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Integration of AR/VR Technologies with Artificial Intelligence in Museums

Özlem VARGÜN[1]

[1] *Harran University, Türkiye, ozlemvargun@harran.edu.tr, ORCID: 0000-0002-4803-5929*

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Abstract
The aim of this paper is to review and examine the effects of the integration of Augmented Reality (AR), Virtual Reality (VR) technologies, and Artificial Intelligence (AI) in museums. Through a literature review method, the effects of these technologies on the preservation of cultural heritage, museum design, and visitor experiences are discussed using current examples. The research question is: "How does the integration of AR/VR and AI technologies in museums transform the preservation of cultural heritage, museum design, and visitor experiences?" This paper compiles examples from the literature to highlight the opportunities and innovations created by these technologies in museums. AR/VR and AI technologies are making museums more interactive, accessible, and engaging, and it is anticipated that the digitization process in museums will accelerate in the future, creating more personalized experiences. However, challenges such as data security, ethical issues, and copyright concerns are also important issues that need to be addressed. Consequently, based on the information gathered through the literature review, it is predicted that museums will increasingly adopt AR, VR, and AI technologies in the future.

Contents

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1. Introduction

Cultural heritage is an important value passed down from the past to the present, and it is a shared responsibility of societies to ensure its transmission to future generations. Museums play a critical role in protecting and presenting this heritage. They utilize both traditional methods and digital technologies to preserve, display, and promote their collections. Among these technologies, Augmented Reality (AR), Virtual Reality (VR), and Artificial Intelligence (AI) are becoming increasingly important.

AR/VR and artificial intelligence not only enhance visitor experiences in museums but also enable the digital preservation, display, and reconstruction of artworks. These technologies offer visitors more interactive and personalized experiences while also helping to reach broader audiences with cultural heritage. Today, especially artificial intelligence, is being used effectively in museum education as well. Initial advancements, such as AI-supported chatbot applications, facilitate voice and text-based dialogues with visitors, enabling the customization of personal experiences and improving guidance services. For example, the Victoria and Albert Museum can perform AI-assisted collection research, instantly finding, reading, and interpreting the collection. The National Museum of African Art also has a chatbot that serves as a museum guide, greeting and providing information to visitors.

AR/VR technologies provide visitors with virtual experiences outside the physical space, allowing for more interactive and comprehensive access to artworks. Artificial intelligence, on the other hand, helps analyze museum data to understand visitor behaviors and create personalized experiences. These integrations are transforming museum interior design, educational activities, and methods for preserving cultural heritage.

This paper uses a literature review methodology to explore the integration of AR/VR technologies and Artificial Intelligence (AI) in museums. A comprehensive search was conducted using key terms such as "AR/VR in museums," "AI in cultural heritage," and "museum digitization" across various academic databases including JSTOR, Google Scholar, and ScienceDirect. The review includes articles published in peer-reviewed journals, conference proceedings, and books from the past decade. The inclusion criteria for the selected literature were based on relevance to the topic, the publication's credibility, and the scope of technological applications discussed. A thematic analysis was employed to categorize and synthesize the findings, focusing on the effects of these technologies on cultural heritage preservation, museum design, and visitor experiences.

2. AR/VR Technologies and AI: Museum Applications

Augmented Reality (AR) refers to environments where the real world and digital content coexist, enriching and interacting with the physical world through a digital interface that integrates visual, audio, and informational layers. AR enhances users' surroundings through smartphones, tablets, and specialized glasses. For instance, in a museum, AR technology allows visitors to access digital information layers added to physical artworks. This creates interactive experiences that instantly present the history or artistic features of exhibited works to visitors. AR can also make the learning experience more dynamic by providing animated repetitions of artworks, information bubbles, and additional visuals.

For example, Wagner et al. (2005) developed an electronic tour guide based on augmented reality, as discussed by İçten and Bal (2017). Additionally, Thalmann and Papagiannakis (2010) developed a system to visualize ancient Roman characters at the archaeological site of Pompeii in Italy using image-based storytelling techniques.

