Cultural Heritage Preservation using Multimedia and AI

Re-imaging Shenzhen Five Thousand Years Ago through Inter-disciplinary Collaboration

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Abstract – Cultural Heritage plays an important role in a modern city like Shenzhen. An archaeological discovery of Shenzhen 5000 years ago is innovatively preserved in the digital library repository using digitalization and multimedia technologies at Southern University of Science and Technology (SUSTech). Multimedia modalities including interactive text, audio, image, graph, and video contents are developed, curated, and preserved in the project. Multimedia animation of a unique ritual culture from the archaeological discovery is further developed through deploying new computer graphics and Artificial Intelligence (AI) techniques. The project is materialized through inter-disciplinary collaboration among members from various teams with expertise in archaeology, multimedia, AI, and digital preservation. This collaboration enables the re-imaging of Shenzhen 5000 years ago innovatively with modern and technical elements.

Keywords – Inter-disciplinary Collaboration, Digital Preservation, Digital Archaeology, Multimedia, Cultural Heritage, Artificial Intelligence

Conference Topics – Enhancing the Collaboration; Scanning the New Development

I. BACKGROUND AND INTRODUCTION

From the Xiajiaoshan site of the Baoan District of Shenzhen city in China, archaeologists discovered thirty pits filled with pottery sherds, which are dated to 6000 to 5000 years ago. These “pottery pits” are elongated in shape, ranging from five to twenty square-meters in area. They are positioned in an arched manner, surrounding the peak of the Xiajiaoshan Mountain and facing the ocean next to the mountain. Pottery containers were broken by the human, and the pottery sherds have stayed inside the pits. The positions and arrangement of the pits and the characteristic of the pottery sherd deposits indicate that these pottery pits might have been a result of ritual activities 5000 years ago.

This paper describes how archaeologists, multimedia experts, and librarians collaborate on Cultural Heritage Preservation using multimedia and AI techniques. Based on the archaeological data from the excavation of four of the pottery pits and the reconstructed 3D model of the pottery sherds, we aim to understand who and why the people broke the containers, reveal how this human behavior pointed to the ritual culture in Xiajiaoshan 5000 years ago, and preserve this valuable cultural heritage.

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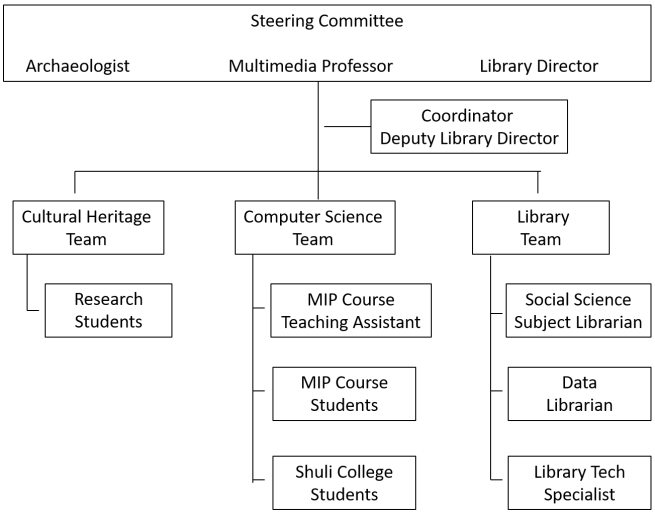

Figure 1: Project Management Structure.

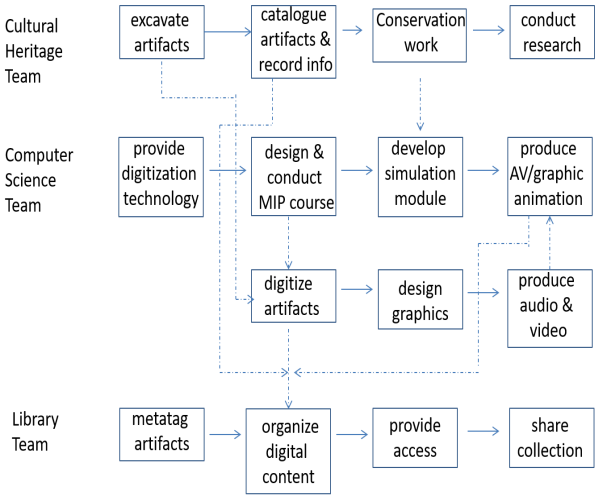

Figure 2: Workflow Chart.

