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VR-driven museum opportunities: digitized archives in the age of the metaverse

Ze Gao

Hong Kong University of Science and Technology

Tristan Braud

Hong Kong University of Science and Technology

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Abstract

VR technology has brought new prospects and energy to art museums, prompting the advancement of new technologies that can tackle future challenges while catering to the demands of the metaverse era. Today's digital archiving and guided tours, which rely on VR and more portable information retrieval, provide optimism for museum development. VR technology overcomes the limitations of traditional museums constrained by space and time as digital archiving gradually becomes a reality. This study highlights the benefits of metaverse-driven online archiving from the users' perspective, followed by a review of recent examples of using VR for media art archiving. We emphasize the importance of further research into unexplored emerging technologies in media art archiving and propose that VR technologies in the metaverse are essential enablers for online archiving purposes. Our work aims to help art researchers, archivists, professionals, and artists to comprehend the challenges and future needs of archiving media art in the developing metaverse. Furthermore, we discuss present cases of employing VR for media art preservation after outlining the advantages of metaverse-driven online archiving from the users' viewpoint. We stress the need for additional studies on new technologies in media art preservation. Moreover, metaverse VR technologies play a crucial role in achieving online archiving goals. This research contributes to a better understanding of the challenges and future requirements of archiving media art in the evolving metaverse for art researchers, archivists, and artists.

Keywords

applied computing media arts; digital art; museums; metaverse; VR; archives

Oportunidades museísticas impulsadas por la realidad virtual: archivos digitalizados en la era del metaverso

Resumen

La tecnología de realidad virtual (RV) ha traído nuevas perspectivas y energía a los museos de arte, impulsando el avance de nuevas tecnologías que pueden abordar desafíos futuros mientras satisfacen las demandas de la era del metaverso. El archivo digital y las visitas guiadas de hoy en día, que dependen de la realidad virtual y de la recuperación más portátil de información, aportan optimismo al desarrollo de museos. La tecnología de realidad virtual supera las limitaciones de los museos tradicionales limitadas por el espacio y el tiempo a medida que el archivo digital se convierte gradualmente en una realidad. Este estudio destaca los beneficios del archivo en línea impulsado por el metaverso desde la perspectiva de los usuarios, seguido de una revisión de ejemplos recientes de uso de la RV para el archivo de arte multimedia. Hacemos hincapié en la importancia de seguir investigando las tecnologías emergentes inexploradas en el archivado de arte multimedia y proponemos que las tecnologías de RV en el metaverso sean facilitadores esenciales para fines de archivado en línea. Nuestro trabajo tiene como objetivo ayudar a los investigadores de arte, archivistas, profesionales y artistas a comprender los desafíos y las necesidades futuras del archivo de arte multimedia en el metaverso aún en desarrollo. Además, analizamos los casos actuales de uso de la RV para la conservación del arte multimedia después de describir las ventajas del archivado en línea impulsado por metaversos desde el punto de vista de los usuarios. Hacemos hincapié en la necesidad de estudios adicionales sobre nuevas tecnologías en la conservación del arte de los medios. Además, las tecnologías de realidad virtual del metaverso desempeñan un papel crucial en el logro de los objetivos de archivo en línea. Esta investigación contribuye a una mejor comprensión de los desafíos y los requisitos futuros del archivo del arte multimedia en el metaverso en evolución para investigadores de arte, archivistas y artistas.

Palabras clave

arte de los medios informáticos aplicados; arte digital; museos; metaverso; RV; archivos

1. Introduction

This study aims to explore the potential of virtual reality (VR) for visualizing archives in the metaverse era. The study examines recent innovations and advancements in visualizing archives, including scholarly discussions on form and value. Although some large art museums and galleries have already utilized VR technology for archiving and online exhibitions, there is still a need for further research into visual archiving and information retrieval in virtual spaces. This paper provides an overview of archive visualization in the metaverse age, focusing on art museums. The impact of the pandemic on museum archiving is also discussed. Additionally, the paper emphasizes the opportunities of using VR-based museums to address the challenges of the lockdown period and identifies recent issues with online archives. The article presents the methodology and scope of the survey and the motivation behind the research. A framework (see Figure 1) is introduced to guide readers through the paper's various sections.

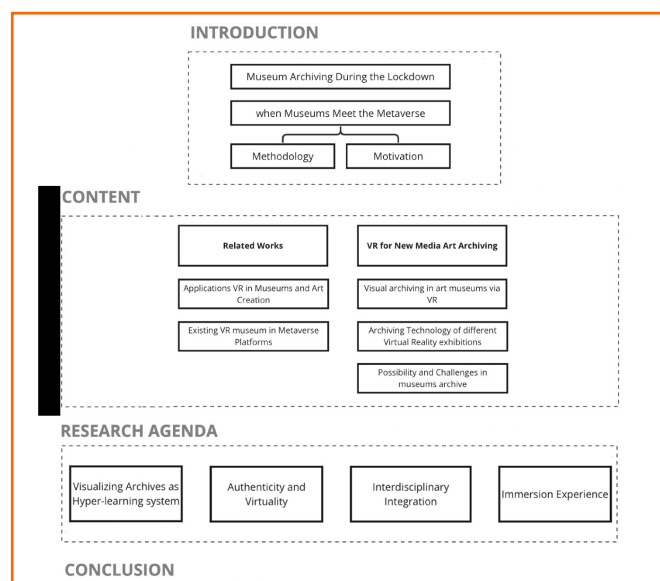


Figure 1. Structure of the research. Source: own creation

1.1. Museum archiving during the lockdown

Choi and Kim propose a strategy for utilizing metaverse content services for museum exhibitions, relying on Beacon and Head Mounted Display (HMD) technology in the fields of inventory and resource management. This plan is suggested as a potential solution for digital preservation during pandemic lockdowns, with visual archiving and navigation identified as key components. Reference to their proposal can be found in (Choi & Kim 2017).