Liestøl (2011) created a mobile AR system for the reconstruction of the Parthenon Temple (431 B.C.), which has been referenced in later studies on cultural heritage applications of AR (Uzun and Gözel, 2022; Akkuş and Akkuş, 2018). Furthermore, Leiva Olivencia, Guevara Plaza, and Rossi Jimenez (2015) designed the RAMCAT system to develop an adaptive tourist guide, which has been widely cited in tourism-oriented AR research.

In Turkey, museums utilizing augmented reality applications include the Sakıp Sabancı Museum, Naval Museum, Bursa Clock Tower Museum, Topkapı Palace Museum, Carpet Museum, SEKA Paper Museum, Burdur Kavaklı Greek Church Nature Museum, and Hatay Archaeology Museum (Sertalp, 2016).

In 2017, the Peterson Automotive Museum in Los Angeles created a new exhibition space using Microsoft HoloLens, offering visitors an augmented reality (AR) experience through interaction with the classic Ford GT40. Visitors benefit from a more immersive experience enhanced by spatial and environmental sounds delivered via headphones. While receiving contextual information about the vehicles, users can also hear the engine sounds and the tires racing on the track, thereby strengthening sensory engagement and realism (Vargün, 2022).

Virtual Reality (VR) immerses the user in a completely virtual world by abstracting them from the physical environment and offering an alternative reality in which users can engage with interactive sounds and visuals. In museum contexts, VR enables visitors to experience virtual exhibitions, including artworks that are normally inaccessi-

Figure 1. Revival of ancient life in Pompeii through augmented reality (AR), 2005.
Source: https://t.ly/dqP2Y

Figure 2. Augmented reality application developed by Arox Bilişim Sistemleri at the Sakıp Sabancı Museum, 2014.
Source: https://t.ly/RoyDb

ble, fragile, or damaged, within a fully digital environment. Applications such as the virtual reconstruction of historical buildings or the reanimation of lost artworks through VR contribute to enhanced experience, deeper understanding, and even the preservation of cultural heritage.

Through VR headsets, visitors can examine artworks in greater detail and explore historical contexts more comprehensively. For example, the *Mona Lisa: Beyond the Glass* project at the Louvre Museum in France provides an immersive VR experience that allows users to access detailed visual and historical information about Leonardo da Vinci's iconic painting *Mona Lisa* (Vargün, 2022). In this virtual environment, visitors can closely inspect the artwork, learn about its historical background, and even embark on a simulated journey aboard a boat inspired by Leonardo da Vinci, extending into the painted background scene.

The Historical AR Mobile Application Project, launched in 2019, was implemented as part of a master's thesis at Yıldız Technical University, Faculty of Arts and Design. The project introduces 15 historical sites located in Istanbul's Sultanahmet district through narrative storytelling, three-dimensional models, and augmented reality (AR) technology.

A survey conducted with 379 participants and analyzed using SPSS revealed that mobile applications incorporating AR make learning more enjoyable, enhance perceptions of cultural heritage through multimedia and AR-based representations, strengthen credibility via aesthetically and realistically designed 3D models, and increase curiosity and interest when cultural heritage is presented through AR. Accordingly, this approach is regarded as both an effective and engaging method for learning history and culture (Vargün, 2020).

The Dalí Museum in Florida, USA, offers an immersive virtual reality experience through the *Dreams of Dalí* exhibition, which allows visitors to step into the surreal world of Salvador Dalí's painting *Archaeological Reminiscence of Millet's Angelus*. This VR application provides visitors with the opportunity to virtually explore Dalí's artwork and engage more deeply with its symbolic and spatial dimensions (Dre, 2016).

In Moscow, Russia, the Space Museum offers visitors the opportunity to explore the International Space Station through virtual reality headsets. This VR experience provides participants with astronaut training in an interactive environment where they can perform various tasks in outer space, simulating real mission scenarios.