II. COLLABORATIVE PROJECT MANAGEMENT STRUCTURE

Digital preservation requires knowledge about a wide area of topics including the contents of digital assets, how and why the assets have been created and included in a repository, as well as technical expertise on digital preservation methods [1]. Therefore collaboration in terms of sharing domain knowledge, sharing resources, and coordination among the inter-disciplinary members is a major challenge in this project. A common understanding of project goals is essential, while it is also vital to meet the objectives of various teams. The project management structure comprising teams from each discipline is shown in Figure 1.

The project is led by a steering committee comprising the three-team leaders from SUSTech (Southern University of Science and Technology). The archaeologist from the Cultural Heritage Laboratory Center is in charge of excavating the pottery sherds from the thirty pottery pits and researching how and why the people broke the containers to understand the ritual culture in the area 5000 years ago. Research students from the Cultural Heritage team contribute to the project by providing expert knowledge in archaeology.

The multimedia professor, an AI expert, teaches Multimedia Information Processing (MIP) course to 19 Computer Science undergraduates. He leads the undergraduates to create the pottery sherds' multimedia content and simulate how the pottery containers were smashed using AI technology. He and his teaching assistant guide the undergraduate students to create multimedia images and 3D animation in the media labs. Some other students from SUSTech Shuli College and their tutor, who are also members of the Micro-film Students Club, assist the professor in designing graphics as well as producing audios and videos.

Library Director leads the library team to work on the digital curation and digital preservation. The Library team comprises the Deputy Library Director who is the coordinator of the project, a Social Science Subject Librarian, a Data Librarian, and library technology specialists. They are responsible for organizing the digitized artifacts and building the platform for content discovery, presentation, sharing, and preservation.

III. DISCOVER THE HERITAGE

The steering committee designs the workflow as illustrated in Figure 2 where tasks are distributed based on the expertise of the members in the three teams. It is aimed to maximize the strength of every member and at the same time to collaborate effectively.

A. Discover the heritage

At the beginning of the collaboration, four of the thirty pottery pits have been encased and transported to SUSTech in Shenzhen. A Chair Professor in Archaeology at SUSTech and his students started indoor excavation in the SUSTech Cultural Heritage Laboratory. The goal of the excavation is not to retrieve the artifacts but to learn about the behaviors of the past people through the process of the excavation. The excavation included excavating the pottery pits, recording the archaeological information, and cataloging all the artifacts they recovered. In this process, all the pottery sherds stay in the place they were discovered, so the archaeologists can study the relationship between the individual sherds and deduce how they were broken. The archaeologists can then study the spatial relationship between individual pottery containers and reconstruct the pottery pits from 5000 years ago. At the same time, the archaeologists will provide the data of the scanned pottery pits, which will be very helpful to the multimedia experts for the three-dimension (3D) reconstruction of the pits.

The entire excavation process was completed following the "Register of Professional Archaeologists (RPA) Standard of Research Performance" [2]. The archae-

ologists recorded information during excavation as detailed as possible, including the description of environmental and cultural features, depositional strata, the methods of data collection, and the provenience of all specimens collected. Following the standard, all specimens are stored in the appropriate curatorial facilities in the Cultural Heritage Laboratory. The process of cataloging and recording follows "The Standard and Guide to Best Practice in Archaeological Archiving" [3]. According to the standard in archiving, the archaeologists select China's archaeological recording framework and stick to the standard consistently in recording during the whole archiving process. All information, data, photographs of the sites, artifacts, and features have been digitized and remained available to those who are relevant to the excavation project.

The next step of the excavation is to conserve the pottery containers and piece the pottery sherds together, so the archaeologists would deduce how the pottery broke and what are the points of smashing on the sherds. The information the archaeologists collected during the process of recovery and conservation of the artifacts is provided to the multimedia experts who design the 3D multimedia simulation and animation to present how the people in the past smashed the pottery containers. The archaeologists will also use the information and artifacts collected to conduct further research including residue analysis. From the result of the analysis, the archaeologists will learn what kind of food or drink might be in the container, and this information would also be helpful for the multimedia experts to consider in designing the 3D simulation and animation.

