IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

A CRITICAL RESEARCH ON FUTURE TECHNOLOGIES IN MUSEUMS

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Abstract:

This paper discusses about future of museum design which is closely connected with the technology that will be used to improve the experience of the visitors, preserve the cultural heritage, and promote educational values of museums. This paper will explore a few emerging technologies which are revolutionizing museums, which includes virtual reality, augmented reality, artificial intelligence, blockchain, 3D printing and identify some of the challenges and opportunities that these technologies pose for museums, like ethical, legal and financial issues, as well as the need for collaboration and innovation. This paper will look into a few examples of the way how museums around the globe are adopting and experimenting with these technologies to create new and interactive setting for its audiences.

IndexTerms **- Virtual Reality, Augmented Reality, Artificial Intelligence, Blockchain, 3D Printing.**

INTENT OF THE TOPIC.
To study the future of museums, and identify the role of technologies in transforming the museum setting.

AIM.
To explore the current and future trends of technologies that are used in museums, and to examine how they affect the museum design. This paper will also provide some insights and recommendations for museum professionals and researchers who are interested in adopting and evaluating these technologies.

RESEARCH QUESTIONS.
1. How did museums come about, what was their purpose initially?
2. How can virtual reality (VR) and augmented reality (AR) enhance the immersion and interactive experience, for visitors at museums?
3. What advantages and challenges come with using intelligence (AI) to create adaptable museum experiences?
4. In what ways can blockchain technology improve the authenticity, security and transparency of museum collections and transactions?
5. What ethical, legal and social implications arise from utilizing 3D printing to restore and repair museum artifacts?

OBJECTIVES.
1. To investigate the history of museum design in different contexts and cultures.
2. To explore the potential of digital technologies and artificial intelligence to enrich museum design and interaction.
3. To review the literature on the current and emerging technologies that are used in museums, and to identify their advantages and disadvantages for museum practices and outcomes.
4. To compare and contrast the different types of technologies that are used in museums, and to explore their suitability and compatibility for different museum contexts and purposes.

I. INTRODUCTION.

1.1 Definition

According to the Extraordinary General Assembly of ICOM the approved new proposal for museum definition is: "A museum is a not-for-profit, permanent institution in the service of society that researches, collects, conserves, interprets and exhibits tangible and intangible heritage. Open to the public, accessible and inclusive, museums foster diversity and sustainability. They operate and communicate ethically, professionally and with the participation of communities, offering varied experiences for education, enjoyment, reflection and knowledge sharing." [1]

A museum is a place where one should lose one's head. – Renzo Piano

1.2 History of Museums

Museums are public institutions that preserve and interpret the primary tangible evidence of humans and their environment. For centuries museums have played an important role in the society as cultural, religious and political institutions shaping the society. The word museum comes from the Greek word mouseion, which meant "seat of the Muses" a temple for daughters of the Greek God Zeus. The Muses were considered to be deities of Art, Culture and Literature, so these temples served as places of worship, knowledge and as treasuries. The temples were large in scale and had harmonious proportions, the spatial organization was simple yet information was spread out everywhere, from the walls to friezes.

From the 9th to the 12th centuries in European history, museums were known as the `House of Relics'. They served to protect and display the relics of saints who had a significant influence on the politics and culture of that time. The relics were the focus of intense sacred activities that shaped the political and cultural life of the people. They also helped the people to make sense of the world around them. The Christian Church used these relics for religious purposes and persuaded the masses with its dogmatic ideology.

The Ashmolean Museum in Oxford, which opened in 1683, was the first museum of its kind. It was based on a private collection of natural and artificial wonders that Elias Ashmole gave to the University of Oxford. In the 18th century, great museums such as the British Museum, Louvre, and Uffizi Gallery opened their doors. By the early 19th century, it had become common to let the public see formerly private collections. For the next 100 years, museums for the public were founded all over the world.