In China's Mogao Caves, also known as the Dunhuang Digital Tour, Buddhist wall paintings dating from the 4th to the 14th centuries can be explored within a virtual en-

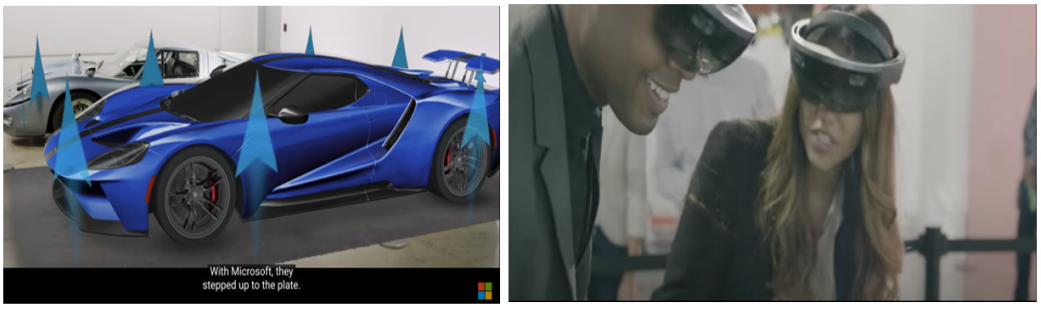

Figure 3. Peterson Automotive Museum in Los Angeles, 2017 with Microsoft Hololens

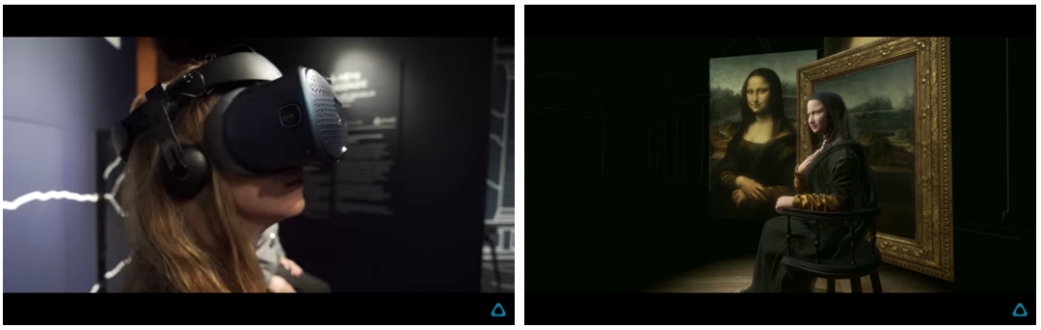

Figure 4. Mona Lisa: Beyond the Glass, 2019, France, Paris, Louvre Museum

Figure 5. Historical AR Mobile Application, 2020, Turkey, Istanbul

Figure 6. Download Dreams of Dalí from Oculus Home (Rift), 2016

Source: https://t.ly/D8Dy2

vironment using VR technology. Through this immersive application, visitors are able to virtually navigate the caves and examine the artworks in detail, overcoming physical and conservation-related limitations (Dun, 2016).

In 2019, the Hiroshima Peace Memorial Museum in Japan introduced a virtual reality (VR) experience that allows visitors to witness the destruction of Hiroshima during the atomic bombing of 1945, as well as the extensive devastation that followed the explosion. Through immersive VR headsets, visitors can explore the cityscape before and after the bombing, fostering historical awareness and emotional engagement with the event.

Similarly, the "Robben Island Virtual Tour" (2019), developed by the Robben Island Museum in South Africa, enables visitors to virtually explore key historical locations

Figure 7. Dunhuang Digital Tour, China.
Source: https://t.ly/frEiN

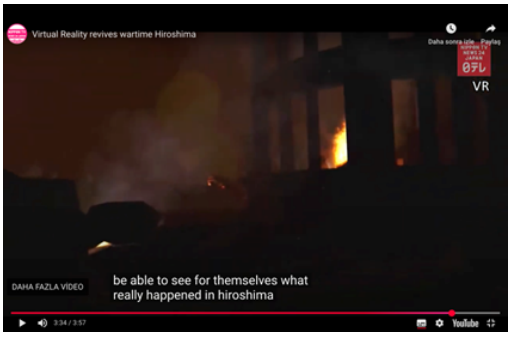

Figure 8. Hiroshima Peace Memorial VR
Source: https://t.ly/xj4

on the island. This includes the prison cell where Nelson Mandela was incarcerated, along with other significant sites, providing global audiences with remote access to an important heritage location.

