5), which, with its unique melody and lyrics, carries on the cultural memory and family spirit of the Su family. The lyrics not only express admiration for ancestors, but also reflect the desire for family unity and harmonious life. The family songs are sung at family gatherings and important festivals, enhancing the cohesion and sense of identity among family members.



Figure 3 Genealogy of the Su family

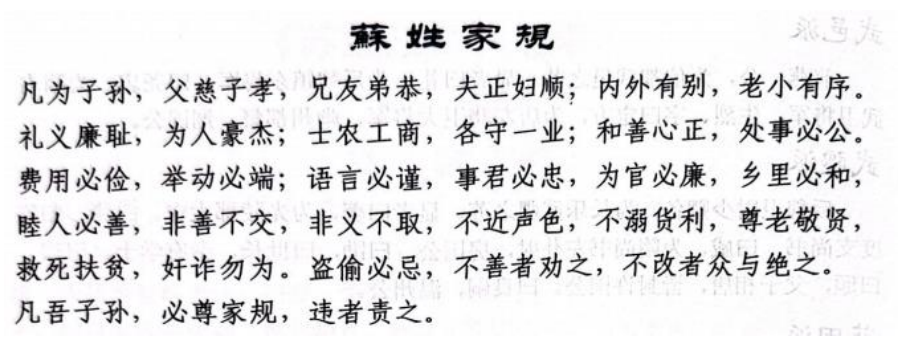


Figure 4 Su family rules

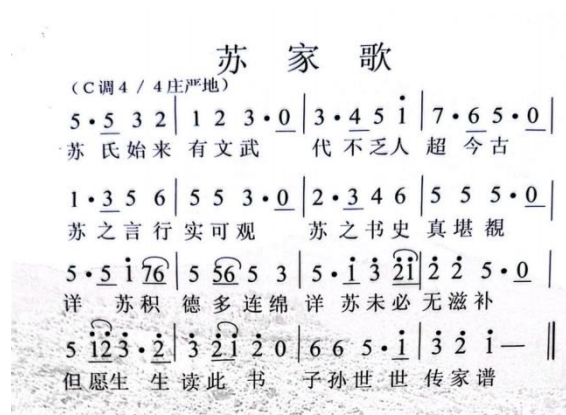


Figure 5 Su family song

Data collection is the initial stage of the research, while the screening, integration, organization, and analysis of data constitute the core of the research. To validate the model's effectiveness, various mathematical analysis methods are employed to process the data. Conducting field surveys in the local area involves analyzing the surrounding environment of Shen Yuan Tulou, interviewing residents, and examining historical genealogies. A survey was designed to assess Fujian Tulou residents' understanding of Tulou culture, satisfaction with living conditions, acceptance of preservation technologies, and attitudes towards development.

A total of 70 valid responses were collected. Using cross-analysis based on "age" (Table 3) and "length of residence" (Table 4), the survey identified differences and commonalities in participants' involvement in Tulou preservation, living satisfaction, and attitudes towards new technology applications. The findings indicate that residents with longer tenures are more likely to engage in preservation efforts. Living condition satisfaction is influenced by multiple factors, not solely residence duration. New technologies, as a means of preservation and display, are widely accepted and supported by residents, offering new possibilities for Tulou protection. These insights provide crucial references for formulating effective Tulou protection policies, improving living conditions, and promoting new technology adoption.

3.1.3 Current Status of Inheritance: The Weakening of Clan Culture in Modern Society and Challenges

Table 3 Cross-Analysis Results Chart – Age

Question	Answers	Age					Sum
		Under 18	18-30	31-45	46-60	60 or more	
Will you participate in the preservation and maintenance of Shen Yuan Lou?	No	0(0%)	10(76.923%)	2(15.38%)	0(0%)	1(7.692%)	13
	Yes	1(1.754%)	23(40.351%)	20(35.088%)	12(21.053%)	1(1.754%)	57
Sum		1	33	22	12	2	70
Do your current living condition (e.g., space, facilities) meet your daily needs?	Very satisfied	0(0%)	13(65%)	5(25%)	2(10%)	0(0%)	20
	Basically satisfied	1(4%)	8(32%)	5(25%)	2(10%)	1(4%)	25
	Dissatisfied	0(0%)	4(66.667%)	2(33.333%)	0(0%)	0(0%)	5
	Very dissatisfied	0(0%)	8(42.105%)	5(26.316%)	5(26.316%)	1(5.263%)	19
Sum		1	33	22	12	2	70
Are you open to the use of new technologies (such as digital tools: VR/AR, etc.) for the preservation and presentation of the Tulou?	No	0(0%)	7(77.778%)	1(11.111%)	1(11.111%)	0(0%)	9
	Yes	1(1.639%)	26(42.623%)	21(24.426%)	11(18.033%)	2(3.279%)	61
Sum		1	33	22	12	2	70