1.2.1 History of Museums in India

In Asia, there were also similar social institutions that preserved the collective memory of the people. In India, a stupa was a sacred structure that contained the bodily relics of Buddha. The relics of Buddha were stored and honored inside the stupa, which gave it a high social and religious status. A stupa also functioned as a treasure house because it held the most valuable objects. It also reflected the moral and social values of that time. A stupa was built with great care and beauty to match its precious contents.

In India, a stupa, containing the bodily relics of Buddha, was an embodiment of sacredness and spiritual value. The relics of the Buddha were collected and preserved inside the stupa which gave it the social status and sanctity. A stupa also acted as a treasure house because it treasured the most precious objects viz, relics of the Buddha. It also acted as the Mirror to reflect the moral and social values of the time. A magnificent structure viz., stupa was built suiting to valuable contents. Thus, the stupa like a modern museum collected valuable items in the form of relics of Buddha; it conserved these objects and ultimately passed on the message to its devotees who flocked there from far off region and lands.[2]

The development of museum in India can be divided into five distinct phases:

1. The Early Company Phase (1757 – 1858)
2. The Victorian Era (1858 – 1901)
3. The Era of Curzon and John Marshall (1901-1928)
4. The Pre-Independence Era (1928-1947)
5. The Modern Phase of Post-Independence Era (1947-1987)

1.3 Types of Museums

General museum, holds collections in more than one discipline and is sometimes known as a multidisciplinary or interdisciplinary museum. It may come from private collections or reflect cultural contact through trade. Examples of general museums include the Louvre and the Smithsonian Institution.

Natural history and natural science museums, display natural phenomena and objects, such as animals, plants, fossils, minerals, meteorites, human remains and may have dioramas, models, and interactive exhibits of identify natural and environmental factors. Examples of natural history and science museums are the Natural History Museum in London and the Field Museum of Natural History.

Science and Technology Museum, displays objects and equipment related to science, technology, engineering and math (STEM). They offer hands-on activities, demonstrations, experiments and simulations to engage visitors in learning about scientific and technical concepts and concepts Examples of science and technology museums are the Exploratorium, the Science Museum in London, and the Deutsches Museum Akorae.

History museums display objects and information about the history of a particular place, region, country, or subject. It may also include historic restoration, reconstruction, or living history projects to bring the past to life. Examples of history museums include the National Museum of American History, the Imperial War Museum, and the Anne Frank House.

Art museum, provides works of art from a lot of cultures, eras, patterns and styles. Educational applications, workshops, lectures and excursions are offered to increase appreciation and knowledge of the arts. Examples of art museums encompass the Metropolitan Museum of Art, the National Gallery of Art, and the Uffizi Gallery.

A more recent type of museum is the **digital museum**, which surpasses all other types with its specific digital display. It can exist absolutely online or supplement a physical museum. It can offer digital photos, films, audio files, three-D fashions, animations, or physical access to museum collections or reveals. Examples of digital museums encompass the Google Art Project, the Smithsonian National Museum of Natural History Virtual Tour, and the Virtual Museum of Canada.[3][4]

1.4 Stakeholders in a museum

Set of people who have similar interests, goals or concerns. They can be social, special interest or software-related. This may include external and internal people like, staff members, especially if they share the same interests or goals as the other users.

Archivist: An archivist is responsible for keeping the collection of artifacts, art, items, files, and historic or in any other case relevant objects to the museum. They need to have an element-orientated and detailed organizational abilities and a bachelor's diploma in relevant subject matter.

Curator: A curator is chargeable for managing and overseeing collections for a particular show, gallery, or section of a museum. They need to have a grasp in relevant challenge and abilities in making plans, organizing, fundraising, and promoting their thoughts.

Conservator: A conservator is in charge of maintaining and restoring the museum's artifacts and historic documents. They need to have knowledge and technical abilities and a degree in conservation or an associated field.

Museum Technician: A museum technician is chargeable for supporting the curators and conservators in preparing, installing, and maintaining exhibits. They need to have a degree or certificates in museum studies or a related area and abilities in handling and displaying museum technologies.

Educator: An educator is liable for developing educational packages and activities for the museum's visitors, especially for schools. They need to have a degree in education or an associated area and competencies in conversation, creativity, and pedagogy.