The Australian Centre for the Moving Image (ACMI) in Melbourne, Australia, is another prominent institution offering virtual reality (VR) experiences focused on film and digital media. At ACMI, visitors engage with interactive VR films and immersive visual narratives that expand traditional cinematic storytelling into experiential digital environments Ostoja-Stobiecka (2025).

From Turkey, the Pera Museum in Istanbul provides a notable example of VR-based exhibition practices through

Figure 9. Australian Centre for the Moving Image, 2020
Source: https://t.ly/0zubD

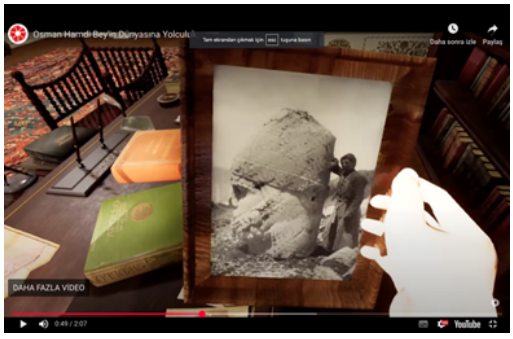

Figure 10. Journey to Osman Hamdi Bey's World, Turkey, 2019
Source: https://t.ly/lLWnd

the experience entitled *Journey to Osman Hamdi Bey's World* (2019). This VR application allows visitors to digitally explore Osman Hamdi Bey's renowned painting *The Tortoise Trainer*. Through immersive interaction, visitors can step into the artist's workshop environment and closely examine the artwork within its historical and artistic context Vargün (2022).

Overall, the integration of augmented reality (AR) and virtual reality (VR) technologies in museology extends beyond the enhancement of exhibition displays. These technologies also contribute to the transformation of museum education, interactive guiding systems, and visitor flow management. By enabling personalized, immersive, and participatory experiences, AR and VR technologies strengthen visitors' emotional and cognitive connections with artworks and support museums in reaching broader and more diverse audiences.

3. Definition of Artificial Intelligence and Its Integration into Museums

Artificial Intelligence (AI) is a technology developed to enable machines to think, learn, and solve problems like humans. AI can perform tasks such as analyzing data, recognizing patterns, predicting future events, and making autonomous decisions. In museums, AI is used to extract meaningful information from large datasets, organize inventories of artifacts, classify collections, and design exhibits that attract museum visitors. Specifically, in inventory management, the National Museum of the Royal Navy in the UK uses AI in the HMS Victory "Great Repair" project. AI assists the team of shipbuilders, owners, conservators, and archaeologists in meticulously documenting the historic repairs of the ship and helps capture vital information about damaged parts, offering planning suggestions for subsequent stages of the project.

With the rapid advancement of digital technologies, museums have increasingly adapted to processes of digitalisation. Artificial intelligence (AI), together with innovative

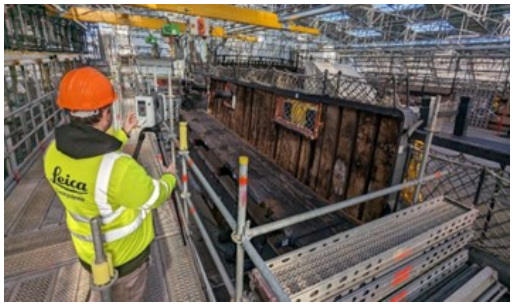

Figure 11. Archaeology meets AI in groundbreaking collaboration between The National Museum of the Royal Navy and the University of Southampton
Source: https://t.ly/CbZrY

technologies such as augmented reality (AR) and virtual reality (VR), has significantly enhanced exhibition design and interpretative practices within museum environments. As noted by Aslan Aslan (2022), these technologies play a transformative role in reshaping visitor interaction by enabling more engaging, interactive, and personalized experiences.

The integration of AI into museum practices has led to substantial transformations across multiple domains, ranging from collection management and archival processes to visitor engagement and educational activities. Moreover, the combined use of AR, VR, and AI technologies holds the potential to revolutionize not only the visitor experience but also the conservation, interpretation, and presentation of cultural heritage. Through data-driven analysis, immersive visualization, and intelligent interaction systems, museums are increasingly able to preserve cultural assets more effectively while making them accessible to broader and more diverse audiences.

