The review of AI and cultural heritage protection-Taking the whole process of cultural heritage protection as an example

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Abstract. This article aims to summarize the application of artificial intelligence (AI) in cultural protection, taking the entire process of cultural heritage protection as an example. In each process, AI has its own prominent applications. The process of cultural heritage protection is divided into the archaeology of cultural relics, classification, identification, and restoration of cultural relics, cultural heritage management after information identification, and finally, presentation to the public, which is also a part of cultural protection. With the development of technology, AI has participated in various aspects of society. While this study encourage the scientific protection of cultural heritage protection. Through the establishment of regulations and related implementation, this studywill jointly advance the application of AI in the field of cultural heritage protection into a new era.

Keywords: artificial intelligence, cultural heritage protection, Heritage Archaeology, Restoration, Language Extraction, Exhibits.

1. Introduction

The advancement of technology has led to an enhancement in the protection of cultural heritage. The advent of artificial intelligence and its pervasive integration into modern society has revealed the immense potential of this technology, which is yet to be fully realised and applied. As a traditional field, the protection of cultural heritage should also proactively engage with the artificial intelligence industry to identify new opportunities for the protection of cultural heritage.

The traditional field of cultural heritage protection is confronted with significant challenges. Cultural heritage is a unique category of material heritage. It is not merely an object of artistic and historical value; it is also the tangible embodiment of the cultural and spiritual essence of the Chinese nation. It is widely distributed throughout China in a variety of forms and in considerable quantities. The question of how to strengthen the excavation and restoration of cultural heritage, protect and manage cultural heritage, and at the same time explore its potential value to provide services for society and the people has consistently been a focus and a challenging issue.

Artificial intelligence represents an emerging means of addressing the aforementioned gaps in this field. From the initial conceptualisation of artificial intelligence at the 1956 Dartmouth Conference[1], through the advent of novel technologies such as expert systems, perception machines and natural language processing in the 1980s, to the present era of deep learning, which has become a dominant technology within the field of artificial intelligence, the age of artificial intelligence has undoubtedly

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arrived. The utilisation of big data analysis, image recognition, natural language processing and other technologies enables the intelligent restoration, identification, classification, interpretation, display and other functions of cultural heritage to be realised, thereby enhancing the efficiency and utilisation of cultural heritage protection.

This article examines the application of artificial intelligence in the context of cultural heritage protection. From the perspective of the protection process, the application of artificial intelligence has the potential to streamline operations, enhance efficiency, and facilitate the digitisation of cultural heritage. Conversely, it would be unwise to rely unduly on the application of artificial intelligence algorithms in the context of cultural heritage protection. It is of the utmost importance to safeguard the independence and distinctiveness of the data pertaining to cultural heritage.

2. Cultural heritage preservation and artificial intelligence

Cultural heritage is further divided into two categories: intangible cultural heritage and tangible cultural heritage. This article primarily focuses on the utilisation of artificial intelligence technology throughout the entire process of protecting tangible cultural heritage, also known as "cultural relics". The process of heritage protection is divided into five stages: the discovery and identification of the object, restoration, comprehensive management of the heritage, and exhibition and dissemination for the public (as shown in Figure 1).[2]



Figure 1. the whole process of cultural heritage protection

Among these stages, the excavation, identification, and restoration of the object represent the initial point and the core of the entire process. It is evident that the protection of an object encompasses not only the physical safeguarding of the object itself, but also the environmental protection of its surrounding context. Given the inherent unpredictability of the environment in which cultural relics are situated, coupled with the multitude of factors that can potentially impact their condition, such as natural weathering, environmental transformation and human-induced damage, a comprehensive approach to the protection of cultural relics necessitates a dual focus on their restoration and the environmental context in which they are situated.

