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EXPLORATORY APPROACH UTILISING VIRTUAL REALITY TECHNOLOGY TOOLS FOR DONGBA SCRIPT CULTURAL HERITAGE PROMOTION

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A R T I C L E   I N F O

A B S T R A C T

The pictographic Dongba script is a traditional script that is used by the Naxi people in Lijiang, Yunnan Province, in China. Despite being a cultural heritage, it is not actively promoted causing its depletion to continue. The purpose of this study is to discuss and identify the non-individual characters in the Dongba script, as well as to investigate the dynamic approaches to promote them. The study has used a qualitative research approach to discover the characteristics of the Dongba script's non-individual characters utilising the 'composition element', which is the smallest unit of script composition. This study's findings demonstrated that non-individual characters might be created and used, and cultural heritage can be broadly promoted through virtual technologies, including AR animation and digital museums. Significantly, this study offered a model for the future promotion of Dongba script non-individual characters.

1.   Introduction

The Naxi people are believed to be the ancient ancestors of the people in the northwestern part of China who evolved into the Naxi minority in China today. The origin of the Naxi Dongba script remains a topic of debate among scholars, whereby some academics

propose that the Muzhi script and the ancient Ba script of Sichuan may have a common ancestor and that the Dongba script could be the earliest to date. By the mid-eleventh century, scriptures were already written in the Naxi script, which had begun in a pictorial form. Previous studies, including "A study of the non-individual character structure of the Naxi Dongba script" (Li Jing, 2009), "A study of the development of the Dongba script based on the description of heterogeneous phenomena" (Liu Yue, 2010), and "A study of the nature of early pictorial scripts" (Zhu Ran, 2013), have mainly focused on the construction, development, stylisation, and pronunciation of the Dongba script. However, there needs to be a clear distinction between individual and non-individual characters in the script. This study aims to provide an unambiguous distinction between the individual and non-individual characters in the Dongba script and to promote the non-individual characters as cultural heritage. The authors' research highlights the importance of promoting the Dongba script's non-individual characters, which should have been more noticed in previous studies.

In conclusion, the Dongba script is an important cultural heritage of the Naxi minority. While previous studies have concentrated on the various aspects of the script, this research focuses on the distinction between the individual and non-individual characters; it promotes the latter as an essential element of the script's cultural heritage.

2.   Literature Review

2.1   History of Dongba Script

The Naxi people in China have a rich cultural history, including the Dongba script, which is also known as the living hieroglyphic script. According to Fu Maoji, the Dongba script is a type of writing that lies between the picture and the corresponding graphic notation in terms of meaning. Research has revealed that the Dongba script can be categorised into distinct and non-separate characters. Accordingly, non-separate characters can be divided into word groupings, word segments, concatenated texts, and compound glyphs. Unlike a single script, the Dongba script is composed of multiple scripts or symbols that are stitched together, resulting in a new figure that is known as a non-individual character.

The Dongba script, as a cultural heritage, has yet to be widely promoted despite its steady depletion. To ensure its accessibility and transmission to a broader audience, alternative methods have been employed in recent years, such as virtual technology tools like mixed reality, virtual reality, digital interactive exhibitions, and digital museums. In this regard, the non-individual characters of the Naxi Dongba script serve as a crucial focal point for authorial research. Notably, "A Study of the Grammatical Structure of Non-Solitary Characters in the Naxi Dongba Script" (Li Jing, 2009) is a foundation for investigating the structural properties of non-solitary characters in the Dongba script. This study represents the first comprehensive investigation of the non-solitary character structure of the Naxi Dongba script, categorising it into four distinct groups: integrated text, character groups, character segments, and compound glyphs.

Based on the preceding discussion, the author initiates an inquiry into the unique morphology of non-individual characters in the Naxi Dongba script and their current usage and evolution over time. The use of virtual reality technology to enhance cultural tangible and intangible heritage has been the subject of research. According to the findings of a recent study by Lucio Tommaso, D. P., et al. (2022), the inclusion of physically inaccessible sites, such as an abandoned building in a small town on the Adriatic coast of Salento, in valorisation programs can increase public engagement and participation. The study highlights the importance of utilising innovative

solutions based on information and communication technologies (ICTs), such as mixed reality (MR) and virtual reality (VR), to achieve this goal.