4. Digitalization in Museums and Digital Exhibit Designs

Digitalisation in museums has emerged primarily from the need to keep pace with contemporary developments and adapt to rapidly evolving technologies. According to Yap et al. Yap, Kamble, Kuah, and Tolkach (2024), this process unfolds through two closely related yet distinct concepts: digitalisation and digitisation. Digitalisation refers to the conversion and storage of existing collections into digital formats, whereas digitisation focuses on transforming these digital assets into interactive, accessible, and manageable resources for both institutions and visitors.

Digitisation encompasses the use of advanced technologies such as virtual reality (VR), augmented reality (AR), and artificial intelligence (AI) to enhance visitor engagement and improve the quality of museum experiences and information delivery Parry (2007); Rizvic et al. (2018). Through these technologies, museums are able not only to preserve cultural heritage in digital form but also to reinterpret and communicate it in more immersive and meaningful ways.

Digital exhibition design has evolved significantly alongside technological advancements. Early digital exhibitions were largely limited to static visual displays and textual content; however, contemporary exhibitions increasingly employ AR, VR, and AI technologies to create interactive and experiential environments. This evolution enables visitors to engage more dynamically with artworks, facilitates the virtual preservation of cultural objects, and extends access to wider and more diverse audiences.

The transformation of digital exhibitions can be understood as the integration of traditional museological practices into the digital domain. Initial applications included projections and audio guides, which gradually gave way to interactive digital screens, kiosks, and virtual tour applications. More recently, these platforms have incorporated AR, VR, and holographic technologies, allowing visitors to actively participate in digitally mediated environments. Such developments support the personalization of visitor experiences and enhance the global visibility of museum collections.

In addition to expanding accessibility, digital exhibitions offer practical advantages such as overcoming spatial limitations, enabling the digital reconstruction of artworks, and supporting the management and archiving of collections. Nevertheless, careful attention must be paid to the design of three-dimensional models and symbolic representations during reconstruction processes. As emphasized by Pietroni and Adami Pietroni and Adami (2014), these representations must be both visually compelling and emotionally engaging in order to sustain visitor interest. Furthermore, to ensure the long-term sustainability of digital narratives, exhibition content should be continuously updated and restructured in response to audience feedback.

4.1 Gamification in Museums: Enhancing Visitor Engagement

Artificial intelligence has further expanded the potential of digital exhibitions through the integration of gamification strategies, making museum experiences both enjoyable and memorable. AI-powered interactive games enable visitors to acquire knowledge while exploring museum spaces in an engaging manner. Activities such as solving puzzles, following clues, or participating in competitive challenges transform learning into an interactive process, thereby improving visitor retention and exploration efficiency.

The Dalí Theatre Museum represents one of the earliest institutions to invest in virtual reality-based experiences

Fundació Gala–Salvador Dalí (2019). By integrating AI and machine learning technologies, the museum has developed a virtual environment in which visitors are welcomed and guided. Through the use of the Matterport platform, users can enter the virtual museum, navigate freely within the space, and engage in immersive learning experiences related to Dalí's artworks. These applications not only stimulate curiosity but also demonstrate the capacity of AI-driven gamification to deepen visitor engagement within digital museum environments.

One of the most debated applications of artificial intelligence in museums is the use of deepfake technology. The Dalí Museum in St. Petersburg, Florida, employs this controversial AI-based technique to create a holographic representation of Salvador Dalí as part of the *Bringing Salvador Dalí Back to Life Project*. This installation features an AI-generated simulation that closely resembles the artist, created using deepfake technology (Aouf, 2019).

Through this application, visitors encounter a digitally reconstructed Dalí who greets them, delivers fictional commentary blended with authentic quotations from the artist, and ultimately takes a selfie with visitors using a smartphone interface. The primary aim of this experience is to symbolically "bring the artist back to life" more than 30 years after his death, thereby enabling visitors to establish a novel and emotionally engaging connection with Dalí's artistic legacy. While the installation has attracted significant public attention and increased visitor engagement, it has also raised ethical discussions regarding authenticity, authorship, and the responsible use of AI in cultural heritage contexts.

