Exploring the Potential of Artificial Intelligence and Computing Technologies in Art Museums

Sunanda Rani[1*], *Dong* Jining[1], *Dhaneshwar* Shah[1], *Siyanda* Xaba[1] and *Prabhat Ranjan* Singh[2]

[1] School of Art & Design, Wuhan University of Technology, Wuhan 430072, Hubei, China
[2] Amity Institute of Information Technology, Amity University, Patna 801503, Bihar, India

Abstract. The research intends to explore how Artificial Intelligence (AI) and computing technology can be used to create a more immersive and enjoyable experience within the context of a museum visit. Specifically, the study aims to identify ways in which AI and computing technologies can be leveraged to enrich the visitor's experience, including by providing interactive content, automated personalization, and real-time access to relevant information. Additionally, the research will assess the potential for AI and computing technology to support improved data analytics and utilization of resources within museums, such as enhanced curation, digital preservation, and increased engagement with audiences. The study employed a qualitative methodology, utilizing interviews with museum professionals and surveys of museum visitors to collect data on visitor experiences. An analysis of the data was conducted to identify current and potential uses of AI and computing technology in art museums. The findings reveal that AI and computing technology are currently being used to facilitate access to collections, tour guidance, and educational activities while emerging technologies show promise for providing even more immersive and personalized visitor experiences. The results of this study suggest that AI and computing technology can play an important role in enhancing the visitor's museum experience. The research provides recommendations for art museums to leverage AI and computing technology to optimize visitor engagement and foster more meaningful connections with works of art.

1 Introduction

Artificial Intelligence (AI) and computing technology have become ubiquitous in almost every field. In the art museum context, AI and computing technology are being used to improve the visitor experience, enhance the preservation of artworks, and facilitate access to these collections. AI technologies, such as facial recognition, can be used to personalize the museum experience and provide personalized recommendations or tours. Computing technology can enable remote or virtual tours that allow far-flung visitors to view artworks

*Corresponding author: sunanda2017@whut.edu.cn

online or enable augmented reality experiences within the museum space. Both technologies have the potential to add further depth to the interpretation of artwork and to create new, immersive opportunities for visitors to engage with art. As AI and computing technology continue to develop and become more ubiquitous, the applications of these technologies in art museums will also become increasingly varied and innovative [1]. The use of AI in object detection and recognition can be used to systematically inventory museum collections, identify pieces that need conservation, or assist in the authentication of artworks. Computing technology can also be applied to create a virtual record of artwork, allowing for 3D tours of sculptures, and augmented reality experiences allowing visitors to view the artwork from multiple angles or in different lighting conditions [2].

Additionally, the use of facial recognition and personalization can be used to curate a museum's programming and exhibitions to best suit visitors' preferences or to allow for a more interactive, immersive visitor experience. Finally, the use of AI for predictive analytics and research has the potential to revolutionize our understanding of artwork and art history [3]. For example, predictive analytics and machine learning can be used to build virtual collections, analyse museum visitor behaviour to improve curatorial decisions or enable more detailed analyses of artworks, such as facial recognition to detect elements of emotion, age, or gender. As AI technologies continue to develop, and computing technology becomes increasingly available, these opportunities will become more advanced and prevalent in the art museum landscape. There are a variety of research questions that can be explored through the use of AI and computing technology in art museums [4]. Questions may include how these technologies can best be utilized to enhance the visitor experience, which visitor demographics will benefit the most from these experiences, and how the use of these technologies can help preserve the artwork and provide increased access to these collections.

Additionally, more advanced research questions may explore how AI technologies can be used to uncover new information about an artwork or its history, or how predictive analytics can be used to inform decisions about exhibitions and programming. There are many different research methods that can be used to answer questions about how AI and computing technology are used in art museums. Qualitative methods like interviews and focus groups can be used to find out how visitors feel about these technologies, and surveys can be used to find out what kinds of technologies visitors like and how they feel about them. Quantitative methods as predictive analytics or machine learning can be used to find insights into the data that has been collected or to figure out how well these technologies are at giving visitors a more meaningful experience. Moreover, case studies can be done to find out how AI and computer technology have changed certain museums or collections. Lastly, knowing how these technologies affect people can help people decide how to use them more effectively in the future.