In cultural heritage, the 'cultural heritage communication system' serves to recover and preserve the tangible and intangible aspects of a place's historical memory. However, there is a drawback in that the focus tends to be on developing communication tools and technical systems without translating them into practical applications. With the distribution of cultural heritage as a starting point, the authors aim to investigate the unique content and context of cultural heritage dissemination. In the study titled "Immersive Cultural Heritage Digital Documentation and Information Services: A Collection of Historical Figures - The Case of Zhu Xi in Song Dynasty China", the authors (Zhanling, F., et. al. 2022) present their findings, which demonstrate that the metaspace-based framework is effective in digitising the multimodal data of cultural heritage, and satisfies the presentation needs of metaspace for digital documentation of historical figures. This research aims to investigate the development of a contactless virtual and physical cultural heritage experience system for cultural study and preservation. This system aims to provide an immersive and comprehensive cultural tourism information service for travellers before, during, and after their tour. Notably, the study focuses on developing the Zhu Xi meta-spatial system, representing a significant advancement in creating a meta-space for historical figures.

This study proposes a systematic approach to acquiring cultural heritage with high precision and fidelity. It investigates a framework for the digital documentation of cultural heritage on historical figures, highlighting the need for immersive digitisation methods to capture multimodal resources accurately. Based on this framework, the article suggests the development of an information service platform for the cultural heritage of historical figures. To cater to the diverse audience, the proposed platform integrates metaspace elements and offers customised services. Although some users argue that a single 3D reconstruction model or oblique model may not fully encapsulate the essence of civilisation and that additional knowledge is necessary to supplement it, the researchers in this study utilise museums as a foundation for developing virtual art galleries and digital museums.

The study "Virtual people at cultural heritage sites and museums" by Sylaiou, S. and Fidas, C. (2022) reveals that optimising virtual agents in the cultural heritage domain requires an interdisciplinary effort. This article conducts a comprehensive survey of relevant research and solutions. It proposes recommendations for future research based on the analysed technical aspects of user avatars and virtual agents that are related to cultural heritage and emerging patterns. The authors have identified trends and concerns by investigating pertinent literature to draw conclusions about the subject's current state and extrapolate future directions. The significant conclusions include the development of real-world, intricate installations or applications, with increasing investment in mixed reality. Furthermore, optimising agents such as virtual companions, mediators of cultural content, and participation facilitators are receiving remarkable attention.

The virtual augmented reality cites IDC and other organisations' estimates that the global virtual reality market size was approximately RMB 90 billion in 2020, comprising RMB 62 billion for VR and RMB 28 billion for AR. It is predicted that from 2020 to 2024, the worldwide virtual reality market will expand at an average annual rate of around 54%, with VR growing at about 45% and AR at a pace of about 66%, resulting in a combined market share of RMB 240 billion in 2024. These projections suggest that the demand for virtual technology will continue to increase over time, further supporting the promotion of cultural heritage.

The research results on virtual humans have been criticised for their lack of integration with the cultural heritage of the theme statement. However, the author's findings on developing virtual humans for Dongba script's non-individual words offer valuable insights for future research. Specifically, this study paves the way for the development of applications for the theme of virtual humans for the Dongba script's non-individual words, which refer to as "Wisdom Humans." The present study by Selim, G. et al., (2022) showcases the application of virtual heritage technologies in representing the Umm Qais heritage in an interconnected and interrelated manner, hence, contributing to the formation and preservation of its identity and values. The findings suggest that using such technologies can enhance the visitors' engagement with cultural heritage sites and enable them to explore and appreciate the multifaceted nature of cultural practices and their historical layers.

This study produced the inaugural model of a 'virtual living museum' that merged the tangible and intangible heritage of the site and community into a cohesive virtual environment that accorded equal significance to the local community's narratives, traditions, and history. The employed technique has been utilised as the basis for a sustained training program that benefits the local community and links local businesses as part of the initiative to construct a long-term and sustainable living heritage model.