The article by Hazan (2010) investigates the use of Second Life by museums and cultural institutions, in partnership with the OSA Archivum (Open Society Archive) located in Budapest, as discussed by Müller (2012) [46]. The preservation, evaluation, and perception of memory in the metaverse are examined in this study, which features three case studies. The Permanent Visual Archive (PEVIAR) is one such example and is presented as a potential solution for digital preservation. Metaverse libraries, which rely on community resources for management, have been successful in archiving digital information in virtual worlds, according to research by Dunavant *et al.* (2018). These libraries allow users to access information in the virtual world and create connections between real-life narratives and the virtual world.

This research (Hong & He 2021) examines the challenges and opportunities of intermedia art moving from physical public spaces to virtual public spaces, such as the metaverse, utilizing traditional intermedia art intervention methods and analysing data from CryptoVoxels and Decentraland to connect virtual spaces via social connections among online visitors, in order to deconstruct museum space democratically for an improved visitor experience. Additionally, this highlights the potential for device industries to design museum gamification systems to improve narrative purposes as the metaverse gains popularity as a new digital trend.

As the metaverse gains momentum, it is anticipated that the device industry will develop museum gamification systems to improve narrative experiences, and one study (Jeon, Moon & Ryu) proposes a system where visitors can choose a personalized game based on the museum's theme for a more immersive experience, applied through a gamification app and VR; in addition, due to the impact of COVID-19, the metaverse has become a significant focus for industry professionals, educators, and academics.

Virtual reality triggered by the epidemic has enabled a new era of museum archiving. With Web 3.0, metaverse technology could lead to a more humanistic society (Wang, Gao, Lee, Braud & Hui). More notably, the metaverse context created by virtual online exhibitions facilitates art exploration and access to novel content at art exhibitions in virtual environments.

During the COVID-19 pandemic, there was a strong desire for culture, leading museums and galleries to offer 3D and video tours, artist talks, and conferences (Aparecida Sarzi Ribeiro 2021). In *Watch and Chill: Streaming Art to Your Homes*, for example, M+ held a travelling moving image exhibition featuring 20 video works from Asia in February 2022. Many museums have also begun using VR display platforms such as Google Arts & Culture (Zhang 2020) to view high-resolution images and videos of artworks. More than 2,000 cultural institutions, including the Guggenheim Museum in New York and Orsay Museum in Paris, use

this platform to provide virtual content (Lee, Kim & Lee). The above examples demonstrate how museums and galleries adapted to the COVID-19 pandemic by utilizing VR technology to provide virtual tours, artist talks, and conferences. These efforts allowed individuals to satisfy their thirst for culture and art exploration from the safety and comfort of their own homes. This highlights the potential of VR technology in fulfilling humans' hunger for culture and suggests that museums and galleries could continue to utilize this technology even after the pandemic ends. Art digitization has increased consumption and globalization, driven by artificial intelligence (AI), virtual reality (VR), and augmented reality (AR) (Giannini & Bowen 2019). According to (Markopoulos, Ye, Markopoulos & Luimula 2021), scholars suggest that online virtual museums offer public access to art at their own pace without limitations on time or location. A survey by the Network of European Museum Organizations (NEMO) across 48 museums showed that four out of five museums had adopted digital services to reach broader audiences (NEMO 202). Digitization increases interest in museums and artworks [59]. Art institutions' interest in VR applications has increased due to the pandemic, especially after the launch of the Oculus Quest 2 VR headset. This technology registered five times the projected number of pre-orders, allowing professionals to resume their work more meaningfully.



Figure 2. Well-known online archives of digital arts

Source: *Ars Electronica* screenshot: <https://archive.aec.at/> (left). *ADA* screenshot: <https://www.digitalartarchive.at/> (right)

1.2. When museums meet the metaverse

The metaverse is a new type of Internet application and social form centred around immersive technologies (Ning, Wang, Lin, Wang, Dhelim, Farha, Ding & Daneshmand 2021) (Man & Gao 2022). The metaverse faces many future challenges in terms of immersion, authenticity, and virtuality. As digital interfaces increasingly mediate our lives, virtual interaction becomes ubiquitous in our technologically-saturated environment. This spillover from the moderated room of digital technology into the living space reconnects the areas we inhabit. At the same time, viewers are also seeking more efficient interfaces to access information, and museums and institutions interact through the metaverse to maximize the presentation of artworks and seek better forms of communication. In response to the great potential of the metaverse, the industry has developed many metaverse platforms, such as Decentraland, Sandbox, and Cryptovoxels. However, the development of models for museums and audience experience in the context of the metaverse still has significant

