

Applications and Challenges of AI Technologies in the Preservation of Dongba Script and Naxi Cultural Heritage

Jiahao Sun *

Shenzhen International Foundation College, Shenzhen 518000, China

* Corresponding Author Email: alvinsun071228@outlook.com

Abstract. Nowadays, cultural heritage preservation is currently under a serious global threat that around 20% of UNESCO heritages face a risk of disappearance. Naxi paper and Dongba script, an ancient hieroglyphic system, located in southwestern China, face the serious challenges of digital preservation and transmission. Moreover, there are two problems with current conservation methods. Firstly, the traditional oral transmission lacks permanence. Besides, the methods existing fail to combine multimedia such as text, audio and image together. This study will investigate how AI could boost and enable cultural transmission by using existing academic literature and documented AI applications including Deep Learning, OCR, Large Language models, and Generative AI models. These tools could digitize manuscripts, reconstruct damaged characters, and enable global dissemination. Acknowledging that using AI tools do have some limitations such as cultural ownership concerns, unusual digital access, and AI reliability. Beyond these three limitations, AI tools are potentially responsible for cultural heritage's preservation.

Keywords: Artificial intelligence; Cultural heritage preservation; Naxi script; Dongba culture; Digital preservation; Large language models; Intangible cultural heritage.

1. Introduction

With the development of technology, AI tools as well as large language models (LLM) have become more and more powerful that could help people in different fields to do many jobs and tasks which can be done only by human beings. For instance, cultural work including heritage conservation could be done perfectly by using AI. According to Xu et al., AI platforms can protect and share materials associated to the culture globally and do not lose authenticity and accessibility [1]. Meanwhile, Machine learning tools can promote and facilitate works' transmission through immersive storytelling and giving users an interactive experience with ancient works [2]. In summary, AI can be a useful tool to promote and boost transmission work.

According to Fu et al., AI tools have already achieved a remarkable, perfect, effective capabilities in doing cultural heritage applications such as conservation works in a significant high success rate of 90% to 95%, and also with a high accuracy rate of 88%, not only showing that AI has been already developed but also showing that AI could help people done a lot of work perfectly [3]. Moreover, currently, AI could provide unprecedented opportunities for cultural transformation work by using automated design generations and enhanced creativity [4]. This study aims to demonstrate that AI could help human beings to do protection work under the current situation, not many people protecting the cultural works. A disadvantage for traditional oral transmission methods is that it lacks permanence and is necessary for long-term preservation, which means oral transmission often disappears by some reason, negatively affecting cultural conservation works [5].

Besides lacking preservation resulting in oral transmission, some cultural works are actually being destroyed. Around 20% of UNESCO intangible cultural heritages are currently facing engagement threats [6]. And also, an ancient script located in southwestern China, Naxi script, facing this problem: the Naxi script which being described as living hieroglyphs confronts serious challenges in digital preservation and processing, which means that once it preserves improperly, it might have chance to disappear [7].

While currently growing threats to intangible cultural heritage, the actual number of preservationists is insufficient. The cultural heritage institutions face three pressures: limited personnel, underfunding, and lacking a quantitative number of materials which need to be documented. Some cultural works such as Naxi ancient script is facing the problem, Therefore, the gap between limited human resources and preservation needs to be reduced. Against this background, this study will address: How can AI tools enable and boost traditional cultural heritages and works?

As some cultural works are being threatened by disappearing, having this research is very significant. Some cultural work is being destroyed or there isn't a media to transmit cultures, for instance, nowadays conservation works lacks comprehensive media approaches to combine text, audio, image and video technologies for transmission work [8]. Therefore, using AI platform could be a useful way to proceed cultural transmission works because AI tools could become a media to transmit the cultural works or even permanently restore the works.

2. Solution

Nowadays, generative AI models become more and more professional and versatile, which boost and benefit culture conservation in many different ways including producing animations from ancient script images, visualizing meanings and history for global transmission, engaging diversity of audiences via social media. Lai et al., conducting research about benefits provided by AIs of culture conservation mentions that transitioning from static display to narrative reconstruction and situational engagement, culture works blended with AI tools are largely enhanced people's experiences' immersion [9].

AI and extended-reality systems are now used to document, reconstruct, and preserve built cultural heritage, and such methods can support conservation work including script restoration. Moreover, techniques such as a filtering developed by Gauss, and an adaptive thresholding enhanced readability of some ancient script images successfully which are degraded by noise, blur, helping to reduce the loss of information during digitalization [10]. Bi and Luo also mention that by using a multiscale featured restoration network, DB2RNet, to reconstruct the missing strokes in some of the handwritten Dongba characters, which are partially incomplete, prior to recognitions and digital archiving [11]. In addition, by linking some visual artifacts with textual metadata through frameworks such as CIDOC-CRM, large language models can now effectively extract semantic relationships from cultural heritage data, which largely enables richer catalog and interpretation. Combining and adopting such local projects such as ECNU's intelligent recognition and recitation system, these techniques can be adapted to Naxi and other Yunnan collections, which could largely benefit both researchers and historians.