During the project's 24-month investigation, analysis, modelling, and experimentation phase, specific systems, methodologies, and training programs were implemented to actualise the vision. Nonetheless, challenges that are related to collective buy-in may arise. The authors' study delves into integrating the non-individual characters from the cultural heritage Dongba script into the virtual museum, taking the virtual living museum as its origin.

In summary, the current research on the non-individual characters of the Dongba script, mainly the Naxi script that is used by China's ethnic minorities, predominantly concentrates on its structure, pronunciation, and pictoriality. Furthermore, the development of virtual technology systems has been the main focus in utilising virtual technology tools, with cultural museums being the primary application. By leveraging virtual technology tools, the non-individual characters of the pictographic Dongba script have been expanded and distorted to form a virtual children's script museum. To what extent are the Dongba script's non-individual characters distinct? The authors' research objectives, which involve promoting cultural heritage and employing virtual technology tools to accomplish the goal, are enabled by technological innovation.

3.   Methods

The authors' research approach aimed to centre around the cultural heritage of the Naxi minority group in China. Specifically, the research design focused on the non-individual characters of the Dongba script, with a selection made using technological instruments. Implementing virtual scenarios, including augmented reality, was utilised to promote cultural heritage sustainably. Qualitative research methods were employed to identify the research scope by analysing the relevant results.

The present study (Li Jing, 2009) employed the findings of previous studies (Maoji, F., 2012) to select pictorial, quasi-script, and monogram characters from a mixture of Naxi pictorial script (White Bat Sutra), Naxi pictograph dictionary, and nine classical translations, as well as the single-character structures. The non-single character structures of the Dongba script were categorised into four types: combined text, character groups, character segments, and compound glyphs. These structures were then systematically analysed based on their constituent elements, pronunciation, and relationship with linguistic units.

Many domestically relevant works, documents, source materials, and Dongba dictionaries were recorded, translated, and subjected to thorough analysis and commentary as part of the research methods.

The present work provides a summary and analysis of the evolution of the Dongba script. It presents an in-depth investigation of the non-individual word structure of the Naxi Dongba script. The study by Li Jing (2009) exemplifies the utilisation of qualitative research methods in uncovering the nuances of the Dongba script.

Utilising virtual reality technology to enhance tangible and intangible cultural heritage, the case study of Lucio Tommaso, D. P., et al., (2022) sheds light on an otherwise inaccessible medieval castle in the small village of Cosano in Salento, Italy. Through the creation of a 3D reconstruction of the castle, an interactive system was developed to provide the users with knowledge about the castle's historical formation. The content was derived from the analysis of tangible cultural heritage, such as the castle's architectural features, furniture, and decorative themes, as well as the evolution of these features over time, and the collection of intangible cultural heritage, such as folk customs and traditions that are associated with the castle's surroundings. Additionally, to assess the user's experience of the developed application, various user samples were subjected to a series of tests, which garnered favourable feedback regarding the immersion and presence of the program.

In this study, the research methods relied on the oral testimonies from women in the tobacco processing industry during the 19th century in the castle of Cosaño. Given the historical significance and popularity of tobacco production in the southern region during this period, these oral accounts allowed for a comprehensive reconstruction of the different stages of tobacco processing. The results were concluded using the personal interview survey research method to reconstruct the oral description of tobacco processing at Cosano Castle during the nineteenth century.

The study "Immersive Cultural Heritage Digital Documentation and Information Services A Collection of Historical Figures: The Case of Zhu Xi in Song Dynasty China" Zhanling, F., et. al. (2022) proposes a metaspace-based framework for digitally documenting historical figures and their cultural heritage. This framework addresses the need for metaspace display and facilitates the digitising of multimodal data on cultural heritage. The findings of this study offer a new paradigm for documenting historical figures in a more comprehensive and immersive way. Various documents were collected for this study, including profiles, biographies, genealogies, historical titles, photographs, anecdotes, theoretical studies, lectures, publications, and legal documents. In order to promote the dissemination of knowledge about Zhu Xi, the creator of Neo-Confucianism, a qualitative research approach was employed in his study, which formed an essential part of the Wuyishan World Heritage Site. Implementing a mixed reality is accelerating, and the combining of the strengths of mixed and augmented reality through qualitative research methodologies can speed up the development and deployment of mixed reality applications.