B. Technical architecture for building the multimedia title and event simulation

Cultural Heritage like archaeology can be presented by digital multimedia that contains different media types like text, image, graphic, audio, animation, and video. Digital multimedia of cultural heritage can be preserved for a long time and can be shared conveniently.

We design a multimedia framework for digital preservation of the project as shown in Figure 3. The framework includes four parts: the multimedia video presentation of the project background, 3D image presentation of the digitized artifacts, 3D simulation of the ritual culture 5000 years ago, and audio recordings from the archaeologists and experts involved in the project.

The first part introduces the background of this project and the excavation process using video and animation multimedia technologies based on the text provided by historians and archaeologists. It would be completed by MIP course students and Shuli College students under the guidance of the multimedia professor and his assistant. 3D image presentation of the digitized artifacts is achieved by scanning the excavated sherds for historical relic reconstruction, which MIP course students and librarians accomplish together. Animation presentation is used to reproduce the life of Shenzhen

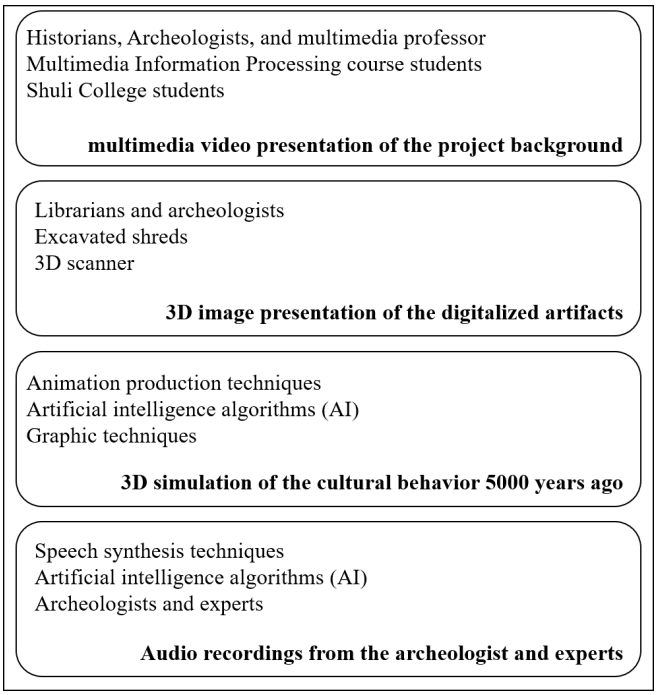

Figure 3: Project Multimedia Framework.

five thousand years ago by applying animation production techniques, AI, and graphic techniques. Adobe Animate CC software is used as the animation production software environment, which is utilized to reconstruct the 3D simulation of the cultural behavior 5000 years ago. AI algorithms are used to infer and simulate the behavior based on the limited sherds from the excavation by collaborating with historians and archaeologists, in which human-computer interaction techniques, 3D modeling and calibration techniques, and deep learning techniques are adopted. These AI algorithms can enrich the diversity of behaviors in 3D simulation. Audio recording and sound-track editing of the comments from the experts describing the customs of Shenzhen 5000 years ago is also provided in the framework. To improve the quality of the audio, speech synthesis technology is used to incorporate the voice of interviewees by using AI techniques like signal processing algorithms, convolutional neural network (CNN), and recurrent neural network (RNN). Furthermore, the team also plans to develop an AI-based speech synthesis application API (Application Programming Interface) for users to synthesize different types of sounds.

C. Teaching practice innovation: Students' participation and contribution in the project

How to engage students to be interested in cultural heritage is a challenge in the modern world. When designing our MIP Course in the Department of Computer Science and Engineering of SUSTech, we innovatively integrate archaeology and cultural heritage preservation in the MIP Course in which every student as a member of the project and is responsible for different tasks. The course is designed to have a theoretical/technical mod-

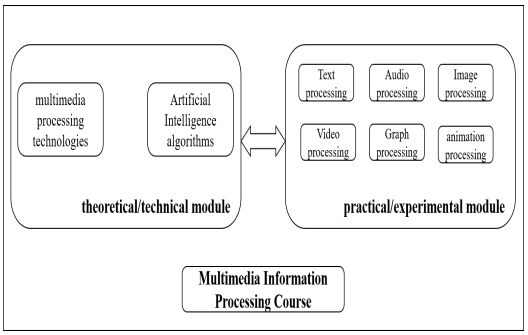

Figure 4: Multimedia Information Processing Course Structure.