2 Developments in AI and computing technology

The concept of AI has been around for many years. As early as 1950, scientists began to explore the possibility of creating a machine capable of thinking like a human. From that point forward, the field of AI has grown significantly, with many researchers and developers working to create intelligent systems and machines. The history of AI can be divided into four distinct periods: classical AI, connectionism, symbolic/sub-symbolic, and multi-agent AI. Each of these periods saw advances in the underlying technologies that made AI possible, as well as changes in the way AI was viewed and employed. The first period, known as classical AI, began in the late 1940s and early 1950s and saw the development of approaches such as rule-based systems and expert systems [5]. During this period, researchers sought to create systems that could think like humans by programming them with large collections of rules and facts. While these approaches have been useful in certain contexts, they have been

limited in terms of their ability to learn and adapt to new information. The second period, known as connectionism, began in the late 1960s and early 1970s. This period saw the emergence of neural networks, which are composed of computing elements that are connected in a manner inspired by biological neurons [6]. This approach has become the foundation for much of modern AI research, as it allows machines to learn from data rather than relying solely on pre-programmed rules and facts. By training neural networks on large datasets, researchers have been able to create systems that can recognize objects, understand language, and even generate images and music. The third phase of AI development, symbolic and sub-symbolic AI, began in the 1980s. This approach combines elements of both classical and connectionist AI and is based on the idea that machines can learn from data, but also reason symbolically [7]. This allows for a greater level of flexibility and adaptivity than was possible with classical AI. The fourth and most recent phase of AI development is multi-agent AI. In this approach, multiple agents are used to collaborate and solving problems. Each agent is specialized in a specific task, and the agents can interact with each other to complete complex tasks. The history of AI has seen a steady progression from its early days of rule-based systems to its current status as a powerful and versatile technology. With recent advances in the underlying technologies, such as deep learning, the possibilities for AI applications have grown even greater. As the field continues to evolve, AI will likely play an increasingly important role in our lives.

There are three primary types of AI as Machine Learning, Deep Learning, and Narrow AI. Machine Learning uses algorithms and statistical models to enable machines to learn from data and experience. This type of AI is used to automate processes, identify patterns in large datasets, and make decisions based on these patterns. Deep Learning is a subset of Machine Learning that uses sophisticated neural networks to identify patterns and make decisions. Lastly, Narrow AI is a type of AI that is specially tailored to a specific task, such as image recognition or natural language processing. Deep Learning is a subset of Machine Learning that uses complex, layered neural networks to identify patterns in large datasets. It is used in a variety of applications, such as computer vision and natural language processing. Deep Learning allows machines to "learn" by training them on large datasets, allowing them to recognize patterns and make decisions accordingly [8]. This type of AI has been used in a range of applications, from medical diagnosis and autonomous vehicles to customer service automation and financial forecasting. Narrow AI is a type of Artificial Intelligence that is specifically tailored to a specific task [9]. Unlike other AI, such as Machine Learning and Deep Learning, Narrow AI does not attempt to generalize from the data it is given; instead, it has been programmed to focus solely on the task at hand, such as recognizing objects in images or processing natural language [10]. Narrow AI has become increasingly popular due to its ability to quickly and accurately solve a wide range of problems with minimal resources. Narrow AI is used in many applications, such as automatic speech recognition, image recognition, and pathfinding.

AI can be used in a variety of ways to assist art museums. Machine Learning and Deep Learning can be used to analyse large datasets, such as digital images of artworks, and to identify patterns in the data. This can be used to classify artworks and identify trends in art history. Narrow AI can be used to automate tasks such as image recognition and natural language processing, which can be used for cataloging artworks and understanding their meaning [11]. AI can also be used to create personalized experiences for museum visitors by recommending artwork based on their interests.AI has the potential to revolutionize the way art museums operate, from helping to catalog and classify artwork to creating immersive experiences for visitors. AI can help museums reach a wider audience by allowing them to easily share their collections online and can help automate tasks such as cataloging and curation. Additionally, AI-powered personalization services can create tailored experiences for each visitor, making visits to the museum more engaging and enjoyable. Ultimately, AI

has the potential to transform the way museums operate and how they interact with their visitors.

