

# Exploring the Boundaries of Digitalization of Cultural Heritage: Opportunities, Challenges and Future Directions

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**Abstract:** This contribution explores the opportunities and challenges of digitalizing cultural heritage, using the *Digitalization of Cultural Heritage* project as a case study. The project, a collaboration among universities from multiple countries, focuses on creating 3D models of historical artifacts, exemplified by the 3D modelling of Roman-period fragments using photogrammetry. The paper discusses the broader implications of digitalization with a particular focus on the use of AI technologies, including its potential to enhance education, accessibility, artifact preservation, and cultural tourism. It also addresses the technical and ethical challenges involved, emphasizing the need for ongoing innovation and interdisciplinary collaboration to maximize the benefits of digital cultural preservation.

**Keywords:** Digitalization of Cultural Heritage; 3D Model; Photogrammetry; Virtual Preservation

## 1 Introduction

This contribution is written in the context of the project *Digitalization of Cultural Heritage* [Di24]. The project is conducted by different universities from Germany, Jordan, Lebanon, Iraq, Sudan and Oman. Its objective is to digitize historical artifacts and cultural assets from the participating countries. Due to various reasons, including political conflicts, difficult access and a lack of development, many historical sites are not easily accessible to interested people. In order to gain virtual access and preserve cultural heritage, students created 3D models of these historical sites. The models can be used for educational purposes to arouse interest in cultural heritage and the culture in general of these countries. Furthermore, these models can be used for the purpose of scientific preservation, with the objective of preventing, monitoring, and planning restorations on an ongoing basis [Zi15]. The preservation of cultural heritage is of great importance, as an increasing number of natural and human made disasters pose a significant threat to it. Especially earthquakes present a considerable risk to cultural heritage, as masonry is particularly vulnerable [PA13]. Additionally, the increasing sea level and other consequences of climate change necessitate the preservation of cultural heritage through digitalization [ML14].

By describing an exemplary 3D modelling process within the context of the *Digitalization of Cultural Heritage* project, a potential implementation of such a digitalization process is demonstrated. Building upon this, this contribution examines opportunities and challenges, in particular related to AI, associated with the digitalization of cultural heritage in general.

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## 2 Creation of 3D Models

In this section a sample digitalization process is demonstrated by the creation of a 3D model of a hand and elbow fragment from the Roman period at the Amman Citadel. The hand, which is known as the hand of Hercules, is thought to have belonged to a larger statue dedicated to Hercules from the Temple of Hercules, which was located at the site of Amman Citadel [Ma24]. There are several hypotheses regarding the destruction of the statue. In addition to the commonly accepted explanation that it was destroyed by an earthquake, there is also the hypothesis that the remainder of the statue was burnt in a kiln during the Umayyad period [Ar03]. However, the remaining fragments are important historical objects and a tourist attraction, thus it has been selected to preserve them by creating a 3D model. For creating the associated 3D models two main approaches can be applied. One widely spread approach is to scan the object with laser technology to obtain the 3D data of the object [LLY20]. This approach requires a professional laser scanner, which was not accessible. Thus, an alternative, low-cost approach has been applied, namely photogrammetry. With this method, the resulting 3D model is based on a large number of 2D images captured from the object. The higher the number of images captured from different perspectives, the more detailed the 3D model will be at the end of the reconstruction process [Dr23]. The images captured from different perspectives and distances can be provided to a software, for example Metashape [Ag24] in order to create a 3D model. Furthermore, there are other options of processing the image data applying the photogrammetry approach by using an app that computes a 3D model from a taken video. This approach has been applied in this contribution by utilizing the app Scaniverse [Sc24] to create 3D models of the hand and elbow of Hercules. The app is iOS compatible and can be used for highly accurate 3D models that are also used in neuroscience [Er24]. To obtain 3D models of very high quality, the same relationship applies as with classic photogrammetry. The more detailed the video is recorded from different perspectives, the more detailed the resulting 3D model will be. The following figures show the results.



Fig. 1: 3D model of the hand fragment



Fig. 2: 3D model of the elbow fragment

Upon examination of these models, several questions about the digitalization of cultural heritage in general arise. These include the extent to which the digitalization of cultural

heritage offers opportunities and boundaries of it. Additionally, potential challenges and threats to this area should be considered. These topics are discussed in the following sections.

### **3 Opportunities and Challenges of Digitalization of Cultural Heritage**

One of the most significant opportunities of digitalization is the provision of digital 3D models, which make rare and valuable artifacts accessible to a global audience. These models allow researchers to conduct detailed analyses and comparisons without needing physical access to the originals, thereby promoting research and enhancing interactive and immersive learning experiences [Be17] [RC14]. Fundamentally, the digitalization of cultural heritage increases accessibility for individuals who, due to various factors, are unable to visit cultural sites in person [Pi21]. High quality and completeness are essential, yet difficult to achieve with digital copies [RC14]. Additionally, the costs of the required technologies might be high, and skilled personnel must be found to carry out the digitalization process. Depending on the economic situation, it may be challenging to secure the necessary resources [Pi21]. Nonetheless, investing in digitalization can be worthwhile, as digital models can be preserved and better protected from physical damage caused by humans or natural disasters, thus being available for future reconstructions in case the original is destroyed [RC14]. There is much debate on whether digitalization promotes or harms tourism. On the one hand, digital models provide a better understanding of cultural sites, potentially sparking curiosity to visit these places in person [Be18]. On the other hand, digital models can never fully replace a direct visit, they can replicate the experience to some extent [Be18]. Moreover, legal and ethical challenges must be addressed during digitalization. Handling cultural heritage is a sensitive issue that raises discussions regarding ownership. It is crucial to ensure that digital replicas are created and used respectfully, honouring the rights and customs of the original civilizations [Ch16]. In particular, the use of artificial intelligence and machine learning holds great potential as well as considerable risks. These technologies can improve the efficiency and accuracy of digital reproductions and create new opportunities for the investigation and presentation of cultural artifacts [Ch16] [Pi21]. As these technologies will push the boundaries of cultural heritage digitalization in the future, they will be explored in more detail in the next section.