Guide: A guide is chargeable for presenting statistics and excursions to the museum's visitors. They need to have a detailed information of the museum's collections and records and abilities in communication, customer service, and languages.

Other Staffs: Functions beyond those listed above are done by different staff members or workers on contract basis. Examples are information technology, cafe workers, and human resources.

Visitors: Visitors of a museum are individuals who come to a museum for various purposes, consisting of studying, amusement, proposal, or interest. They can be defined as a non-profit, everlasting group inside the society that researches, collects, conserves, interprets and exhibits tangible and intangible heritage.

II. MUSEUMS OF THE MODERN WORLD.

AR and VR are technologies that can be used in museums to create immersive and interactive experiences for visitors. AR adds digital information or objects to the real world, while VR transports the user to a simulated environment. They can be used to provide context and information for exhibits, such as historical backgrounds, narratives, or explanations, to create personalized and adaptive tours, such as allowing visitors to choose their own paths, interests, or languages, gamify learning and engagement, such as using challenges, rewards, or feedback to motivate visitors, expand the museum's reach and accessibility, such as allowing remote visitors to access exhibits or creating virtual replicas of fragile or rare artifacts, foster collaboration and creativity, such as enabling visitors to interact with each other or create their own content.

Use of AR and VR in museums does not have a uniform or predictable effect on visitors, but rather depends on how visitors interact with the technology and the museum context. For example, different visitors may have different levels of prior knowledge, interest, motivation, or expectations that affect how they perceive and respond to AR and VR experiences. Similarly, different technologies may have different features, affordances, or limitations that affect how they present and communicate information or emotions. Furthermore, different museum contexts may have different missions, strategies, physical environments, or display of artifacts that affect how they support or constrain AR and VR experiences. Therefore, to understand and evaluate the impact of AR and VR in museums, one needs to consider the interaction of these three factors: visitors, technology, and museum context. Psychological frameworks and methods are tools that can help researchers and practitioners to study this interaction. Psychological frameworks are theories or models that explain how humans think, feel, and behave in relation to themselves, others, and the environment. Psychological methods are techniques or procedures that collect and analyze data about human cognition, emotion, and behavior.

By using psychological frameworks and methods, it is possible to identify how AR and VR influence visitors' learning outcomes, emotional responses, engagement levels, satisfaction ratings, memory retention, or behavioral changes. The factors that facilitate or hinder the effectiveness of AR and VR in museums can be identified. For example, using cognitive psychology to study how AR and VR affect visitors' attention, comprehension, or problem-solving skills. Social psychology to study how AR and VR affect visitors social interactions, group dynamics, or identity formation. Developmental psychology to study how AR and VR affect visitors age-related differences or needs. Experimental methods to compare different types of AR and VR interventions or measure their causal effects. Survey methods to assess visitors' attitudes, preferences, or feedback. Observational methods to record visitors' behaviors, expressions, or movements.[5]

2.1 Projection Mapping

Projection mapping is a technique that projects images or videos onto surfaces, like walls, ceilings, flooring, or objects, developing an illusion of depth and motion. Projection mapping may be used to transform and animate museum spaces and exhibits, creating immersive and interactive studies for visitors. Projection mapping can also be used to highlight and enhance existing features or structures within historical buildings, or to illuminate and beautify custom-built systems for an installation.

2.2 Binaural Audio

Binaural audio is a type of audio that is recorded and played back using two microphones or speakers that mimic the position and distance of human ears. Binaural audio creates a 3-dimensional sound effect that makes listeners experience like they're

within the identical environment because the sound supply. Binaural audio can be used to create immersive and practical audio experiences for visitors, like transporting them to a specific instance in time, or making them hear distinctive voices or sounds.

2.3 Digital Twins

Digital twins are virtual replicas or models of physical objects or structures that may be used for simulation or analysis purposes. Digital twins may be used to preserve or replicate sensitive or inaccessible objects or places which might be vulnerable to damage or decay. Digital twins can also be used to modify appearance or functionality of objects or sites which are difficult or expensive to change.