3 Utilizing AI and computing technology in art museums

3.1 Facial recognition technology

Facial recognition technology is a form of artificial intelligence that uses computer vision algorithms to detect and identify people based on certain facial characteristics, such as age, gender, ethnicity, and other demographics. This technology has potential applications in the art museum context, particularly when it comes to personalizing the museum experience for individual visitors. For example, facial recognition can be used to detect the age, gender, and other demographic characteristics of a visitor and use this data to tailor individual tours or recommended artwork with which they might be more likely to engage [12]. Additionally, facial recognition can be used for security purposes within the museum, as well as for tracking customer metrics and preferences for marketing efforts. Facial recognition technology has the potential to revolutionize the art museum experience by providing a more personalized experience for visitors as well as improved security within the museum space. However, there are also potential ethical implications of using this technology, such as privacy concerns, and museum professionals must be aware of and address these issues when using facial recognition technology in their institutions. Examples of facial recognition technology being used at art museums include authentication of artwork, automated security, and visitor tracking. Authentication of artwork utilizes facial recognition technology to detect details that would be difficult to spot with the human eye, such as brush strokes or patterns, which can help verify the authenticity of the artwork. Automated security utilizing facial recognition can also be used to more accurately identify suspicious individuals, helping to protect the art museum against theft or vandalism. Finally, facial recognition technology can also be used to track visitors throughout the museum, providing museum staff with analytics about where visitors are going and how much time they spend in a particular exhibit.

3.2 Virtual and augmented reality

Virtual and augmented reality technologies have enabled new ways for visitors to explore and experience artwork in art museums. Virtual Reality (VR) technologies enable remote or virtual tours that allow far-flung visitors to view artworks online, while Augmented Reality (AR) experiences can be created within the museum space to provide an immersive, localised experience [13]. With the help of VR and AR technologies, museumgoers can have an enhanced, interactive experience with artworks, as they can view them from multiple angles, zoom in for closer examinations, or explore the artwork in different lighting conditions. Additionally, these technologies can be used to create 3D models and simulations of artwork, allowing further exploration into its historical context or potential restoration techniques [14]. Examples of virtual and augmented reality being used at art museums include virtual tours, interactive exhibits, and immersive experiences. Virtual tours provide an immersive experience that allows visitors to explore the museum at a more leisurely pace from the comfort of their own homes. Interactive exhibits present information in a dynamic and engaging way, allowing visitors to get a more detailed understanding of the artwork or artefacts. Finally, augmented reality can be used to bring artwork to life, allowing visitors to have a more immersive experience by providing additional context for each piece.

3.3 Object detection

Improvements in object recognition technology have enabled art museums to better preserve artwork, as well as provide access to digital records of the artwork. With AI object recognition software, museum staff can identify which pieces need conservation and track changes over time, while digital records can be used to create a virtual record of artwork and make it accessible to a wider audience. Additionally, using AI object detection can also help with the authentication of artwork, as it can detect patterns or features of a work that are not visible to the naked eye. Together, these advancements can help improve the preservation of artwork as well as provide increased access to collections. For example, the Cleveland Museum of Art has implemented AI object detection software to help catalog and track artwork in their collections. The software works by using a high-resolution camera to capture images of the artwork and then employing algorithms to detect individual objects such as paintings, sculptures, or artefacts [15]. With this system, the museum can accurately capture digital records of each piece, as well as create a virtual record of the artwork so that it can be easily accessed by both onsite visitors and those accessing the site remotely. Additionally, they are also able to use the technology to authenticate artwork, as its AI object detection can detect fine details that the human eye can't, such as brush strokes or patterns, allowing for improved accuracy when validating.

3.4 Digital record preservation

Digital record preservation is a process where digital records, such as documents, images, videos, and audio files, are maintained and securely stored. By using AI technology, it is possible to effectively track and store digital records, making them easier to access and manage over time. This provides an important capability for archiving and preserving records for posterity. Additionally, AI can also be used more accurately to retrieve records, allowing for easier searching and access to specific documents or files [16]. For example, the National Archives in the United States is using AI to efficiently manage and preserve their digital records. They are leveraging AI solutions to better process documents, build statistical models, and create searchable databases. This allows the archives to store and access records, ensuring that important artefacts and documents can be properly preserved for future generations.