According to a group of scientific researchers named Lai et al. [9], AI-generated cultural heritage platforms such as the "Cloud Tour of Dunhuang" benefits users significantly by using animated narratives and virtual guides, helping users to have a deeper understanding of traditional and cultural heritages meanwhile Enhancing perceived value of cultural heritage, which largely promote people to engage with cultural content. By conveying historical context more dynamically than traditional static labels, particularly for complex artifacts and traditions, AI-powered contextual analysis and natural language processing enables museums to create some interactive experiences for users to experience touchable. According to Europeana & EUN [12], Digital cultural heritage materials incorporated into educational platforms benefits largely and widely, more than 2,200 teachers and museum educators using materials gained from those platforms and also more than 17,000 students were influenced by those platforms, which improves and promotes the Reusability of digital heritage resources in education

Gordin et al. [13] mentions that the system called CuRed, which stands for Cuneiform Recognition with Deep learning, and the technology called Deep Learning Based OCR can read ancient tablets in a relatively low error rates, which shows the feasibility of AI-driven recognition. Models such as DB2RNet could be used to detect damaged characters and also reconstruct damaged characters

outputting a cleaner and improved- quantity digital copies of manuscripts for archival purposes [11]. Moreover, Ma et al. [7] demonstrates that Datasets for single-character detection could be used to read historical documents, supporting building searchable digital archives and enabling query and retrieval by character, resulting in a balance between conservation and scholarly access.

For documentaries, AI can also support a variety of ways of experiencing Naxi culture. First, learners could ask AI models everything about Naxi script and Dongba culture, including their habitats, diets, and social traditions. Sperli [14] asserts that a cultural framework using a deep learning method based on chatbot could support tourists' journeys at heritage sites. In that framework, AI tools could provide detailed information, suggestions, and explanations from users' given interests and locations. Although the original study was focusing on tourism, the same idea can be adapted to Naxi culture. For instance, users could input their own sources about Dongba culture and Baxi script to AI models, and then an AI chat model could be trained on given sources about Dongba script, Naxi festivals, and traditional practices. When a user asks, "What does this Dongba character mean?" or "What is the Three - Duo Festival?", the trained AI model could give detailed explanations based on existing sources. This training method could help students as well as history researchers to get a better understanding of Naxi culture.

3. Limitation

Even though AI could largely benefit AI transmission, it could also be an important ethical and practical concern. First, there is an issue about cultural ownership and representation. Dongba script and Naxi culture belong to the Naxi community and Naxi people, and AI tools should not be used to destroy or distort their words' meanings. A study work based on language and cultural preservation emphasizes that AI projects should be guided by community priorities and be involved in local practitioners in the design process. In this study, the AI-generated videos or chat box tools should be used as a supportive media, but not a replacement of their own culture. Second, there are practical limitations. Not all communities have equal change to access to AI tools or stable internet connections. Some of the tools I used, such as Nano banana pro, may get blocked from the Chinese internet and users need to have the basic knowledge of bypassing the firewall, as known as using VPN. Moreover, advanced AI models are usually costly, meaning that getting access to these AI tools could be a financial burden for some users. To equally give each user access to the AI tools, these projects should be built with Open-code models published on GitHub or other websites, which less likely require a high cost for users. Finally, there is the question of reliability. AI tools can easily make mistakes such as giving made citations and visualizing Naxi script in the wrong way. Therefore, a careful and effective prompt is needed. Users need to have basic knowledge of AI prompt creation, and the courses of that are usually available freely on social media.

4. Conclusion

Overall, NB2RNet and deep learning image restoration reconstructs degraded and incomplete Dongba Manuscripts and other cultural works, resulting in cleaner digital copies which are usable for archiving or other academic use. Besides, OCR systems like CuRed could read the ancient script in a relatively low error ratio, making digital archives that could balance and boost conservationists with more accessibility. Moreover, AI platforms shifting cultural works from display statically to immersive digital experiences, result in a more audience-diverse environment. In addition, AI chatbots trained on cultural works could benefit both the public and scholars, making works more accessible for these people. Accordingly, AI does not just supplement existing efforts but expands what managers could do with those cultural works, especially when scholars and financial resources are in a limited amount.

Even though AI could largely benefit AI transmission, it could also be an important ethical and practical concern. First, there is an issue about cultural ownership and representation. Dongba script and Naxi culture belong to the Naxi community and Naxi people, and AI tools should not be used to destroy or distort their words' meanings. A study work based on language and cultural preservation emphasizes that AI projects should be guided by community priorities and be involved in local practitioners in the design process. In this study, the AI generated videos or chat box tools should be used as a supportive media, but not a replacement of their own culture. Second, there are practical limitations. Not all communities have equal change to access to AI tools or stable internet connections. Some of the tools I used, such as Nano banana pro, may get blocked from the Chinese internet and users need to have the basic knowledge of bypassing the firewall, as known as using VPN. Moreover, advanced AI models are usually costly, meaning that getting access to these AI tools could be a financial burden for some users. To equally give each user access to the AI tools, these projects should be built with Open-code models published on GitHub or other websites, which less likely require a high cost for users. Finally, there is the question of reliability. AI tools can easily make mistakes such as giving made citations and visualizing Naxi script in the wrong way. Therefore, a careful and effective prompt is needed. Users need to have basic knowledge of AI prompt creation, and the courses of that are usually available freely on social media.