In addition to deepfake technologies, chatbots have increasingly assumed the role of museum guides, transforming visitor interaction and information delivery. According to Knott Colace, De Santo, Lombardi, Pascale, and Pietrosanto (2018), chatbot applications offer scalable and personalized guidance services within cultural institutions. One of the pioneering implementations of this approach was developed by InvisibleStudio at Le Case Museo in Milan. By integrating gamification and narrative-driven storytelling, the chatbot-based system was designed to make museum tours more appealing to younger audiences.

Rather than providing linear informational content, the chatbot engages visitors through a treasure-hunt–like structure, encouraging exploration, curiosity, and active participation while simultaneously conveying art historical knowledge. Such applications demonstrate how AI-driven conversational interfaces can enhance learning outcomes, foster engagement, and redefine the traditional role of museum guides.

According to Stefania Boiano and Giuliano Gaia, co-founders of InvisibleStudio, museum chatbots differ from conventional digital guides by incorporating elements of play and discovery. As they emphasize, "unlike other museum chatbots, there is a game, a treasure hunt within the collections, and in this sense, the chatbot 'challenges' the visitor by asking questions" Boiano and Gaia (2017).

This interactive approach encourages visitors to observe the collections more carefully while engaging in exploratory learning. By prompting users with questions and guiding them through a game-based narrative, the chatbot offers creative interpretive services that help visitors uncover unexpected details within artworks and exhibitions. Such gamified conversational systems demonstrate how artificial intelligence can transform passive museum visits into active, curiosity-driven learning experiences.

Pepper is a humanoid robot developed by the French company Aldebaran Robotics and deployed in several Smithsonian museums, including the National Museum of African Art and the National Museum of African American History and Culture in Washington, D.C. The primary aim of Pepper is to enhance linguistic communication and efficiently disseminate information related to culture, art, and science to museum visitors Smithsonian Institution (2018).

Equipped with multilingual speech capabilities, expressive movements, and an interactive touchscreen interface, Pepper is able to respond to visitors' questions, narrate stories, and guide interactions. Through these features, the robot contributes to breaking down language barriers and improving accessibility for international and diverse audiences, thereby enriching the overall museum experience.

5. Reconstruction and Restoration of Artworks: AR/VR and AI Applications

Museums can enhance and reinterpret existing cultural heritage collections through the use of artificial intelligence (AI) technologies, enabling the creation of innovative and engaging conceptual exhibitions. AI-driven systems are capable of converting textual archival materials into audio formats, analyzing large volumes of collection data, generating digital catalogues, and enriching objects with structured metadata Veiga (2022).

These capabilities allow museums to manage their collections more efficiently, improve accessibility for diverse audiences, and provide visitors with richer and more contextualized information. By automating documentation, classification, and interpretative processes, AI technologies significantly reduce the time and human resources required for collection management while supporting more sustainable and scalable museum operations.

Artificial intelligence (AI) plays a crucial role in repairing and reconstructing missing or damaged cultural heritage artifacts. For instance, incomplete sections of cuneiform

Figure 12. Virtual Reality Dali Theatre Museum
Source: https://t.ly/uOViZ

Figure 13. InvisibleStudio's Le Case Museo

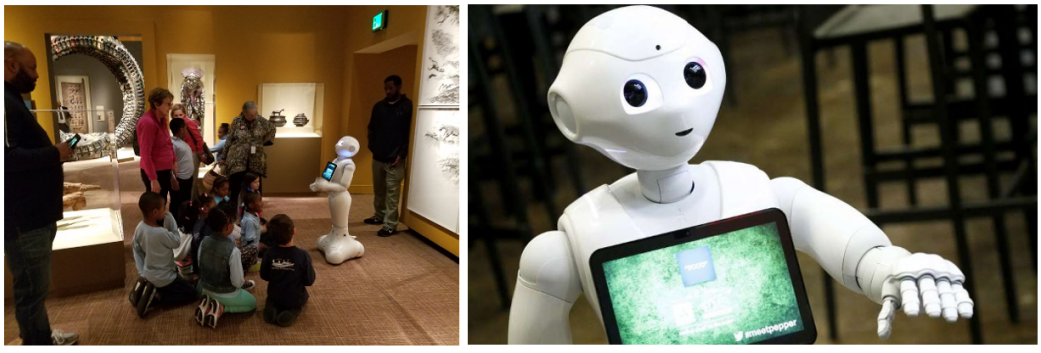

Figure 14. Pepper, a humanoid robot placed in the National Museum of African Art and the National Museum of African American History and Culture.