3.1   Literature Search

In order to comprehend the distinct characteristics of the Naxi Dongba script, its pronunciation, and the indigenous Dongba script paintings, the study conducted face-to-face interviews with Naxi elders in Lijiang, Yunnan, in China, employing the in-person interview technique of survey research. This method required the interviewer to engage with the respondents face-to-face, facilitating the researcher's ability to observe the interview setting, facial expressions, and attitudes. Furthermore, this approach allowed the researcher to regulate

the quality of the respondents' responses, thereby reducing the probability of misunderstandings and increasing the research's precision. To comprehend the intricacies of the hieroglyphic Dongba script, secondary literature was employed in the form of historical documents. The study utilised literature such as "Naxi Dongba Culture" to analyse the non-individual characters of the Dongba script as a starting point for virtual cultural heritage promotion through virtual technology.

4.   Results

4.1   Data Analysis

Data analysis through survey methods was gained in this study. To ensure the accuracy of the analysed data, this study employed a qualitative research method utilising the in-person interview technique in its survey research. The increasing global demand for virtual technology provides supporting evidence for promoting the use of virtual technology in cultural heritage, as is evidenced by the official statistics in the primary literature that is reviewed in this study. Notably, historical documents have been utilised as secondary literature in documentary research, allowing for the analysis of historical data to determine the properties of the non-individual characters of the hieroglyphic Dongba script. Figure 1 illustrate the global virtual reality market which is cloise to 100 billion according to the year.
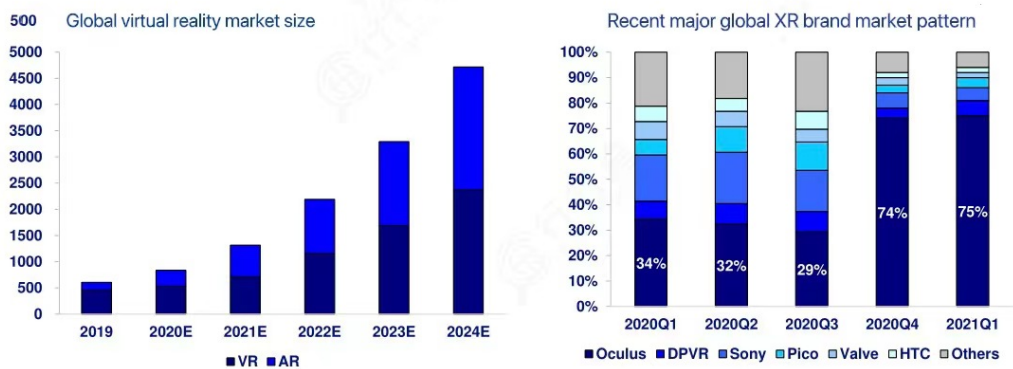
Figure 1. Global virtual reality market size close to 100 billion

5.   Findings

5.1   A Study of Symbolic Morphology

Symbolic physiognomy: Symbolic physiognomy refers to combining a text's rhythm, expressive features, and other elements that constitute its symbolic form and reflect its essence. The symbolic item is an essential component of a script's symbolic form, and it has been argued that it comprises three phases, starting from pictorial symbols, as put forward by Mr Zhou Youguang in "The History of the Development of the World Script". According to Wang Boxi, categorising and presenting words into three categories can distinguish pictorial, hieroglyphic, and symbolic symbols. Moreover, Wang Yuanlu highlights the criterion for weighting words, which pertains to the physical form that is represented by words to record their expression. Although the expression of this characteristic of words may vary, the meaning remains the same, and we can define it as the text's symbolic form.