Moreover, all the findings are from existing research papers, no direct interactions with actual works, which means the conclusions are theoretical, not empirically verified, and it might be limited and could not be applied for some fields. Also, no quantitative performance data collected, which means no feedback from actual cultural workers, largely limit the depth and credibility of evaluation.

A future study could conduct field work in the Naxi community by gathering real data on how community members use and respond to the AI tools. Also, design studies comparing AI chatbots versus the traditional teaching method in cultural transmission to show which one is more effective and efficient by producing quantitative evidence.

References

- [1] Xu X, Li D, Jiang Z, Li N, Wu G, Wang H, Zhang X, Bai F, et al. Construction of an International Digital Sharing Platform of Dongba Manuscripts and Dongba Hieroglyphs. *Computer Systems Science & Engineering*, 2019, 34(4): 191-199. <https://doi.org/10.32604/csse.2019.34.191>
- [2] Ba'ai N M, Aris A. AI and Cultural Heritage: Preserving and Promoting Global Cultures Through Technology. *Nanotechnology Perceptions*, 2024, 20(S15): 170-176. <https://doi.org/10.62441/nano-ntp.vi.3454>
- [3] Fu Y, Shi K, Xi L. Artificial intelligence and machine learning in the preservation and innovation of intangible cultural heritage: ethical considerations and design frameworks. *Digital Scholarship in the Humanities*, 2025, 40(2): 487-508. <https://doi.org/10.1093/lc/fqaf034>
- [4] Li S, Liang Y, Han X. The application of artificial intelligence-assisted technology in cultural and creative product design. *Scientific Reports*, 2024, 14: 31069. <https://doi.org/10.1038/s41598-024-82281-2>
- [5] Sharofova A. The impact of AI on endangered languages: preservation efforts. *Texas Journal of Philology, Culture and History*, 2023, 25(1): 52-59. <https://zienjournals.com/index.php/tjpch/article/view/872>
- [6] Falk M T, Hagsten E. Intangible Cultural Heritage differently exposed across continents. *npj Heritage Science*, 2025, 13: 600. <https://doi.org/10.1038/s40494-025-02169-w>
- [7] Ma Y, Li Y, Long G, et al. Dataset for Single Character Detection in Dongba Manuscripts. *Scientific Data*, 2025, 12: 1075. <https://doi.org/10.1038/s41597-025-05434-6>
- [8] Du J, Zhang X, Jiang K, Hu Y, Tang J, Liu J, Henian E. Cultural Heritage Preservation using Multimedia and AI. *Proceedings of the 17th International Conference on Digital Preservation (iPRES 2021)*, 2021. <https://www.digipres.org/publications/ipres/ipres-2021/cultural-heritage-preservation-using-multimedia-and-ai/>
- [9] Lai S, Tian Y, Zhang Q. The impact of AI-generated technologies-driven digital cultural heritage platforms on users' offline cultural participation intentions. *npj Heritage Science*, 2025, 13: 574. <https://doi.org/10.1038/s40494-025-02148-1>
- [10] Jayanthi J, Maheswari P U. Comparative study: enhancing legibility of ancient Indian script images from diverse stone background structures using 34 different pre-processing methods. *Heritage Science*, 2024, 12: 63. <https://doi.org/10.1186/s40494-024-01169-6>

- [11] Bi X, Luo Y. Incomplete handwritten Dongba character image recognition by multiscale feature restoration. *Heritage Science*, 2024, 12: 218. <https://doi.org/10.1186/s40494-024-01329-8>
- [12] Europeana Foundation, European Schoolnet (EUN). Digital cultural heritage in education – a tool to navigate difficult times. *Europeana Pro*, 2021-08-30. <https://pro.europeana.eu/post/digital-cultural-heritage-in-education-a-tool-to-navigate-difficult-times>
- [13] Gordin S, Rusakov Y, Yates A, Shmidman A, Smith D A. CuReD: Deep learning optical character recognition for Cuneiform text editions and legacy materials. *Proceedings of the 1st Workshop on Machine Learning for Ancient Languages (ML4AL 2024)*, 2024: 130-140. <https://doi.org/10.18653/v1/2024.ml4al-1.14>
- [14] Sperli G. A cultural heritage framework using a Deep Learning based Chatbot for supporting tourist journey. *Expert Systems with Applications*, 2021, 183: 115277. <https://doi.org/10.1016/j.eswa.2021.115277>