room for improvement. According to Tallulah Harvey, in her eco-critical research *The Archive*, the role of a digital archive is to digitize human cultural productions (Harvey 2010). Well-known art museums are beginning to build their online collections archives, more traditionally kept in images and videos. Some museums are using VR tours with 3D reconstructions or even virtual museums. Furthermore, art and cultural products are digitized by designing peripherals based on the artwork on display and opening online gift shops –for instance, [The MoMA Design Store](#). However, none of these formats offers an immersive experience that qualifies as a metaverse. This raises the question of whether the metaverse will lead to a massive change in how audiences interact with art exhibitions. Moreover, the metaverse can potentially drive the new possibility of the museum archives. As spaces prone to experimentation with novel visualization technologies, museums have embraced VR for archiving purposes. Facebook changed its name to Meta in October 2021, announcing a new era of social interaction enabled by metadata technologies (Kraus, Kanbach, Krysta, Steinhoff & Tomini 2022). VR headsets allow users to interact with other users in virtual cyberspace, offering a second life (Getchell, Oliver, Miller & Allison 2010) for multi-spatial interactions. The metaverse has given rise to virtual museums and led to more opportunities and possibilities, such as using immersive technology in museums, online trading, and the archive of virtual artworks. However, the metaverse in commerciality and the unknown crisis remains a topic of major academic interest. For instance, in the virtual universe of Decentraland, users can buy, sell, create, and monetize artworks (Ante 2021). Horizon Worlds (Meta) but some platforms have experienced harassment issues (Qingxiao, Ngoc, Lingqing & Yun 2022). In addition, as augmented reality and virtual reality become more commercially available, more and more people can experience art and technology at home using head-mounted glasses, tablets, or even cell phones. For example, users can view VR exhibitions with Google Arts & Culture and Matterport (Cecotti, Day-Scott, Huisinga & Gordo Peláez 2020) (Sulaiman, Aziz, Bakar, Halili & Azuddin 2020). While VR may be better suited to exhibitions than traditional web methods such as ADA or Ars Electronica Archive (see Figure 2), the former need not necessarily preclude the latter. On the contrary, they can coexist in harmony. VR technology can be used as an auxiliary archiving tool to enhance the user's experience while exploring the archive and can help them recall their experience. As a result, VR will be more likely to increase the number of digital arch users, and the rise of the metaverse can expand the artistic community (Franceschet, Colavizza, Smith, Finucane, Ostachowski, Scalet, Perkins, Morgan, & Hernandez 2021).

The COVID-19 pandemic also confirms a more participatory life and entertainment in cyberspace and virtual space. Apple, Meta (Facebook, pre-rebranding), and Microsoft are [planning to enter the meta-boundary era](#). Furthermore, the metaverse allows users to socialize, learn, work, collaborate, create, and play in 3D virtual spaces (Lee, Braud, Zhou, Wang, Xu, Lin, Kumar, Bermejo and Hui). The Metaverse technology can be used to build virtual galleries, online art communities, and audience interaction for a better user experience.

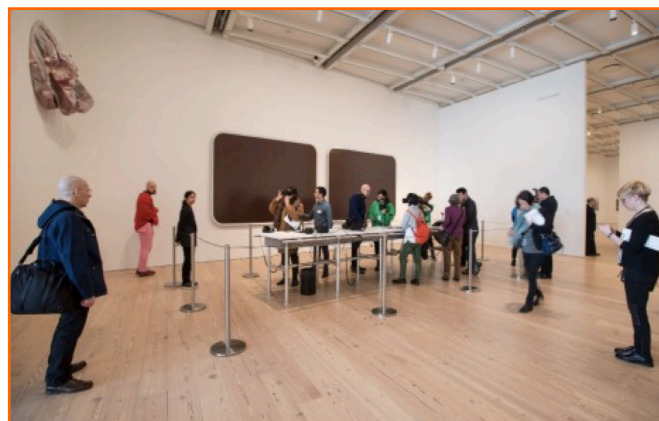
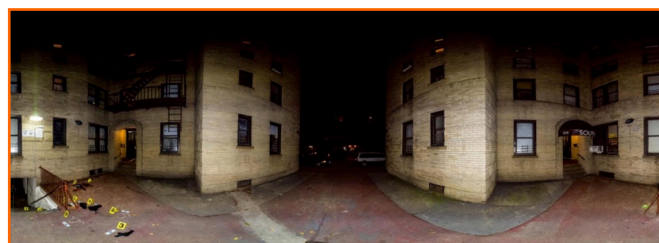


Figure 3. VR as an artist's toolkit.

Source: *VR Crime Scene*, Niko Koppel (up). *Real Violence* an extremely bloody virtual-reality project by Jordan Wolfson, Whitney Biennial, photograph by Bill Orcutt (middle). *Emissary Forks For You*, a VR Pokemon Go-like installation by Ian Cheng, The Liverpool Biennial, photograph by Pilar Corrias (bottom)

1.3. Methodology and scope

This survey aims to provide a comprehensive analysis of the latest art research into the concept of VR-driven museums. Therefore, we conduct a systematic literature review based on Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page, McKenzie, Bossuyt, Boutron, Hoffmann, Mulrow, Shamseer, Tetzlaff, Akl, Brennan, *et al.* 2019). It involves multiple stages of identifying related publications – **a**) identifying publication, **b**) two-step publication screening, and **c**) synthesizing screened publications.

a) Identification. We first formulated a Boolean algebra query to combine related keywords for publication identification.

The query is shown as follows: (“virtual reality” OR “VR”) AND “museum” AND (“interaction” OR “interface”) AND (“archiving” OR “archives”).

We mainly focused on the databases ACM DL, IEEE Xplore, and ScienceDirect. Besides these databases, we also considered several art and technology journals, such as Leonardo and Electronic Imaging, which are widely-used sources for publications related to virtual reality and computational art. In addition, three criteria were applied for searching: **1)** preferably published in the past five years (2017-2022), **2)** written in English, and **3)** underwent peer-review. Our query into these databases resulted in 74 potential publications on VR-driven museums. We then used Zotero, a publication managing tool, to remove 14 duplicated items. Overall, we identified 60 distinct publications for this survey – ACM DL 17 (28%), IEEE Xplore 20 (33%), ScienceDirect 10 (17%), and others 13 (22%).

b) Screening. For the publication screening, we employed a two-phase process consisting of an abstract screening and a subsequent full-text screening.

Abstract screening. We established a mandatory requirement for inclusion: the publication must pertain to virtual museums. This encompasses any publication discussing or using virtual reality technology for museum archiving, including related applications. We also identified additional inclusion criteria that were not explicitly coded but were always considered during the selection process. These included: **1)** the presence of a comprehensive literature review, **2)** studies related to museums, and **3)** the visualization and user experience aspects of archiving. In this stage, we removed 10 publications that did not match our criteria, with 64 publications left for full-text screening.