Furthermore, comprehensive heritage management is of great significance. There are numerous types of cultural heritage, distributed widely. It is essential to establish a systematic approach to managing archives and cultural heritage restoration plans. These substantial and seemingly trivial tasks form the foundation of cultural heritage protection. Comprehensive heritage management must be scientific and sustainable to ensure the consistent advancement of cultural heritage protection.

Exhibitions and public dissemination are also integral to the purpose and significance of cultural heritage protection. In the protection of traditional cultural heritage, exhibitions and education represent the primary means of dissemination, while tourism, cultural and creative industries, and other novel forms of entertainment also assume an increasingly significant role in the transmission of cultural heritage. As societal norms evolve, the manner in which cultural heritage is promoted must also adapt to remain relevant and resonate with the public.

3. Artificial Intelligence in Heritage Archaeology

Indeed, the application of Artificial Intelligence in cultural heritage excavation (archaeology) is the basis of all cultural heritage preservation. And many different approaches exist for its application in archaeology. These include creating 3D models of historical sites, or scanning the land with LiDAR to identify possible ancient burials, such as through machine learning algorithms that predict the excavation depth of a site and potential artefacts.

As the technology develops, more and more tools are ready to be deployed. There is no doubt that AI can assist archaeologists in site excavation. Iris Kramer[3] has taken the first step in this direction. He is a former archaeologist turned computer scientist. Using deep learning, he has been able to identify potential archaeological transplants, which effectively reduces the cost of archaeology and protects important cultural heritage, especially ancient buildings, from being destroyed. In addition to this, a group of academics from Binghamton[4] used Object-Based Image Analysis (OBIA) to process data related to 3D scanning techniques (e.g. light, radar, LiDAR), which is important for finding potential historical sites. The fact that AI is being used for the analysis of aerial data can be very straightforward in finding archaeological evidence. For example, they are able to determine the general area where artefacts are being excavated, but not the exact location of sites within that area. Using some sort of algorithm, this algorithm is able to analyse the groundwork of archaeologists by analysing photographs that are already available to identify areas with similar patterns.

Using AI technology, it is possible to automate 3D scanning and modelling of sites for digital preservation and visual display. At present, the convergence of point cloud technology and AI has emerged as a prevailing approach, significantly enhancing the precision of 3D modeling while concurrently facilitating the extraction and classification of architectural or artifactual features. AI's capacity to interpolate and reconcile areas absent from point cloud data has considerably streamlined this process; however, it is essential to acknowledge that certain discontinuities may indeed originate from intrinsic characteristics of the structures or artifacts themselves, necessitating ongoing advancements in algorithmic development. As researchers continue to refine these methodologies, it is envisioned that AI-generated virtual representations of ancient sites will soon be accessible to the public, offering a promising avenue for the promotion and preservation of cultural heritage..

Data processing and recording is a crucial aspect in archaeology. Record cards are the basis for subsequent work. In addition to the buildings and artefacts found, the cards contain natural language descriptions, pictures and drawings, as well as other special attributes and features. Basically, thousands or even tens of thousands of record cards are generated for each archaeological event. Traditional methods are often cumbersome and error-prone.

The introduction of AI technology, however, has made the process much more efficient and precise. For example, archaeological data can be analysed, organised and stored quickly and accurately using AI's automated processing and recording capabilities. This method can reduce data loss or errors caused by human factors and improve the reliability and efficiency of research. This is a fundamental guarantee for the subsequent protection of cultural heritage.

Next, the author is going to explore the application of artificial intelligence in the classification, identification and restoration of cultural heritage.

4. Artificial Intelligence in Artifact Classification, Identification and Restoration

There are many mature AI techniques in this area, the authors led by Belhi and Bouras[5] for the study of cultural heritage images, they proposed a deep learning based method for completing the missing labels of cultural heritage images, using deep learning algorithms to train on the cultural heritage images and their text labels, so as to achieve the automatic classification of cultural heritage images by the machine, and then complete the missing labels of the cultural heritage works. After that, the researchers at Chitkara University[6] performed multi-classification recognition of Indian monuments based on hybrid Convolutional Neural Networks (CNNs) and Long Short-Term Memory (LSTM) models and then further multi-classified various famous Indian heritage monuments. This includes binary classification of Indian monuments to identify heritage Indian monuments with 92% accuracy.