Table 4 Cross-Analysis Results Chart - Duration of Residence

Question	Answers	Duration of Residence				Sum
		Less than 1 year	1-5 years	5-10 years	More than 10 years	
Will you participate in the preservation and maintenance of Shen Yuan Lou?	No	3(23.077%)	5(38.462%)	2(15.385%)	3(23.077%)	13
	Yes	6(10.526%)	18(31.579%)	9(15.789%)	24(42.105%)	57
Sum		9	23	11	27	70
Do your current living condition (e.g., space, facilities) meet your daily needs?	Very satisfied	4(20%)	6(30%)	6(30%)	4(20%)	20
	Basically satisfied	2(8%)	8(32%)	2(8%)	13(52%)	25
	Dissatisfied	1(16.667%)	4(66.667%)	0(0%)	1(16.667%)	6
	Very dissatisfied	2(10.526%)	5(26.316%)	3(15.789%)	9(47.368%)	19
Sum		9	23	11	27	70
Are you open to the use of new technologies (such as digital tools: VR/AR, etc.) for the preservation and presentation of the Tulou?	No	3(33.333%)	4(44.444%)	0(0%)	2(22.222%)	9
	Yes	6(9.836%)	19(31.148%)	11(18.033%)	25(40.984%)	61
Sum		9	23	11	27	70

3.2 Digital Design Concepts

In the digital display process, greater emphasis is placed on the embodiment of cultural connotations. Virtual reality (VR) technology offers users an immersive experience, such as virtually walking into the interior of Tulou to observe architectural details and participate in cultural activities. Augmented reality (AR) technology superimposes virtual information onto the real world to enhance cognition and interaction, such as visiting Tulou to learn about the history and cultural stories through AR devices. Digital narrative technology makes cultural information vivid, interesting, and easy to disseminate, such as the production of Tulou cultural documentaries to showcase the construction process and cultural inheritance, and to enhance audience interest and sense of identity. The digital shift in cultural communication focuses on digital technology to change the mode and path of communication and to achieve inter-temporal communication through digital platforms to expand influence. These theories provide a basis for the study and guide how to combine Hakka cultural elements with digital technology to design effective communication programmes.

After referring to numerous cases, the plan is to design and develop an interactive tour system, using VR technology to develop a virtual ShenYuan Tulou roaming project, where visitors can explore every corner of ShenYuan Tulou in virtual space and learn about its history and cultural background. The tour interactive point design (Figure 6) is based on the tour sequence of each floor and introduces the function of each space through short stories, which are extracted through pre-interviews and questionnaires.

Through digital narrative technology, philosophical stories embedded in Hakka culture, such as the history of the southward migration of Hakka ancestors and the construction process of the Tulou, can be told so that users can understand the philosophical ideas behind the cultural stories. In addition, the digital platform can also be used to carry out online cultural exchange activities, such as Hakka cultural forums and virtual exhibitions, to promote exchanges and collisions between different cultures and further disseminate and promote the philosophical connotations of Hakka culture.