Full-text screening. We excluded publications that met at least one of the following exclusion criteria: **1)** the use of outdated virtual reality technology, **2)** studies that only focused on VR technology or museums without exploring their intersection, and **3)** studies that discussed only a narrow aspect of the topic, as this article focuses on the wider aspects of VR applications for museums. We filtered 4 publications unrelated to the target topic and kept 60 publications to synthesize in this systematic literature review.

c) Synthesis. In addition to the aforementioned publications from the three databases, our review also involves other 7 directions: platform & application, artworks, place, archive visualization, existing platforms, and future direction. We also include 7 VR museum applications, 4 metaverse platforms, and 3 artworks. The art exhibition was searched through Google and supplemented with information from official museum websites. Relevant content beyond articles, such as essays, online resources, and news, was also included in the study. We acquired the VR museum platforms according to the virtual display and digitizing content as archives as the theme,

which resulted in 7 candidates for reviewing. We filtered three of them, because commercial use is not included in this research, and synthesized the remaining five platforms in our systematic literature review. The main 4 metaverse platforms presented were selected because they all involve the online VR archiving of museums. The artworks were sourced from new media art archives such as Ars Electronica, ADA, and ISEA. We selected 5 artworks and finally introduced 3 related works because of the uniqueness of their visual display. In conclusion, we review 74 works on VR-driven museums in this paper – academic publications 60 (81%), applications 7 (9%) platforms 4 (6%), and artworks 3 (4%). Overall, the review focused on the current research and future challenges in art museum VR archives, with 71.23% of the reviewed articles published between 2018 and 2022.

1.4 Motivation and Contributions

There are many bright prospects for VR in architecture, manufacturing, design, healthcare, and learning. VR can improve communication efficiency, especially for education (Arnaldi, Guitton & Moreau 2018). However, VR may cause discomfort, headaches, and stomach sickness (Weißker, Kunert, Fröhlich & Kulik 2018). In addition, VR devices require high-end computers to run (Ávila & Bailey 2014). Thus, VR development is limited by physical limitations and high costs. However, in 2020, the COVID-19 pandemic led to many museums closing their doors, with the Web as the only form of access. Art museums worked to digitally convert their archives to virtual reality, such as the well-known VR museum platforms [Google Art & Culture](#) and [Matterport](#). VR technologies revolutionized museum viewing during the pandemic. Their ubiquitous impact requires us to rethink the concept of virtual tours and visual guides (Pokhrel & Chhetri 2021). While much research is dedicated to VR museums, there needs to be more research into the visual archiving of museums in the metaverse; visualizing archiving and navigation is essential for virtual reality and metaverse museums.

In contemporary times, computer screens and head-mounted VR glasses have been extensively used for virtual art exhibitions, leading to the formation of metaverse communities. As a virtual social world, the metaverse has the potential to host various art exhibitions, creations, and virtual art transactions. Users can explore beyond traditional online archives’ fundamental functions, including images, sounds, and texts to understand exhibitions, works, and even artists. Additionally, the combination of the metaverse and museum narrative can be a pivotal future model to attract and engage diverse audiences, regardless of their cultural backgrounds or expertise levels, by providing a better understanding of the curator’s (artist’s) creative intent and curatorial narrative in an interactive virtual world. In the following sections, we will examine the application of virtual reality in art museums and art creation, then critically analyse the strengths and weaknesses of virtual reality applications in archiving new media art museums.

Virtual tours of museums, whether through museum archiving websites, web-side VR tours, or VR headsets, require considerable time to access valid information on specific works and artists. The presentation of museum archives is still simplistic and needs improvement through the media being accessed. Although visitors can filter to find the information they want, this does not allow for an immersive, up-close look at the works in a 2D list format. As large art museums continue to archive works, the limitations of physical space and online archiving become more serious. Although platforms like Matterport exist to archive physical exhibitions and museum spaces through 3D reconstructions, they are still limited to the 2D space of a computer screen. By introducing the third dimension through VR technology, immersive technology, and the metaverse, we can present these collections in a hybrid 3D format.

2. Virtual museums in practice

With the emergence of immersive technologies and the COVID-19 pandemic fallback, many museums are starting to use virtual reality display platforms, like the aforementioned example [Google Arts& Culture](#) and [Matterport](#).

Over 2000 cultural institutions use these platforms to provide virtual content through virtual galleries. Therefore, as VR technology grows, VR applications in the art sector will also be potentially valuable for art creation and digitizing archiving. Of course, many visitors would like to see these excellent exhibits on-site after the pandemic has passed. However, because these large museums have so many artworks, a good museum on the metaverse platform becomes especially important when there is insufficient space for physical displays.



Figure 4. Implementation of VR technology in museum exhibitions. Source: *Modigliani VR: The Ochre Atelier*. Courtesy of Preloaded, Tate Modern, 2017-2018 (up, left). Still from *Mona Lisa: Beyond the Glass*. Courtesy Emissive and HTC Vive Arts – the Louvre, 2020-2021 (up, right). *WONDER 360*, Renwick Gallery VR Exhibition, 2016-2016 (bottom, left). Testing *Curious Alice* in VR. Victoria and Albert Museum, London, 2020 (bottom, right)