Figure 15. AI can generate voice information about artworks, analyze data to interpret missing parts, and visualize missing pieces of a historical settlement in 3D.

tablets can be digitally reconstructed using AI-based restoration and image analysis techniques. Several museums employ AI-powered systems to analyze visual data and digitally complete deteriorated artworks, contributing significantly to the preservation of cultural heritage (Veiga, 2022).

Augmented Reality (AR) serves as a vital interface for presenting these digital reconstructions within physical museum spaces. AI-generated visualizations of restored artifacts can be superimposed onto original objects through AR, allowing visitors to interact with reconstructed elements and explore their historical context in real time. By enriching reconstructions with three-dimensional models, AR enhances visitor engagement and interpretability.

Virtual Reality (VR), on the other hand, offers deeply immersive experiences that allow visitors to explore reconstructed historical environments in their original temporal and spatial contexts. Through VR simulations, users can observe AI-completed missing components while navigating three-dimensional virtual settlements, thereby gaining comprehensive insight into lost or inaccessible cultural spaces. Consequently, the integration of AI with AR and VR technologies provides museum visitors with enriched educational experiences and interactive engagement with cultural heritage artifacts.

5.1 Increasing Museum Visitor Numbers with AR/VR and AI

AR/VR technologies and AI are increasingly utilized as strategic tools to enhance visitor engagement and increase attendance in museums. A notable example is the St. James' Cavalier Creativity Centre in Malta, where AI-powered analytics were employed at Spazju Kreattiv, resulting in an 11% increase in visitor numbers. This initiative followed a three-phase strategy: (1) tracking visitor movements and behaviors using sensor technologies, (2) applying machine learning algorithms to predict visitor flow, and (3) optimizing operational planning to improve visitor experience and exhibition management (Deakin, 2023).

This case demonstrates how AI-driven analysis of both visitors and non-visitors can inform targeted engagement strategies, effectively converting potential visitors into actual museum audiences. Similar analytical approaches could be applied in high-footfall cultural zones, such as Trafalgar Square in London, to optimize museum visitation patterns.

While AI and data analytics enable museums to personalize visitor experiences and create interactive exhibitions, they also raise ethical concerns, particularly regarding data privacy and copyright protection. Museums often face challenges in employing AI-qualified personnel due to financial constraints, and many AI-driven projects depend heavily on external funding (Schnass and Lim, 2023).

5.2 Digitalization in Museums and Future Perspectives

With the continued advancement of AR/VR and AI technologies, museums are expected to become increasingly interactive, accessible, and personalized. Nevertheless, ethical considerations and data security challenges must be addressed to ensure sustainable digital transformation. According to Aslan (2022), the integration of AI and immersive technologies holds substantial potential for personalizing visitor experiences and expanding access to cultural heritage.

Charr (2024) introduces the concept of *invisible experiences*, referring to technologies that operate seamlessly in the background to enhance user engagement without overt technological presence. In the museum context, such experiences may include real-time translation via smart glasses, AI-driven visitor flow optimization, and wearable guidance systems that function without manual input (Charr, 2024).

Overall, invisible experiences are rapidly gaining traction in museums worldwide, contributing to both personalized visitor engagement and operational efficiency. As these technologies continue to evolve, museums are likely to transform into dynamic, data-informed cultural spaces that integrate digital innovation with heritage preservation.

6. Future Perspectives of Digital Museums

In the future, museums are expected to offer hyper-personalized experiences tailored to individual visitors. Artificial intelligence (AI) systems will be capable of analyzing visitors' prior interactions, demographic characteristics, interests, and learning preferences in order to generate fully customized art and history tours. Through AI-driven virtual guides, visitors may explore artworks from the perspective of the artist or experience the daily life of ancient civilizations, transforming the visitor from a passive observer into an active participant in the cultural narrative (Aslan, 2022; Charr, 2024).