2.4 Holographic Displays

Holographic displays are devices that create 3-dimensional pictures or videos that can be visible without unique glasses or headsets. Holographic displays may be used to create practical and real looking visuals which could enhance or complement museum exhibits. Holographic presentations also can be used to create interactive and engaging experiences that can attract visitors.[6]

Table 1: The future technologies in a museum and beneficiary stakeholders

S.no	Stakeholder	Technology
1	Archivist	Blockchain technology, Artificial intelligence, Cloud technology
2	Curator	Augmented reality / Virtual reality, Personalization / Wearable devices, Mobile technologies
3	Conservator	3D printing, Sensors / IoT, Nanotechnology
4	Museum technicians	Indoor GPS tracking systems, Gesture technology / Non-touch interactives, 5G technology
5	Educator	Gamification, Adaptive learning / Artificial intelligence
6	Guide	Voice recognition / Natural language processing, Facial recognition / Emotion detection, Chatbots / Conversational agents
7	Other staffs	CRM / Marketing automation, Predictive analytics / Big data, Blockchain technology
8	Visitors	Augmented reality / Virtual reality, Mobile Apps

III. ROLE OF AI IN THE FUTURE OF MUSEUMS.

AI is defined as "the study and design of intelligent agents" where an intelligent agent is a system that perceives its environment and takes actions that maximize its chances of success. AI can be used for various purposes and functions in museums, such as curation, preservation, interpretation, and visitor engagement. AI can create new possibilities and challenges for museums, as it transforms and enhances museum environments and experiences.

3.1 Collection management:

AI can assist museum curators to manage and analyze massive and complex collections of items, including art work, sculptures, coins, medals, books, manuscripts, maps, vegetation, animals, fossils, and so on. AI can use system gaining knowledge of machine learning algorithms and deep neural networks to categorize, classify, and label items based on their features and attributes. AI can also use natural language processing and computer vision to extract and generate metadata and descriptions for objects.

3.2 Exhibition design:

AI can help museum curators to design and plan exhibitions that suit the theme, content, and purpose of the exhibition. AI can use optimization techniques and simulation models to determine the optimal layout, lighting, colour, material, etc., for each exhibition space and object. AI can also use generative techniques and creative systems to produce new artworks or installations that complement or contrast with existing objects.

3.3 Condition assessment:

AI can assist museum conservators to evaluate and reveal the condition and quality of objects and artifacts in museums. AI can use sensors, cameras, or scanners to collect and process data on the physical properties and characteristics of items, consisting of temperature, humidity, light, colour, texture, and so forth. AI also can use machine learning algorithms and deep neural networks to detect and identify signs and symptoms of damage or decay, such as cracks, stains, fading, and many others.

3.4 Restoration:

AI can help museum conservators to restore and repair deteriorated objects in museums. AI can use image processing strategies and computer vision to reconstruct or enhance missing or faded parts of objects, like paintings, photographs, or manuscripts. AI can also use generative techniques and creative systems to create or suggest alternatives or hypothetical versions of objects, such as sculptures, buildings, or landscapes.

3.5 Visitor engagement:

AI can help museum interpreters to engage and have interaction with museum visitors. AI can use chatbots, virtual assistants, or avatars to speak and engage with visitors in natural language. AI can also use recommender systems, personalization

techniques, or gamification elements to tailor and enhance the visitors experience based totally on their preferences, interests, or feedback.

3.6 Content generation:

AI can assist museum interpreters to generate and provide content and information for museum objects and exhibitions. AI can use natural language processing and computer vision to produce and supply textual content, audio, or video content that describes or narrates the functions, attributes, or functions of objects or artifacts. AI can also use system learning algorithms and deep neural networks to research and synthesize information from numerous sources to create or update content that is applicable and accurate.

3.7 Visitor engagement:

AI can help museum interpreters to engage and have interaction with museum visitors. AI can use chatbots, virtual assistants, or avatars to speak and engage with visitors in natural language. AI can also use recommender systems, personalization techniques, or gamification elements to tailor and enhance the visitors experience based totally on their preferences, interests, or feedback.