2.1. Applications of VR in museums and art creation

Today, visitors want to feel like they are part of the exhibition; they want to interact with artworks personally and relate to the emotions and thinking patterns of the artists who produced them. VR technology offers that illusion to the audience by allowing them to enter a virtual space that may be a 360-degree video or an interactive environment. It enables museums and galleries to bring artworks to life and offers an ideal platform for different and unique experiences as the audience becomes deeply embedded within the virtual exhibition (Han & Cui 2021). For this reason, many leading art institutions worldwide are actively embracing VR programmes for their audience. In 2019, the Louvre integrated VR technology into its *Mona Lisa: Beyond the Glass* exhibition (see Figure 4, upper right). London's Tate Modern merged VR into its Modigliani retrospective in 2017 (see Figure, upper left). The latter offered an immersive experience wherein visitors could interact with a 3D model of Modigliani's artist studio in Paris. Visitors could tour the room and share the artist's personal space; everyone felt like they were the only person in the studio. Renwick Gallery created an exhibition incorporating VR in 2018 (see Figure 4, bottom left). The exhibition's theme was *No Spectators: The Art of Burning Man*. This commemorated the historical event called the Legendary Burning Man that occurs annually in the Nevada Desert. Another ideal example is London's V&A. In the summer of 2021, the museum held an exhibition called *Curious Alice*, the primary objective of which was to allow visitors to explore the reinventions, adaptations, and origins of the Lewis Carroll classic (see Figure 4, bottom right).

Of course, VR is not only used for interactivity by art institutions; it is a part of the artist's toolkit, too. At the Museum of Modern Art (MoMA), Niko Koppel showcased his VR project *Crime Scene* (see Figure 3, up), a story about the victims of police brutality (Vijayakumar 2016); at the Whitney Biennial, Jordan Wolfson exhibited his extremely bloody virtual-reality artwork *Real Violence* (Schwartz 2017) (see Figure 3, middle); and artist Ian Cheng created a VR Pokemon Go-like installation for the Liverpool Biennial named *Emissary Forks For You* (Westall 2016) (see Figure 3, bottom).

2.2. Existing VR museums on metaverse platforms

While academic articles usually explore cultural heritage, modern VR museum platforms focus on contemporary arts and [technologies such as the web](#). These platforms typically include a user interface for visitors and players and an authoring tool for creators. Here are some notable examples:

[Decentraland](#), a blockchain-based platform for virtual worlds, uses virtual land as NFTs on which users can build activities in VR. While not primarily designed for VR museums, people create art galleries, auctions, and other events within the platform. Decentraland provides an authoring tool for creators to build their lands based on the Unity game engine.

[Cryptovoxels](#) is a 3D platform that uses NFTs. The Gangnam district on this platform strongly focuses on NFT art and is a more developed

area. MakersPlace and Async galleries have several virtual galleries on the platform, featuring interesting programmable artwork and early adopters of NFT art. *IT IS ALL AROUND US* is a virtual 3D exhibition featuring 13 artists' works that helps audiences experience the infinite possibilities of NFT digital artworks at the virtual museum.

Cyberxyz is another platform for building 3D/VR experiences to showcase artworks with NFTs.

Spatial is a platform for hosting virtual galleries, where users can view and create virtual galleries. It tends to be more real-life-like and uses more delicate 3D models than the aforementioned platforms. Spatial also provides a creator tool for creators to upload their content or use its templates.

In addition to audience visits and creator creation, these platforms also integrate social elements. For example, in Decentraland, gallery hosts can hold events and give talks to visitors, and visitors can see each other's avatars if they are in the same area. Auctions also take place on these platforms, and traditional auction houses like Sotheby's have embraced this new trend by running online auctions for non-traditional artworks (NFT) (Delaplaine 2022) (Wang, Gao, Lee, Braud & Hui 2022).



Figure 5. 3D reconstruction of a physical exhibition (Online VR tours) as an archive.
Source: VR Tour of HKDI Gallery, Zaha Hadid Architects – Vertical Urbanism (left). VR Tour of MMCA's 2020 Asia project, *Looking for Another Family* (right)

3. VR for new media art archiving

However, when discussing the preservation and online distribution of media art, one of the core issues is the difficulty of representing such artworks' unique and interactive nature in digital archives. For example, the **Ars Electronica Archive** is a relatively complete archiving platform documenting artworks from Prix Ars Electronica Festival from 1979 until today by the award, picture, print, and map. Another essential archive for digital art is the **Archive of Digital Art (ADA)** which uses video, image, text – primarily – and audio formats to document the artworks. In addition, hyperlinks have a significant role in interconnecting various entries in ADA. A good search system engine is a vital part of every archive, enabling people to filter entries by category, date, genre, events, and keywords. Digital archives, the Ars Electronica and ADA, are all extensively used by media art scholars worldwide. However, from the perspective of a non-expert audience, there is effort involved in completely understanding archived artworks by often consuming low-quality videos and/or images. What if art projects could be re-experienced in VR? And how cost-intensive would it be? It is essential to ask what art institutions can do to offer a better experience to their

online visitors and facilitate remote exhibition visits. For instance, while performance art researchers and archivists mainly use video to preserve the art of performance, they admit that it is not the best way (Gray 2011). However, the video is essentially a 2D technology that describes 3D space, which is not always successful. Similar challenges can be observed when archiving interactive and installation art pieces. In addition to image-based media, there are often complex relationships between documents, pictures, and videos. This makes it difficult, if not impossible, to capture all the details and moments of live art to re-create a physical presence experience.