To define the symbolic form of a text, one must consider the elements of line segmentation, size, and weight that correspond to its components. The symbolic morphology of words is dynamic and fluctuates. Given the numerous morphological aspects of the Dongba script, it is challenging to address them in this study. Nonetheless, this study utilises the symbolic morphology of the Dongba script as presented in "A Study of the Character Elements of the Naxi Dongba Script" as an example, breaking down the symbolic morphology of the non-individual characters of the Dongba script into constituent elements for further examination.

The study intends to examine the characteristics of non-individual characters in the Dongba script, commencing with an examination of the structural elements that constitute the script's most minor units. The non-individual characters in the Dongba script are categorised into groups based on their constituent components, including straight lines, folds, curves, dots, and colouring. These categories are briefly outlined. However, since straight and folded lines are minor components with low symbolism, the study will not delve into them in great detail. Instead, the primary focus of the study will be on the curves, dots, and hues.

The Dongba script comprises a multitude of curves, which are a fundamental component of its composition. These curves exhibit considerable variability and do not adhere to a fixed range. For instance, some curves are only slightly arched, such as the curve in the Dongba script character for 'sky' while others adopt a circular arc, as in the case of the character for 'mountain' depicted with its upper part assuming a semi-circular shape. Moreover, certain curves form a spherical shape, as seen in the character for 'eye' in the Dongba script. Arcs play a critical role in the combination of Dongba texts, such as the 'poisonous grass' arc in Dongba which contains numerous arcs that reflect the script's pictorial solid nature.

Dots are a prominent component of the Dongba script, primarily appearing in textual combinations. In this study, selected dots are examined at the level of symbolic morphology, drawing on the "Study of the Character Elements of the Naxi Dongba Script" for reference. The frequency of dot occurrences in the Dongba script constructs varies, with some words consisting of only one dot. In contrast, others feature multiple dots, such as 'cactus' and 'barn'. The prevalence of multiple dots is more common in the script. The Dongba script employs dots to represent small particles or liquids, reflecting its primitive nature. In addition to dots, colouring is another significant feature of the Dongba script. The author cites examples such as 'crow' and 'poisonous grass', both of which are painted black to convey their negative connotation accurately. The use of colouring further highlights the script's primitiveness.

The structures that are discussed above are derived from real-world representations that aim for a high level of accuracy, however, these representations undergo abstraction for writing, which can manifest in different scales. The Table 1 demonstrates the meaning, symbol and characteristics of Dongba Script.

Table 1
Meaning, symbol and Characteristics of Dongba Script

Meaning	Symbol	Characteristics
Sky		Curves and slightly arched
Mountain		Circular arc
Eye		Curves form a spherical shape
Poisonous grass		Arc

Cactus		Multiple dots
Barn		Multiple dots
Crow		Colouring

5.2 Meta-Universe

The Meta-Universe, composed of the Meta Beyond, Verse Universe, and Metaverse Beyond Universe, represents a conceptual space that transcends reality. The term 'metaverse' was initially coined in the science fiction novel "Snow Crash" (Neal, S., 2022). According to Stephenson's work, the Metaverse is a virtual realm where people can interact with each other through avatars. In this virtual world, individuals can engage in entertainment, work, socialise, real estate transactions, and virtual currency exchange, gaining a better understanding of the Meta-Universe. The Metaverse offers individuals the freedom to experiment with new identities and explore alternative realities that would not be possible in the physical world. In October 2021, Facebook's formal name is changed to Meta and its subsequent decision to pivot towards metaverse development catalysed the public's renewed interest in the concept. The year 2021 was even hailed as the "first year of the metaverse," signifying the burgeoning popularity of the Metaverse among people from diverse backgrounds and the emergence of new economic models. Technologically, the Metaverse is a virtual environment that primarily relies on data as its strategic resource, virtual reality (VR/AR/MR/XR) as its primary technical support, and information infrastructure as its carrier. In this regard, the Metaverse transcends traditional technology concepts, representing a paradigm shift in how people interact with virtual reality.

Virtual reality (VR) is a valuable tool for assessing usability, allowing individuals to engage with experiences irrespective of physical location. With a standalone player and no requirement for additional device connections, VR offers a convenient means of evaluating the accessibility and functionality of various systems. The particular characteristic in question affords freedom from geographical and temporal constraints, empowering the users to employ augmented reality (AR) applications in their homes.