Looking ahead, immersive time-travel experiences are likely to become a defining feature of museum visits. Augmented reality (AR) and virtual reality (VR) technologies can transport visitors to historical periods, allowing them to witness landmark events or participate in reconstructed historical environments. Visitors may virtually collaborate with ancient builders, observe pivotal moments of empires, or explore artistic workshops in real time. While VR headsets provide full immersion in these historical reconstructions, AR enables layered exploration of physical spaces by integrating digital narratives into real-world environments (Vargün, 2022; Pietroni and Adami, 2014).

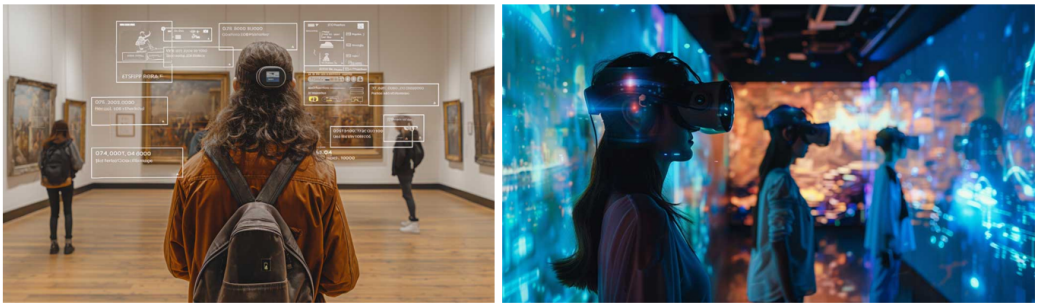

Figure 16. Seamless AR Integration, Operational Efficiency, Personalized Visitor Journeys
Source: https://t.ly/TpW4R

Future museum experiences will extend beyond visual and auditory engagement to incorporate multi-sensory interaction, including touch, smell, and potentially taste. When integrated with environmental sensors and haptic technologies, AR and VR applications may allow visitors to feel textures of artifacts, perceive environmental scents, or interact with simulated historical instruments. These multisensory environments will transform museums into spaces where visitors experience history as lived phenomena rather than static displays.

7. Conclusion

Augmented reality (AR) and virtual reality (VR) have become essential tools in digital restoration and heritage interpretation processes. VR enables the digital revival of lost or damaged artifacts, offering visitors opportunities to explore cultural heritage in immersive virtual environments, while AR allows reconstructed digital elements to be overlaid onto physical exhibition spaces with contextual accuracy. Museums such as the Louvre and the Dalí Museum have successfully employed these technologies to reconstruct artworks and enhance interpretive storytelling (Vargün, 2022; Pietroni and Adami, 2014).

In addition, three-dimensional modeling and holographic technologies support the exhibition of cultural artifacts across both physical and virtual environments. These approaches not only overcome spatial limitations within museums but also expand accessibility and engagement by enabling deeper, interactive exploration of collections.

The integration of AI with AR and VR technologies has also demonstrated measurable impacts on museum attendance and operational efficiency. AI-powered analytics and visitor-tracking systems have contributed to significant increases in visitor numbers, as evidenced by the 11% growth reported at Spazju Kreattiv through predictive visitor-flow optimization (Deakin, 2023). Similarly, immersive digital experiences offered by institutions such as the Louvre and Dalí Museum have enhanced visitor engagement by enabling detailed exploration of artworks in virtual environments (Vargün, 2022).

AI-driven personalization further enhances visitor interaction by delivering real-time, tailored content. Museums such as the Victoria and Albert Museum utilize AI-based systems to improve guidance services and deliver customized information, resulting in more meaningful and individualized visitor experiences (Yap et al., 2024). AI has also been applied in heritage conservation, including the digital reconstruction and documentation of damaged artifacts, as demonstrated in the HMS *Victory* restoration project at the National Museum of the Royal Navy (The National Museum of the Royal Navy, 2024).

In conclusion, the convergence of AI, AR, and VR technologies is reshaping contemporary museology by enhancing digital restoration practices, optimizing museum management, and redefining visitor engagement. These technologies enable museums to preserve cultural heritage more effectively while offering immersive, personalized, and educational experiences. As digital technologies continue to evolve, their role in museums is expected to expand further, positioning museums as dynamic, accessible, and participatory cultural institutions.

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