3.1. Visual archiving in art museums via VR

Kersten *et al.* (2017) in “Development of a Virtual Museum Including a 4d Presentation of Building History in Virtual Reality”, propose that virtual museums should enhance the visitor's experience by providing relevant materials to complement the visitor's understanding of the museum. At the same time, the virtual museum should be used as part of museum education rather than simply showing what the collection looks like. The authors use the virtual museum of the Old-Segeberg townhouse as an example to specify how museums should use detailed geographical data and ICT to fulfil the requirements of the 21st century in terms of technology and media. Gonizzi Barsanti *et al.* (2018), in the article “Winckelmann300 project”, note that virtual reality technology is gradually being used to conserve, document, and restore historical artifacts. Combining VR and 3D models makes museum culture more accessible to audiences (Kersten, Tschirschwitz & Deggim 2017). This article aims to incorporate virtual reality into museums by restoring statues from the Capitoline Museum of the Winckelmann period to increase the variety of archives. Wojciechowski *et al.* (2004), in the article “Virtual and augmented reality museum exhibitions”, describe how designers can use visual templates for virtual exhibitions to solve the problem of museums that cannot present their entire collections to visitors due to space and other reasons (Wojciechowski, Walczak, White & Cellary 2044). This paper focuses on 3Ding museum artifacts for visualization in real and virtual environments and interactivity between viewers and collections, based on which the authors create systems that can help museums quickly build virtual reality exhibitions. In this paper, the secondary presentation and display of the collection become the authors' main intention, and the visual categorization and navigation of the collection are missing to some extent. In Vosinakis and Tsakonas (2016)'s study, “Visitor experience in Google Art Project and Second Life-based virtual museums” referred to Second Life. Many virtual museums based on natural spaces appear in Second Life, such as the Second Louvre. At the same time, the Google Art Project project presents artworks from famous museums and exhibitions in high-resolution images that allow viewers to zoom in and observe details. Viewers can see exhibits in virtual spaces more uniquely and navigate similarly to Google Street View. The authors argue that these approaches stop

replicating the experience of visiting physical museum spaces and exhibits. Research on Second Life and Google Art can further explore how different environments affect visitors' perceptions of the experience. A novel content-based dynamic web SG system (Kiourt, Koutsoudis, Markantonatou & Pavlidis 2016) is proposed in "The 'Synthesis' virtual museum" article. The 'Synthesis' virtual museum system provides each registered user to browse and visit exhibitions. Visitors can browse current exhibitions and request to see a specific one. Exhibitors can create a new exhibition or edit an exhibition they have created. This article focuses on the "porting" of physical museums and exhibitions to virtual museums. Users can interact and choose from within the virtual museum, allowing for better direction in visual archiving. In a paper exploring the concept of virtual museums with a particular focus on cultural heritage conservation issues related to the sculpture collection in the Theodoros Papagiannis Museum of Contemporary Art and the local outdoor sculpture (Merantzas & Zinas 2015). The study aims to create a "virtual museum" for visitors, providing a virtual tour of indoor and outdoor exhibitions with images, recordings, and interactive digital maps. Also, it uses the collection as part of an educational tool, attracting the attention of many national and international visitors through the Internet connection. However, the study also has some limitations and lacks efficient guidelines and guides for secondary visits by art professionals.

3.2. Archiving technology of different virtual reality exhibitions

To create virtual reality exhibitions, physical artworks are scanned or photographed in high quality and then curated in a virtual space using tools such as the VR-All-Art web editor. Alternatively, 3D reconstruction technology can be used to rebuild exhibitions of sculptures and architecture. VR technology also offers a virtual space for the metaverse with a persistent, multi-user environment that blends physical reality and digital virtuality.

There are two types of space design for VR museums: 3D reconstruction and 3D modelling. For the 3D reconstruction of architecture, digital photogrammetry and 3D modelling can capture coloured point clouds, allowing users to design exhibition spaces creatively. Regarding generic VR development, Unreal Engine and Unity are the preferred tools for most VR developers, as they can build highly complex VR games or scenes. AFrame is another option, using declarative HTML syntax and built upon webVR, which is very user-friendly for web developers. Developers can quickly build and share a prototype with a web link, and AFrame is cross-platform. However, AFrame has limitations in performing heavy work that requires high-performance rendering. For instance, Kiourt *et al.* used the Unity game engine as their VR development tool for building museums, while Kersten *et al.* used the Unreal game engine.

3.3. Possibility and challenges in museum archives

Contemporary art museums are embracing digital technology to increase the display of their archives, diversify their exhibitions, and make them available for repeated visits anytime, anywhere. Virtual reality display platforms, such as Google Arts & Culture, have become famous for enabling the viewing of high-resolution images and videos of art. Over 2,000 cultural institutions use this platform to provide virtual content, indicating the potential for online VR platforms targeting the art sector to play an archiving role. Virtual reality technology offers advantages for archiving contemporary art, including increased immersion and expanded exhibit diversity.

Considering the diversity of archived works of art in various museums, VR accompanied by guiding instruction – such as the archives' VR tour of the MMCA in Seoul, Korea – may be a practical and efficient method of archiving¹. Such documentation methods can provide a spatial feeling and immersive experience strengthened in navigation (Choi, Tessler & Kao 2020). The narrative and iconographic guidance further enhance this. For instance, the online VR tour *Vertical Urbanism* on the Hong Kong Design Institute website showcases directional circle signs for better navigation (see Figure 5, left).

As of 14 January 2022, the website of MMCA in Seoul had 8,771 exhibits on display online, all of which could be viewed in VR, offering visitors a more interactive and immersive experience (see Figure 5, right). Nevertheless, the use of one method of archiving need not require the exclusion of another. On the contrary, VR can supplement and support digital archives, introducing novel tools such as VR tours that help to better entire document exhibitions and make the archives more engaging and accessible for a more comprehensive, non-professional audience. Like all technology, VR does have its limitations. For example, current VR tours do not offer metadata tagging, making searching for specific artists or artifacts challenging without navigating the virtual exhibition.

The VR tour *To Exhibit – Not to Expose – To Expose – Not to Exhibit*, by artist Mario Santamaria, was produced to reopen the Centre d'Art Santa Mònica in Barcelona, Spain, in September 2021 (Santamaría 2021). The tour enabled its audience to visit the museum's cloister and exhibition areas, investigate its most inaccessible corners, explore unusual perspectives, and follow its routes without leaving the comfort of home. This example shows how VR can offer an alternative to traditional museum visits.