5.3 Application Development

It is recommended to utilise either commercial software such as SLIDE AR or artificial intelligence techniques for version-building purposes.

The project was structured into three distinct phases. In the first phase, the reconstruction of the ancient script involved a comprehensive study of the Naxi Dongba script archives in understanding the script's non-individual characters.

The second phase focused on creating the characters of some of the Dongba script's non-individual characters based on the results of the studies that were documented in the ancient writings, such as "White Bat Taking Broker" and "Naxi Dongba Research Series" (Maoji, F., 2012; Sheng Xu,Y., 2003). Finally, the dynamic processing of all texts commenced, as illustrated in Figure 2.

Figure 2. Graphic text was obtained from ancient texts

Additionally, the AE software was employed for the study to create dynamic panels of non-monograms from the Dongba script and to achieve particular effects that could be made in AE. The fascinating development of the text was based on the non-single character text property of the Dongba script that was utilised to produce the special effects in AE in alignment with the underlying design concept.

The selection of ARTIVIVE was based on a thorough evaluation process that considered the research findings of Maoji, F. (2012) and Sheng Xu,Y. (2003), which examined ancient Chinese manuscripts such as "White Bat Fetching Brokers" and "Naxi Dongba Script Research Series." The positioning of the dynamic text was a crucial factor in the design process, and the software was rigorously tested to ensure that it met high standards of usability and dependability. Resultantly. ARTIVIVE emerged as the preferred choice after considering its suitability to the project requirements and software standards.

To get started, create an account and follow the instructions that are provided. Then, upload a visual representation of the object that is to be recognised, along with a high-quality GIF. Finally, design the spatial location of the dynamic text on the webpage, considering the dimensions of the X, Y, and Z axes.

The AR experience can be accessed through various devices, allowing the users to choose the device of their preference. For this purpose, the application option for the AR experience is the 'Reality Composer,' a powerful tool that is capable of creating and simulating augmented reality experiences for various devices such as iPhones, iPad, and even Apple computers that are running Xcode. This feature ensures that the users enjoy a lifelike AR experience regardless of their device.

5.4 User Interaction: AR Animation

The non-individual characters of the Naxi Dongba script, which are a form of traditional text display, are limited to specific times and locations in Yunnan, China, making them inaccessible to a broader audience. To address this issue, the utilisation of AR animations to present storytelling scenes incorporating virtual and authentic cultural heritage representations. This creates an interactive mixed-reality experience that enables the public to learn about the Dongba script through AR animated stories (refer to Figure 3).
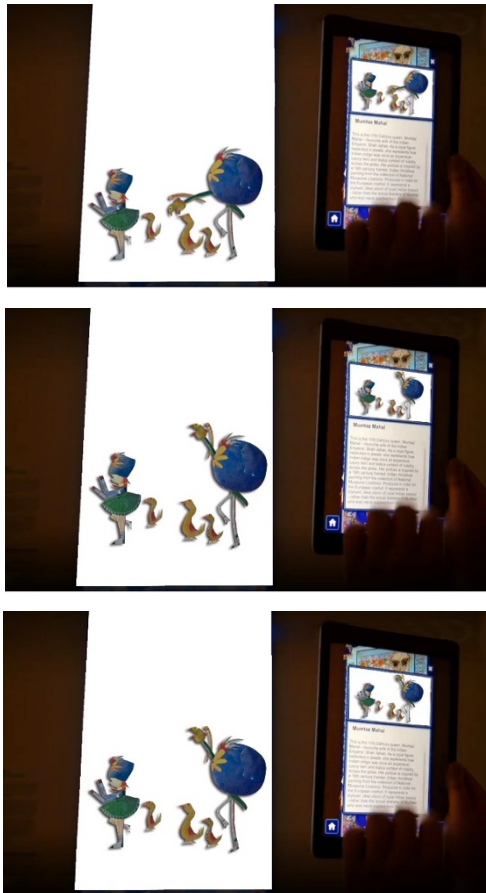