3.5 Predictive analytics and machine learning

Predictive analytics and ML are techniques used by AI systems to predict future outcomes based on current data. They are used in various fields, such as marketing, healthcare, and finance, to identify trends and make decisions that can provide a competitive advantage [17]. For example, predictive analytics can be used to analyse customer behaviour to anticipate demand for products or services, while machine learning can be used to develop more accurate models for predicting the effects of certain policies or decisions. As AI technologies continue to evolve and become more sophisticated, these applications can provide invaluable insights into the future and help organizations gain a competitive edge [18]. For example, a company might use predictive analytics and machine learning to develop marketing strategies that anticipate customer preferences and needs. By leveraging data from customer interactions, AI can make data-driven decisions to effectively target customers with specific products or services. Additionally, machine learning can be used to develop more accurate models for predicting the effects of certain policies or decisions, allowing organizations to better plan for the future and remain competitive in ever-changing markets.

3.6 Natural language processing

Natural Language Processing (NLP) is a branch of AI that focuses on the ability of computers to comprehend, interpret, and generate human language. The technology is used in various applications, from voice recognition to understanding customer feedback. With NLP, computers can process and understand natural language, allowing them to accurately respond and interact with users in more naturalistic ways. Additionally, this technology can be used for natural language generation, where computer programs can generate text from structured data. This can be used in a variety of ways, from generating structured content from unstructured text to creating automated responses to customer inquiries [19]. For example, customer service departments are now using NLP technology to understand customer inquiries and respond with automated responses. The AI can analyse incoming customer messages, identify key customer requests, and generate a response that is tailored to the customer's needs. This allows customer service teams to quickly and accurately respond to customer inquiries, resulting in improved customer satisfaction. Additionally, this technology can also be used for natural language generation, allowing companies to automate certain customer-facing tasks such as generating content for their website or online store.

3.7 Robotic assistants, interactive displays & chatbots

Robotic assistants, interactive displays, and chatbots are all examples of AI technologies being used to interact with humans. These technologies can be used in various applications, from customer service to entertainment. For instance, robotic assistants can be used to aid customers, such as helping them find products or providing recommendations. Interactive displays are also becoming increasingly popular, allowing users to interact with digital content in more natural ways. Finally, AI-powered chatbots can be used to answer customer inquiries or provide helpful product information on websites [20]. For example, the Art Institute of Chicago, they have implemented robotic assistants and interactive displays to enhance their visitor experience. The robotic assistant provides visitors with information about the collections and guided tours, while the interactive displays give visitors a more engaging way to explore and interact with the art. Additionally, the museum also uses AI-powered chatbots to provide answers to commonly asked questions, which helps to reduce the strain on the staff and improve their overall customer service.

4 Challenges of implementing AI and computing technology in art museums

4.1 Lack of interpretation

AI technology can provide a wealth of data, but it is difficult to quantify the importance of this information in a way that is meaningful to museum visitors and staff. For example, machine learning algorithms may be able to detect patterns in the artwork that humans cannot, but without contextual understanding, it can be difficult for this information to be used effectively. Interpreting the data produced by AI technology in a way that makes sense to humans is one of the key challenges of implementing AI in art museums. This requires knowledge and expertise in both AI technology and museum operations, making it difficult to find professionals with the right combination of skills. Additionally, developing strategies to communicate the insights gained from the data to visitors can be challenging.

4.2 Lack of expertise

Lack of expertise refers to the need for trained professionals that can use AI technology in art museums to create effective solutions. This requires knowledge and experience in both AI technology and museum operations, making it difficult to find professionals with the necessary skills. Implementing AI technology also requires an understanding of the challenges faced in a museum setting, such as varying levels of digital literacy amongst visitors and complex issues related to preserving works of art. The right personnel with the right skills must be identified and recruited to implement AI technologies in an art museum effectively.

4.3 Limited data access

Limited data access signifies the challenge of obtaining the data necessary to develop AI applications. Due to regulations and sensitive information, art museums may have difficulty gathering data from multiple sources, such as visitors, third-party vendors, and other external organizations. This can be a further challenge when implementing AI in an art museum setting, as data is needed to develop effective models and solutions. Additionally, security and privacy considerations must also be considered when collecting and storing data. To successfully implement AI in art museums, it is necessary to identify and use data sources that can be accessed without compromising security or privacy. Additionally, the data must be of high enough quality and share consistent formats to be used effectively. Utilizing strategies to ensure data accuracy and integrity while also protecting its security and privacy are key considerations when developing AI solutions for use in art museums.