ule and a practical/experimental module, as shown in Figure 4. In the theoretical module, we teach multimedia processing technologies and Artificial Intelligence algorithms to equip the students with the knowledge required for the project. In the class, the professor often relates the theory teaching to the practical situation in the project. In the practical/experimental module, students are divided into different task groups like image processing, video processing, text processing, audio processing, graph processing, and animation processing according to their interests, knowledge of the subject, and project requirement. When forming the task groups, students positively look for partners who have the same interests rather than being assigned passively. Furthermore, members of the Micro-film Student Club from Shuli College are also attracted to work with the MIP students in the project with assistance from their tutor.

D. Organize content for discovery, presentation, sharing, and preservation

One way to help preserve digital objects is to make sure that as much information as possible is gathered when they are created [4]. The information is recorded at the container level when the pottery sherds were excavated from the site. As each piece of the pottery sherd is scanned into a 3D image by the MIP course students, the meta-tagging has to be done at the pottery sherd level to record the details of each piece of the sherd, including material, shape, and color for the digital preservation and future re-use in other research projects. The format of the 3D image is Polygon File Format (PLY), which comprises a series of properties: transparency and color, surface normals, texture coordinates, and data confidence values. It contains much information about digital objects and is appropriate for digital object preservation. Furthermore, it is appropriate for different platforms and decreases the difficulty in 3D image preserving. We use two storage formats for the animation by considering exhibition and future animation development: video and Object File Format (obj). Video is used for exhibition, while obj format is used to support future animation development.

Working together with the archaeologists and the multimedia experts, the subject librarian defines the metadata template based on DC to ensure the detailed information of every 3D image is recorded as well as the accuracy and effectiveness of the metadata. Resource types are categorized using the "Resource Categories and Codes for Digital Content" defined by China Audio-video and Digital Publishing Association in December 2020. All fields are bi-lingual, which is in both Chinese and English for easy access and re-use globally.

The existing multimedia server in the library does not support 3D images and animation; therefore, a new platform needs to be built which should comply with OAI-PMH so that the digital objects of the valuable cultural heritage content could be discovered together with other library resources on the library's discovery interface. The backup of the contents and metadata are properly planned and managed. Local and remote backups are done regularly. The metadata can be exported to CSV format while the digital content can be exported in their original formats for migration and re-use in the future. Metadata of this special collection will also be shared with the Pacific Rim Library, a collaborative venture among PRRLA members which SUSTech Library is one of them.

It is a great challenge for librarians to cope up with the transforming technologies involved in digital preservation. On the other hand, it also creates opportunities for librarians to collaborate with experts to upgrade their knowledge and skills. Librarians' involvement in the project by planning the preservation strategy for the digital objects as early as when they are created can save a great deal of time and stress comparing with trying to retrieve the information an object holds later on [5]. Our early involvement in the project is an excellent attempt to adopt this best practice.

IV. CONCLUSIONS AND FUTURE WORK

The project is an interdisciplinary collaboration among members from different teams with expertise in archaeology, multimedia, AI, digital curation, and digital preservation. Efficient and effective coordination is the key to the success of the collaborative effort in the project. Inter-disciplinary collaboration requires but is not limited to knowledge sharing, resource sharing, coordination, and proper project management. There have to be common tools, agreed processes, standards, and strategies. Library as the stakeholder of the digital repository, coordinates the diverse expertise and resources in the life cycle of the project. Multiple channels are set-up for communications of different nature, including documents sharing, knowledge sharing, informal discussions, and formal meetings, which are especially important during the nationwide CORVID-19 fight in China when face-to-face meetings are not possible.

The involvement of the students from the MIP course and micro-film student club distinguishes this digital preservation project from others. It is not only an innovative way to teach them about multimedia and AI but also contributes to the sustainability of the digital

preservation of the artifacts of cultural heritage.

This is our first digital preservation project for multimedia cultural heritage content. Through this project, we established a collaboration model and process for future preservation practices. They will evolve further when we work on other digital humanities projects of similar nature.

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