Figure 3. Evolving text

5.5   User Interaction: AR Digital Museum

The Dongba script digital museum employs a novel approach in which non-individual characters from the original texts are transformed to create captivating new texts. These texts are used to convey stories that showcase the cultural heritage of the Dongba script. By presenting these stories in a virtual exhibition hall, the museum offers a modern interpretation of this ancient script that is accessible without spatial or geographical limitations. Furthermore, the digital museum provides a high-quality virtual experience through AR and interesting audio story guide functions. Importantly, it offers a low-cost and efficient way to update the exhibits anytime, making it an innovative tool for preserving and promoting cultural heritage (Figure 4).
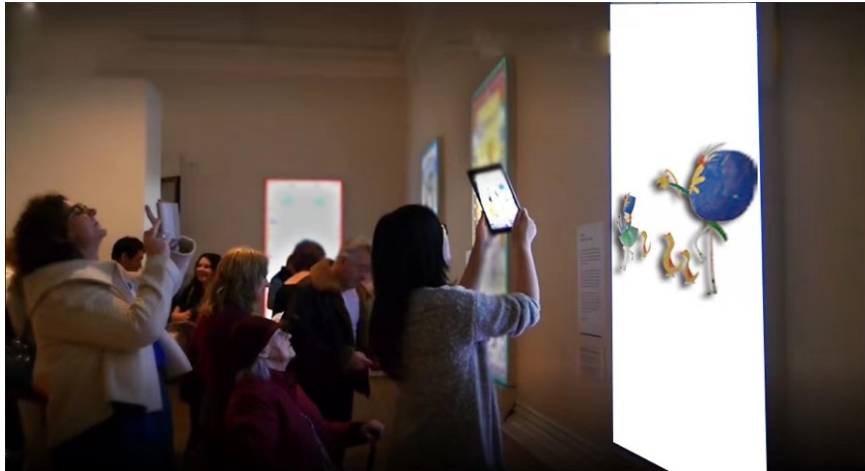
Figure 4. AR Digital Museum

Table 2
User experience evaluation

Question	Agree (%)	Uncertain (%)	Disagree (%)
AR animation museum helps you to learn more about Dongba script non-monogram	95	3	2
AR animation combined with the interesting evolution of the Dongba script appeals to you	92	6	2
AR animation museum under the Dongba script non-monogram can let you better understand the cultural heritage	95	4	1
AR animation museum have enhanced effect on promotion of non-monogram cultural heritage of Dongba script	90	8	2

According to the findings in Table 2, there was a 90% acceptance rate for AR animation and museums in their ability to promote the Dongba script non-individual characters' cultural heritage, with 8% of participants expressing uncertainty and 2% expressing disagreement. Later interview follow-ups revealed that the minority of participants who had expressed dissatisfaction believed that pure AR animation resulted in less interaction between the museum and the participant. In contrast, 2% desired to improve emotional interaction with the Dongba script non-individual characters. These results will serve as a foundation for the author's future development of virtual human wisdom people applications.

6.   Conclusion

The authors utilised the construction element, the smallest unit of script construction, to study the hieroglyphic Dongba script. Their research has revealed that the construction elements, such as straight lines, dashes, curves, and dots, enable the Dongba script to be distinguished into non-individual characters. However, due to cultural heritage, the Dongba script is not widely accessible.

In order to address the increasing challenges of preserving and promoting the non-monogrammed cultural heritage of the Dongba script, technology can be utilised to engage more people and achieve sustainable and dynamic promotion. Virtual technologies such as AR animation and digital museums offer borderless opportunities to showcase and explore the script culture.

The virtual museum of Dongba script non-monogram digital is utilised as an initial reference to forecast the trajectory of the development of Dongba script avatars in the virtual museum, which includes their costumes, emotions, and language. This projection is rooted in the insights that are gained from the initial research.

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Authors Contributions

Liang Xin: Responsible for the research, and the main author which responsible for the reliability of the article.
Azhari Md Hashim : Corresponding author with guidance on research and article revision.
Li Wen feng: Contributed indirectly to the research, providing indirect research guidance on data collection and the topic.

Conflict of Interest

No conflict of interest indicate in this article.

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