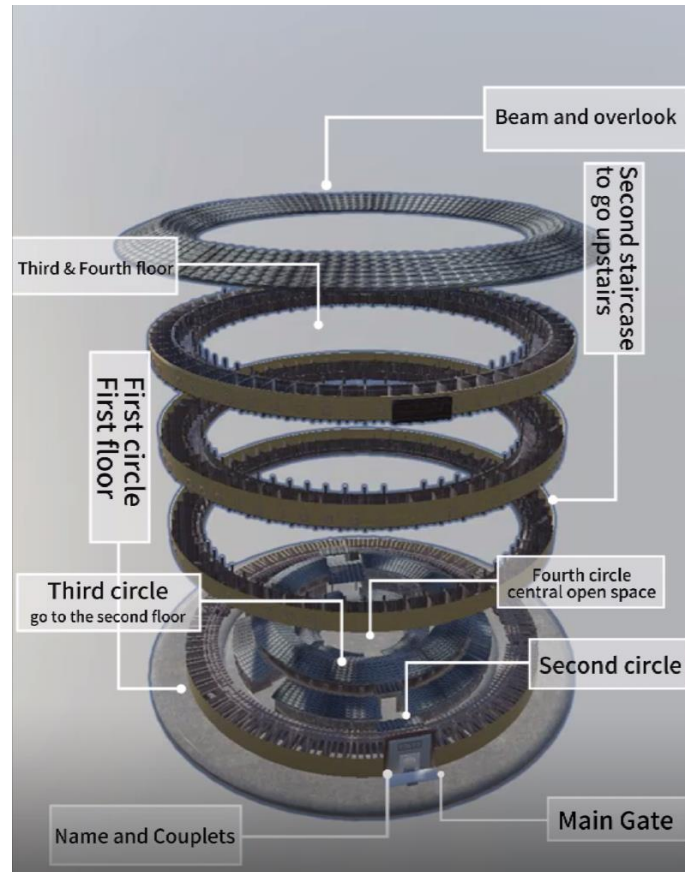


Figure 6 Tour Interaction Point Planning and Design

3.3 Integration of Digital Technology and Philosophical Nature of Hakka Culture

In the context of digital transformation, the digital preservation of traditional villages is of great significance. By employing technologies such as 3D scanning, digital modeling, and virtual reality (VR), it is possible to digitally document and reproduce the architecture of traditional Hakka villages like Luodai Old Street, thereby providing a scientific basis for their protection and offering immersive tourism experiences for visitors. With the development and popularization of digital tourism platforms, the use of high-tech means for cultural and tourism projects has become a trend.

The integration of digital technology and the philosophical nature of Hakka culture can be explored at multiple levels. First, in the experiences of virtual reality and augmented reality, philosophical ideas of Hakka culture can be incorporated, allowing users to feel the concepts of “unity of heaven and man” and “people-oriented” during their experience. For example, in the virtual Tulou environment, natural landscape changes such as the transition of seasons and weather events can be simulated, enabling users to experience the harmony between humans and nature.

Second, through digital narrative technology, philosophical stories embedded in Hakka culture, such as the history of the southward migration of Hakka ancestors and the construction process of the Tulou, can be told. This allows users to understand the philosophical ideas behind the cultural stories while learning about the history of Hakka culture.

Additionally, digital platforms can be utilized to conduct online cultural exchange activities, such as Hakka cultural forums and virtual exhibitions, to promote exchanges and collisions between different cultures, and further disseminate and promote the philosophical connotations of Hakka culture.



Figure 7 Interactive display conceptual diagram

4. Results

Preliminary Data Collection: Through data collection and literature review, the architectural form and artistic style of Shen Yuan Tulou were analyzed and determined.

Resident Interviews and Questionnaire Surveys: Data were collected through interviews and questionnaires with residents of Shen Yuan Tulou and then organized and summarized. (This includes user feedback and technical performance assessments to enhance the practical relevance of the study).

Data Acquisition: Based on the data of the facade and surrounding environment of Shen Yuan Tulou captured by drones, a 3D model of the building was completed, meticulously restoring the architectural structure, historical traces, and material details of the Tulou.

Model Processing: The model was imported into the Unreal 4 engine for light, material, and volume processing to achieve a visually realistic restoration and showcase the historical sense of the ancient architecture of Shen Yuan Tulou. (In terms of modeling technology, we employed high-precision 3D scanning techniques combined with professional modeling software to accurately restore the architectural structure and details of Shen Yuan Tulou. Through these technical means, we ensured a high-quality presentation of the digital model in terms of visual effects and historical accuracy).

Interactive Guided Tour System Development: Using VR technology, a virtual Shen Yuan Tulou roaming project was developed, allowing visitors to explore every corner of Shen Yuan Tulou in virtual space and learn about its history and cultural background. (Unity 3D was chosen as the development platform, leveraging its powerful graphics rendering capabilities and cross-platform support to effectively implement virtual reality (VR) and augmented reality (AR) functions).