### **4 Potentials and Risks of Artificial Intelligence in Cultural Heritage**

One of the greatest opportunities of the digitalization of cultural heritage lies in the utilization of artificial intelligence (AI). However, this technology also entails risks. During a virtual event hosted by the German UNESCO Commission on October 4, 2023, 80 experts from politics, science, and culture discussed this topic. It was explained that AI could enable new creative outputs and improve the accessibility and adaptation of cultural offerings to society. AI can support creative processes and serve as a tool and dialogue partner for artists. It offers the potential to make art and culture more accessible and to accelerate creative processes.

This new form of utilization could even be considered an artistic achievement in itself [Ge23]. AI technologies can significantly contribute to the preservation and accessibility of cultural heritage. For instance, neural networks and AI models can be used to classify and interpret artifacts, objects, and damaged buildings. These technologies also support the restoration and reconstruction of artworks such as paintings and mosaics and assist in the recovery of texts and inscriptions. Another advantage of AI is its ability to analyze and visualize historical data, which can gain new insights and expand knowledge about our past [Sp24]. This can greatly support research in the fields of archaeology and history, helping to better understand and document cultural heritage [KBO21].

Despite the many advantages, at the German UNESCO Commission it was emphasized that AI could threaten jobs and intellectual property rights. Dependencies on tech corporations and uncertainties regarding the ownership of important data might be central issues. Additionally, AI can exacerbate social conflicts and reproduce structural discrimination. The participants agreed that differentiated regulation of AI is necessary to ensure ethical development and use. Self-regulation by tech corporations is insufficient, thus clear legal regulations are required [Ge23]. Furthermore, there is the risk that AI systems could reproduce biases, as they are trained on existing data, thereby potentially reinforcing existing errors. Additionally, there is the danger of a *content flood*, where the quality and authenticity of content are diluted by mass-produced AI-generated content [Sp24]. The legal framework presents another challenge. Protecting intellectual property and ensuring fair use and distribution of digital cultural goods requires the adaptation of existing laws and the development of new regulations [WC23].

## 5 Discussion and Conclusion

Examining the opportunities presented by the 3D models of the hand and elbow of Hercules, these digital representations offer educational and research opportunities by providing detailed representations of the historical artifacts for study without physical access [Be17] [RC14]. Additionally, the digital reproductions support the preservation of these objects by serving as potential records for restoration and conservation efforts [RC14]. The models allow global sharing of accurate replications through the technologies photogrammetry and Scaniverse. However, the demonstrated project as well as digitalization of cultural heritage in general faces challenges including technical constraints related to the accuracy of Scaniverse, the lack of completeness of digital reproductions and the need to handle sensitive data respectfully and legally. By using AI capabilities as described in section 4, some of these problems can be addressed. The presented models of the hand and elbow could be completed from every perspective and then integrated into an AI-generated Hercules statue to make the cultural heritage more tangible. However, the merging of real and generated cultural heritage raises further legal challenges for which regulations need to be created in the future. The use of AI thus creates new opportunities to further advance the digitalization of cultural heritage by making digital reproduction more effective and experienceable, but it further intensifies the ethical and social challenges.

On 10 November 2021, the European Commission took a first step towards exploiting the opportunities of digitalization of cultural heritage by publishing recommendations proposing the creation of a common European data space for cultural heritage. This initiative aims to accelerate the digitalization of cultural assets while ensuring their protection and accessibility. By 2030, the goal is to digitize all endangered monuments and half of the most visited tourist sites. As cultural tourism accounts for up to 40% of all tourism in Europe, it is important to seize the opportunities despite the challenges in times of increasing natural and human made disasters [Eu21].

In conclusion, the digitalization of cultural heritage, as exemplified by the 3D modelling project of the hand and elbow of Hercules, demonstrates both significant opportunities and notable challenges. In particular for 3D models of cultural heritage, the potential to enhance research, education, accessibility, and preservation is immense. The presented opportunities foster a greater appreciation and understanding of cultural heritage and support the conservation of invaluable historical artifacts. By addressing the challenges, the benefits of the digitalization can be fully realized, justifying the investments and efforts required to overcome the associated challenges. When weighing the opportunities and challenges, it becomes evident that the benefits provided by the digitalization of cultural heritage outweigh the challenges overall. Future advancements in AI and machine learning promise to further improve digital reproductions. Addressing the associated challenges through innovation and collaboration will ensure the preservation and appreciation of cultural heritage in the digital age.

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