While art institutions have utilized this technology during lockdowns to satisfy their audience's yearning for art and culture, will this new practice of virtual museums continue after the pandemic? The example of MMCA in Seoul demonstrates that VR can be applied to almost any physical exhibition. More importantly, traditional media can be easily integrated into a VR archive, such as photographs, videos, audio, and texts in digital archives.

1. VR Tour of MMCA 2020 Asia project, *Looking for Another Family*. <https://my.matterport.com/show/?m=pmHCAXnPHVu&brand=0>

To summarize, the potential of VR applications for archives is as follows:

- VR archives can capture the precise details of an exhibition's set-up when the artwork(s) were exhibited. Hence, the audience can glimpse the physical space and design of the exhibition in addition to viewing individual artworks.
- Time and location do not matter. Visitors can browse an archive at any time and from any location.
- Installation art can be viewed more fully in VR.
- VR archives can accommodate huge collections and offer an easily scalable solution to the growing archives of museums. The [Art Institute of Chicago museum collection online](#) has more than 300,000 paintings, sculptures, and decorative artworks from around the world. The [Guggenheim Museum's permanent collection](#) offers a searchable database of selected artworks from an online archive of around 8,000 items and is continually expanding. The [MOMA collection](#) includes more than 150,000 paintings, sculptures, prints, photos, architectural models, drawings, and design objects, and the personal archives of more than 70,000 artists.
- Further developments in VR may enable us to expand beyond visual material and integrate other sensory materials, such as touch and haptic feedback.
- Digital and VR art can be viewed in its original format.
- VR in digital archives makes artworks accessible to a broader, non-professional audience.
- The interactivity of VR provides additional potential for educational and curatorial programmes.
- Visualizing archives in VR may have huge potential, especially with visual semantics. It is expected that they will bring more energy to the field of efficient information access, although the experience of its users remains to be further investigated

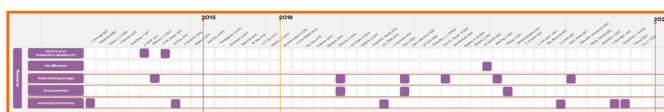


Figure 6. Research trends from 2007-2022. Contains major archiving research articles. Diagram design. Source: own creation

VR applications in archives also present challenges:

- The equipment can be expensive. Although a VR mode may be available in all visual tours, due to the equipment cost, only a few people can view that content simultaneously in VR. For the remaining audience, a screen may be used for viewing. Hence, the immersiveness of virtual exhibits may be compromised or lost.
- Older people may find it challenging to use VR technology. This could be overcome with additional help and assistance.
- Building a VR environment is labour- and cost-intensive, especially at first.

- Much time and money can be spent on retaining archived data and VR maintenance.
- Existing 3D tour applications, like Matterport, use proprietary software, and this limitation may cause problems in the readability of models in the long term. For instance, Matterport does not offer access to source files.

4. Research agenda

This article surveys many examples of museum VR archiving tied to the Metaverse. We predict that with the advent of the metaverse era and the proliferation of emerging technologies, our access to exhibitions and knowledge in virtual spaces will be infinitely amplified. As a result, museum professionals, curators, and artists will soon utilize various virtual technologies, from visual archiving, user interfaces, and authenticity to the combination of natural environments and virtual art, to achieve effective communication and collaboration with audiences. The research trends of archiving in the past few years have focused on online archiving (storage), authenticity, and virtuality. More than five articles have been published in the red box in the last five years (2018-2022) (see Figure 6). The main challenges and opportunities for using metaverse technology in museum archiving are still related to user-centred experiences. Some of the issues that merit discussion include whether visualizing archives in the age of Metaverse is an efficient way to promote education in a museum. Also, the user experience might be improved in authenticity and virtuality in the metaverse community. In addition, what new possibilities does integrating digital art experience with Meta-space offer? We argue that these questions are crucial to accelerating the integration of meta-space and museum archiving. Therefore, we outline a research agenda to reflect several urgent matters concerning establishing a better meta-space ecosystem for user experience and the future possibility of a museum.

4.1. Visualizing archives as a hyper-learning system

Museums can provide much education, especially from a non-formal educational perspective (Taylor & Neill 2008) – for example, quick access to expertise and virtual avatars (Ghanbarzadeh & Ghapanchi 2018); new learning interfaces under metaverse and web 3.0 (Kawas 2009); intellectual property law and intangible assets (Narayanan & Krishna 2022); knowledge in metadata structuring, storage, security, and scalability (Khan, Sim, Vazhkudai & Kim 2021); efficient learning interfaces regarding technical aspects and challenges (Dincelli & Yayla 2022). *Hyper-learning* is defined in education as a definite leap beyond artificial intelligence, resulting from a combination of technological trends (Hess 2020). Edward D. Hess defined the term *hyper-learning* as “the ability of humans to learn continually, unlearn, and relearn to adapt to the pace of change”. Certainly, hyper-learning is relatively poor in a traditional

educative context because of the value proposition of the conventional education model (Mazoue 2013). However, visualizing archives may have huge potential, especially with visual semantics (Afanador-Llach 2014) (Manovich 2012), supposing such ways of visualizing knowledge continue in the context of the metaverse. In that case, it is expected that they will bring more energy to the field of efficient learning, although the experience of its users remains to be further investigated.

4.2. Authenticity and virtuality

It is essential to note that VR archives are not intended to replace physical exhibitions entirely. Instead, VR is intended to support art institutions in documenting and preserving exhibitions. Some authors and researchers believe simulations may have ultra-realistic physical similarities to the actual physical environment (Herrington, Reeves & Oliver 2007).