Display and Interaction: Shen Yuan Tulou was transformed into a living museum, with a digital display platform set up at the entrance to replace the original introduction plaque. Additional screens were installed to support scanning and on-site tours, reducing the reliance on human and material resources such as tour guides without affecting the lives of the Tulou residents.

5. Discussion

In exploring the application of digital technology in the transmission and preservation of Hakka culture, there are still many practical challenges and problems to be solved. Further exploration of potential issues in the digitalization process, such as technological limitations and cultural misunderstandings, and comparison with other global digital heritage projects, are necessary to highlight the strengths and weaknesses of this study. At the same time, a more detailed description of how to ensure historical accuracy in digital modeling is provided. During the digital modeling process, we strictly followed historical data and archaeological research results to ensure that every detail of the model conformed to historical facts. In addition, comparisons with other global digital heritage projects revealed that this study is innovative in terms of technological application and cultural presentation, but there are also some shortcomings, such as the need for further in-depth exploration of cultural connotations.

The development of virtual clan cultural activity scenarios requires us to delve into and accurately restore the details of Hakka culture to enhance user participation and cultural experience. The development of digital experience tours, with the help of AR and VR technologies, is expected to enhance the attractiveness of tourism and the effect of cultural inheritance. However, in practical applications, the stability and compatibility of the technology, the optimization of user experience design, and the application of big data analytics in the optimization of tourism products all need to consider user privacy protection and data security. At the same time, simplifying the process of obtaining tourist information and improving the accuracy and timeliness of information are also urgent issues to be addressed.

Meanwhile, it is also necessary to establish a digital heritage education mechanism. Recording traditional handicrafts and folklore activities and conducting online education are effective ways to attract young people to participate in cultural heritage. However, ensuring the quality and attractiveness of educational content, assessing educational effectiveness, and establishing and maintaining a smart management system all require professional technical support. Enhancing the digital skills of relevant personnel, strengthening cooperation with universities and research institutes, and introducing professional talents and advanced technologies are crucial for the effective operation of the mechanism. In addition, how to use digital means to protect intangible cultural heritage and prevent cultural distortion and over-commercialization is also a problem that we must pay attention to.

6. Conclusion

In the context of cultural and tourism integration, how to use digital technology to achieve living protection has become an important issue for the sustainable development of traditional villages. This study, through an in-depth analysis of the philosophical connotations of Hakka culture, explored the application of digital technology in the inheritance and dissemination of Hakka clan culture, and proposed specific digital design solutions using Fujian Shen Yuan Tulou as an example. The results show that digital technology can not only enhance the younger generation's interest and participation in Hakka culture but also promote and protect this unique cultural heritage globally. Through interactive guided systems, AR interactive installations, and digital narrative technologies, visitors can gain a deeper understanding and experience of Hakka culture while protecting the privacy of the Tulou residents' lives. Online cultural exchange activities further promote the dissemination and exchange of Hakka culture. The innovation of this paper lies in combining the philosophical nature of Hakka culture with modern digital technology, which provides new perspectives and methods for the inheritance of traditional culture. This not only enriches the theoretical connotations of Hakka culture research but also provides beneficial references for the digital inheritance of traditional culture in other regions, which is of great significance for promoting the sustainable development of Hakka Tulou culture.

Future research directions include technological optimization and innovation, further optimizing 3D modeling and virtual reality technology to improve model accuracy and user experience. Meanwhile, more innovative digital technologies, such as artificial intelligence and machine learning, should be explored to enhance the efficiency and effectiveness of cultural transmission. In addition, deeper exploration of the philosophical connotations and historical stories of Hakka culture can enrich the content of digital displays and enhance the attractiveness and infectiousness of the culture. Strengthen cooperation with multidisciplinary, such as sociology, anthropology, and architecture, will support interdisciplinary research and a comprehensive approach to the inheritance and preservation of Hakka culture. Finally, future studies should explore how to better promote the participation of community residents in cultural inheritance to realise the benign interaction between cultural preservation and community development, ensuring the living inheritance and sustainable development of Hakka culture. Through these efforts, we hope to provide more comprehensive and effective solutions for the inheritance and protection of Hakka culture and to promote the sustainable development of traditional culture in modern society.

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