As mentioned before, the authors led by Pierdicca and Paolanti[7] have digitally reconstructed historical buildings, and they propose a deep learning framework based on point cloud segmentation, which uses deep learning techniques to semantically segment 3D point clouds of historical buildings. Efficient semantic segmentation of point clouds can help researchers to quickly identify different types of historical building elements, thus improving the efficiency of analysing historical building structures and constructing parametric 3D models.

The main battleground for AI in this process is still the identification and restoration of cultural heritage.

A group of authors led by Belhi and Bouras [8]have worked on a series of applied methods for cultural heritage images based on deep learning techniques. In their work on cultural heritage image restoration, they proposed an improved deep learning based framework for cultural heritage image restoration and complementation in order to improve the effectiveness of cultural heritage image restoration.

Domestic teams are also not to be underestimated, Yang Ting[9] (2019) proposed a self-organising mapping (SOM) image restoration algorithm based on artificial neural networks (ANN), applying artificial intelligence technology to the field of ancient architectural mural restoration. Many scholars applied it practically, Chen Yong [10]used a deep learning-based restoration method for part of the murals of Dunhuang frescoes in the 25th cave. Mingfei Zhang [11]proposed an improved generative adversarial network structure to address the deficiencies of the existing network structure in the colour damage restoration of murals, and verified the effectiveness of the improved network modules. Compared with the existing restoration algorithms, the structural similarity (SSIM) score is improved by 2%.

Xiang Chi and other scholars [12]applied the image recognition technology to the Great Wall restoration in the detection of the Great Wall, and achieved the rapid identification and localisation of the damage on the surface of the masonry structure of the Great Wall. A big data acquisition system for ancient architectural relics was developed, which provides a new idea for deep learning big data acquisition.

5. Application of Artificial Intelligence for Language Extraction in Cultural Heritage

In the field of text recognition, Optical Character Recognition (OCR) using MATLAB software is the traditional method.. OCR uses electronic devices to scan the font symbols on paper or other pages, and determines the shape of the font by detecting the contrast between light and dark on the paper, in which the recognised characters are represented as computer text. Alternatively, the text is recognised using MATLAB software, which filters, enhances, detects and locates the text image information and separates the background noise as well as the useful information in the text image for the purpose of detection and recognition.

However, as there is no uniform standard for the texts in cultural heritage, they are all in the form of pictures of the cultural relics, which brings difficulties to retrieval. At present, in the field of ancient characters, there are two main methods: the first is to confirm the meaning of the characters by reading a large number of documents and materials by learned philologists and historians, and this method is extremely slow, and the addition of artificial intelligence can speed up this process. For example, XU[13] uses YOLOv2, YOLOv2-tiny, Faster R-CNN algorithms to achieve the function of oracle bone character radical detection, based on the semantic analysis of the YOLOv2 network of the evolution of the oracle bone radicals similarity analysis model, to analyse the oracle bone radicals as well as the combination of oracle bone radicals composed of the oracle bone characters of the evolution of the typeface structure of the relationship between the study of characters and their evolution, to provide a reference for the study of the text. and its evolution, providing a reference for the study of characters.

There are also foreign applications in this area. The founding team of the CUNAT application [14]has made a software that can recognise cuneiform characters. The application uses photogrammetry, computer vision, artificial intelligence and neural networks to perform these complex recognitions. The use of artificial intelligence orientated neural networks to recognise individual hierarchical letters,

identify these characters and then translate the meaning of the characters extends the technology of cuneiform detection systems.