IV. CASESTUDY.

4.1 The Museum of the Future in Dubai

The Museum of the Future is a visionary cultural institution that showcases the modern day improvements and technology that will form the future of humanity. It is located in Dubai, United Arab Emirates, and was open to public in February 2022. The museum targets to be a platform for communication and collaboration between experts, innovators, and visitors from distinct backgrounds and disciplines. It additionally seeks to encourage interest, creativity, and optimism amongst its visitors through immersive and interactive experiences that challenge their assumptions and stimulate their creativeness.

The museum is situated inside a marvelous architectural structure that resembles a torus with a huge open space in the middle. The building is covered with Arabic calligraphy that expresses the vision and values of the museum. The museum has seven floors, each devoted to a exceptional theme related to the future, such as climate change, health, education, urbanism, security, and happiness. Each ground features famous, installations, simulations, workshops, labs, and activities that explore the possibilities and challenges of the future.

The museum uses numerous futuristic technologies to attract and engage its visitors, including artificial intelligence (AI), augmented reality (AR), virtual reality (VR), robotics, biotechnology, nanotechnology, and 3D printing. These technologies are included into the museum's design, content, and operations to create a seamless and personalized experience.

Personalization: The museum uses facial recognition and biometric sensors to identify visitors and personalize their enjoy in step with their choices, pursuits, and feelings. Visitors also can use their smartphones or wearable gadgets to interact with the exhibits and access extra records.

Augmented Reality: The museum uses AR to enhance the physical environment with elements that add context, depth, and interactivity to the exhibits, visitors can use AR glasses or tablets to look at historical figures come to life, explore virtual landscapes, or control holographic items.

Virtual Reality: The museum uses VR to immerse visitors in realistic simulations that delivery them to distinct situations of the future, visitors can experience what it might be like to live on Mars, tour in a hyperloop, or fly in a jetpack.

Robotics: The museum uses robots to perform diverse activities, such as greeting visitors, guiding excursions, facilitating workshops, providing entertainment, and performing demonstrations. Some of the robots that the museum features are bionic ants, hexapods, humanoid robots, and robodogs.

Biotechnology: The museum makes use of biotechnology to explore the opportunities of enhancing human abilities and creating new lifeforms, visitors can see how gene modification can cure diseases, how bioengineering can create synthetic organs, or how synthetic biology can create novel organisms.

Nanotechnology: The museum makes use of nanotechnology to demonstrate how manipulating matter at the atomic scale can result in new materials, visitors can see how nanomaterials can improve energy efficiency, how nanosensors can monitor health conditions, or how nanobots can perform tasks inside the human body.

3-D Printing: The museum makes use of 3D printing to exhibit how digital fabrication can revolutionize manufacturing and design, visitors can see how 3D printing can create customized merchandise, how 4D printing can create self-assembling structures, or how 3D bioprinting can create living tissues.

V. WAYFORWARD.

The use of futuristic technologies in museums has become a prominent trend in the cultural sector, as museums seek to enhance their visitor experiences and engagement. However, the integration of these technologies also poses various challenges and opportunities for museum design, management, and evaluation. Based on a systematic review of various literature studies and a case study of the Museum of the Future in Dubai, this paper proposes a four-stage model of evolution for technology and museum visitor experiences, consisting of ICT (Information and Communication Technology) incubation, smart technology adoption, ICT transformation, and futuristic innovation. The paper also discusses the implications of these technologies for museum learning, interaction, personalization, immersion, and innovation.

This paper suggests that museums should adopt a participatory and collaborative approach to technology design and implementation, involving visitors, artists, researchers, and other stakeholders in co-creating solutions for the future.

As a way forward, this paper recommends that museums should monitor and evaluate the outcomes and impacts of technology use on visitor experiences and engagement, using both quantitative and qualitative methods, consider the ethical, social, and environmental implications of technology use in museums, and develop guidelines and policies to ensure responsible and

inclusive practices, foster a culture of innovation and experimentation in museums, by providing opportunities for staff training, professional development, and knowledge exchange on technology trends and applications.

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