4.4 Cost of infrastructure

The cost of building and maintaining the infrastructure needed to implement AI technology in art museums can be high. This includes the costs associated with purchasing hardware, installing networking and communication systems, developing software and applications, and hiring personnel to manage and maintain the system. Additionally, the costs associated with educating staff on the use of AI technologies and maintaining the system over time must also be taken into consideration. As such, designating the necessary financial resources before implementing AI technology is essential. For example, implementing facial recognition technology in an art museum can require costly infrastructure such as cameras, software, and servers. Additionally, the system must be regularly maintained and monitored to ensure it is up-to-date with the latest security and privacy regulations.

4.5 Security and privacy

The use of AI technologies in art museums can potentially increase the risk of security and privacy concerns as it involves handling sensitive customer information as well as confidential art collection data. To ensure that the security and privacy of these data are maintained, appropriate measures must be taken to protect them from unauthorized access, manipulation, or misuse. Such measures include the implementation of encryption algorithms, the use of secured networks, and the implementation of access control mechanisms to limit access to only authorized personnel. Additionally, measures need to be taken to ensure privacy when collecting and processing data from visitors such as using anonymized data or biometric authentication methods. For example, to ensure the privacy of visitors, art museums may implement biometric authentication methods such as facial recognition or fingerprint scanning. This would enable them to keep track of visitor activity

in the museum while avoiding having to collect any personal information from visitors. Additionally, art museums may use mechanisms such as encryption algorithms and secure networks to protect the confidential data of the art collection from being accessed by unauthorized personnel.

4.6 Ethical considerations

The ethical implications of using AI technologies in art museums must be considered and addressed. For example, automated facial recognition systems may raise privacy concerns as they may be used to monitor the activities of visitors without their knowledge or consent. Similarly, using AI to curate museum collections or programs may result in bias due to the data sets being used and the algorithms implemented. It is important to ensure that the technology is being used responsibly and respectfully. Additionally, there must be safeguards to ensure the safety and accuracy of the information being collected, stored, and processed. An example of ethical considerations in implementing AI technology in art museums is the use of automated facial recognition systems. These systems may be used to track the activities of visitors and monitor their behaviour, which could result in a violation of privacy and personal freedom. Additionally, if the data sets and algorithms used to curate exhibitions or programs are biased, this could lead to discrimination against certain groups of people or messages being communicated that are insensitive or offensive. To ensure the ethical usage of this technology, museums need to take measures to protect visitor privacy, implement safeguards to ensure data accuracy, and ensure that the technology is not being used to discriminate against any group of people.

5 Conclusion

Artificial Intelligence and computing technology are increasingly being explored for use in art museums for various purposes. This technology provides significant opportunities for enhancing the experience of visiting an art museum, from providing more immersive experiences to increasing visitor engagement. AI-powered interactive tools can provide personalized information about the works of art, as well as generate meaningful data about the engagement of the visitors. Further, numerous applications have been developed to enhance the security aspect of art museums, allowing for better surveillance and theft prevention. The potential of using AI and computing technology in art museums is vast and it provides a significant opportunity for museums to reach a wider audience, especially in times of mass digitalization. However, such technology must be used responsibly, with an emphasis on protecting the privacy of the visitors, and ensuring that no unauthorized activities are being conducted. Moreover, security precautions should be taken to ensure that AI-powered systems are not compromised and that their data is safely stored away from malicious actors. Furthermore, the implementation of AI and computing technology at art museums requires careful consideration of various ethical and legal implications, such as data privacy and copyright laws. It must also be ensured that such technology is used responsibly, so as not to limit the creative process for either museum staff or visitors. Overall, AI and computing technology present many exciting possibilities for art museums in terms of increased efficiency and enhanced visitor experiences. However, such technology must be used carefully and considered concerning the legal and ethical implications it entails to ensure that these very real benefits are fully realized. With the right processes in place, art museums can take advantage of these technologies to reach a wider audience and help create more meaningful and engaging experiences for the visitor.

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