6. Artificial Intelligence in Cultural Heritage Exhibits

Artificial intelligence can provide smarter solutions for exhibition design and interactive experiences. The group of authors led by Pierdicca and Paolanti [15]have applied AI techniques to several studies in the field of cultural heritage. They propose a model of visual attention of visitors, which uses deep convolutional neural networks to learn from the eye movement data of adults and children observing the paintings, which in turn enables the classification of visitors from the eye movement data. Through such measurements, data-based management and personalised recommendation of exhibitions can be achieved, providing museums with more accurate and efficient exhibition planning support.

In addition, technologies such as virtual reality and augmented reality, which provide audiences with a richer and more vivid cultural heritage experience, can have unexpected effects when combined with the current post-pandemic tourism rush. The authors, led by Belhi and Bouras[16], suggest that 3D holographic imaging technology can be applied in museums to provide digital interaction with cultural heritage. Taking artefacts in museums as the object of study, they propose a deep learning-based approach to improve the quality of 3D holographic imaging. In addition, VR technology can also be applied to outdoor cultural heritage sites.Jovana, Igor [17]generated a recognition model based on a dataset produced at the site of Montenegro with a VR set, which can give tourists a unique experience of visiting cultural heritage.

7. Results and discussion

Cultural heritage is the essence of human civilisation, and its most important value is that it reflects, complements, inherits and proves the authenticity of history. The application of artificial intelligence and the excavation of cultural heritage help archaeologists to analyse and excavate heritage, contribute to the formulation of scientific and effective excavation plans, and improve the efficiency of excavation. This is an effective improvement in the scientific and technological field of archaeology, and it is also an important application of artificial intelligence in the protection of cultural heritage.

At the same time, with the help of artificial intelligence, cultural heritage can be studied in depth, extracting representative symbols and signs. This saves the work of the conservator, improves the accuracy of previous classification and identification, and achieves double verification by machine and human, thus making people's understanding of the signs and symbols of cultural heritage clearer and more concrete.

In fact, the application of artificial intelligence also brings some concerns in many aspects. The first is the safety and stability of the technology. Artificial intelligence is still a developing discipline, and the accuracy of the results it produces is still not very stable, with a certain degree of randomness. At the same time, it brings huge human and material costs.

The second is privacy and data management. For cultural heritage, the privacy of information is far lower than personal information, and data management is also relatively loose, so it can lead to data leaks or other negative events, such as infringement and theft[18].

At the same time, people must be aware that cultural heritage itself is diverse and rich in interpretation. After the application of artificial intelligence, this richness is often weakened, and different eras or periods, as well as different regions, are often confused.

At the same time, there will be some deviation in the interpretation of artificial intelligence. The interpretation of artificial intelligence must conform to the policies and moral standards of the times. In the field of cultural heritage protection, people must pay particular attention to this point. Humans cannot be replaced by artificial intelligence, precisely because artificial intelligence cannot fully understand the ideas and logic of abstract or concrete historical periods.

8. Conclusion

With the rapid development of artificial intelligence, the era of digital and intelligent cultural heritage protection is coming. The author believes that artificial intelligence has great potential in the field of cultural heritage protection. It plays its role in the process of cultural heritage protection at all times, including digital preservation, restoration, interpretation, and even exhibition and innovation. With the help of artificial intelligence, archaeologists can better excavate cultural heritage, and museums and related institutions can also use related technologies to better display and inherit cultural heritage. The combination of artificial intelligence technology with other technologies such as VR/AR technology has also brought benefits to the protection of cultural heritage.

However, people must also remain vigilant about artificial intelligence. The involvement of artificial intelligence can bring uncertainty to the direction of cultural heritage protection, and its technology may cause irreversible damage to the historical and cultural value of cultural heritage. Therefore, relevant staff must apply artificial intelligence within a controllable range and in accordance with relevant regulations and tables to maintain cultural diversity and the right to interpretation.

In the future, artificial intelligence will certainly play an increasingly irreplaceable role in cultural heritage.

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