Thus, in VR archiving, the relationship between the physical simulation of virtual scenes and the cognitive and sensory experience of natural settings should be further explored and understood. When discussing virtual reality displays, simulation is a common topic of conversation, which may lead some people to hesitate (Roberts, Holmes, Alexander, Boto, Leggett, Hill, Shah, Rea, Vaughan, Maguire *et al.* 2019). Hyper-reality, another term for simulation, refers to a phenomenon that transcends and ultimately replaces the real world. Bouri suggests: "We live in a world of simulation, where the principal function of the sign is to push reality into oblivion and disguise its disappearance". It is still unclear whether preserving physical places is more important than allowing art to evolve in a qualified, functional way and spread across more areas and people, resulting in powerful experiences and effects (Park, Choi & Lee 2019). Specific financial cycles would falter, and others would shift course if physical places were destroyed. For the arts to thrive, parts of the economy are already ready to introduce new systems (Muir 2022).

4.3. Interdisciplinary integration

For a more realistic experience in virtual worlds, the video game industry has become one of digitization's most effective sectors. Different disciplines have begun to incorporate the interaction aspects commonly found in the game business (Kiong 2022). Interdimensional products are being created by combining the concepts of *metaverse* and *simulation* (Baía Reis & Ashmore 2022). The metaverse allows gamers to visit a variety of alternate realities using a phone, computer, or virtual reality headset. When it comes to socializing, exploring, playing games, and even making money, many activities that can be undertaken in the real world can now be undertaken in the virtual worlds that have become popular in recent years (Chau, Wong, Wang, Lai, Chan, Li, Chu, Chan & Sung 2013) (Yang, Gao, Hadi Mogavi, Hui & Braud 2023). Using the Internet to generate income for artists in a global pandemic is an ingenious, innovative, and up-to-date strategy. However, the question

of whether the benefits exceeded the drawbacks was raised. It may be possible for certain artists to gain more attention through the metaverse, but many are still struggling to get their work 'out there' (Kim 2021). If artwork is popular on a well-known blockchain platform, it has the potential to sell. However, there is a problem with interconnectivity in that blockchain platforms are not linked. Since the software interchange problems between platforms were so severe, Polkadot was invented as a solution (Binson 2021). Furthermore, due to the general public's lack of knowledge regarding blockchain technology, cryptocurrencies, and NFTs, there is an enormous age gap in educational opportunities (Baía Reis & Ashmore 2022).

4.4. Immersion experience

We can view immersion from four perspectives: We can view immersion from four perspectives: **1)** visual, **2)** auditory, **3)** olfactory and **4)** haptic. Geerts *et al.* (2021) show that inclusive immersive visual technology design is still ignored in the VR industry. They proposed that visual, cognitive, and communication access are the most common aspects of inclusion to be addressed in immersive spaces. From a technological perspective, although the investigation of immersive sound in the context of VR is not new, there is a consensus that sound is an underused modality in VR. Undoubtedly, auditory access to VR galleries is an essential channel for obtaining information. Scent and haptic have not yet been explored in VR museum settings.

Conclusion

Virtual art exhibitions are commonly accessed through computer screens or head-mounted VR glasses. However, the metaverse offers more than just a platform for virtual exhibitions. It is a virtual social world that can host art exhibitions, creations, and transactions. In this virtual world, users can go beyond the traditional online archive functions of images, sounds, and texts to interact with exhibitions, works, and artists. Combining the metaverse and museum archiving can revolutionize how different cultures and generations, professionals and non-specialists, engage with creative and curatorial intent in an open and interactive virtual world. This paper provides a comprehensive review of new media art exhibitions driven by contemporary emergent technologies and the first effort to comprehensively review the intersection of the art museum and the metaverse. Our immersive museum tour experience will be more interactive and platform-based, opening up countless opportunities for artists and general audiences to reinvent virtual and physical environments in disruptive ways. By investigating digital archiving intentions and art-making related to VR, we hope to broaden the discussion within the realm of museum archiving. The paper emphasizes the essential topics relevant to this survey

and discusses researchable directions and challenges in constructing a new era of museums propelled by the metaverse. It also calls for a close integration of technology and art in order to build a new museum metaverse community offering the integrated development of technology and art. Ultimately, this paper aims to shape the future of metaverse museums by inviting researchers, artists, and curators, particularly in fields related to the metaverse, to contribute to the discussion.

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CV

**Ze Gao**

Hong Kong University of Science and Technology
 zgaoap@connect.ust.hk
<https://orcid.org/0000-0001-9347-6312>

He is a New Media Artist, Theorist, and Curator based in Hong Kong and New York. He studied Multidisciplinary Fine Arts at the Maryland Institute College of Art and held an MFA with honours in the School of Visual Arts in New York. His photography, augmented reality, motion-capture performance, and interactive installations have been showcased internationally in China, Japan, Singapore, North America, and Europe. A select sample of his exhibitions includes the ACM Multimedia art exhibition 2022 in Lisbon, ISEA 2022 in Barcelona, ARTeFACTo 2022 in Macau, Chinese CHI 2022 Art Gallery (Diamond Award) in Guangzhou, NTU Global Digital Art Prize finalist exhibition in Singapore, 2019 International Art Exhibition in Paris at Vanities Gallery.

**Tristan Camille Braud**

Hong Kong University of Science and Technology
 braudt@ust.hk
<https://orcid.org/0000-0002-9571-0544>

He is an Assistant Professor in the Division of Integrative Systems and Design at the Hong Kong University of Science and Technology. He directed the Extended Reality and Immersive Media Lab (XRIM Lab) on Augmented Reality, Virtual Reality, and the Metaverse. He earned a PhD from Université Grenoble Alpes, France, in 2016. Before that, he was an engineering student at Grenoble INP Phelma/Ensimag, France, and received both an MSC from the Politecnico di Torino, Italy, and Grenoble INP, France. His primary research focus is Augmented and Virtual Reality from system to application and interaction, following a human-centred system design approach.

