

DOI: <https://doi.org/10.28925/2519-4135.2024.48>

УДК 7.038.5:004.56(100)(062)

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**VIRTUAL AND AUGMENTED REALITY  
TECHNOLOGIES IN THE FINE ARTS OF THE FIRST  
HALF OF THE XXI-ST CENTURY:  
HISTORIOGRAPHICAL REVIEW**

**Abstract.** The article analyzes the history of VR/AR research in the field of art and design throughout 21<sup>st</sup> century scientific publications. Use of virtual spaces for the presentation of artworks and enhancement of visitor engagement is not a new addition to cultural space and was experimented with by multiple people, including the author of this article himself. VR is also increasingly often, albeit, still being more of an experimental novelty, used as a tool for teaching and/or learning art and history, sometimes — technical disciplines like engineering or physics. Solely art-focused research, however, is quite lacking in numbers, in part because there aren't many examples of the use of VR/AR in art and design projects, at least so far, yet there have been a number of different experiments ranging from psychology-adjacent to ones being on the line between art and IT. For the purpose of this article, questions of distinction between “true VR” (fully 3D interactive world experienced through VR gear), virtual environments that do not need VR gear and various types of artificial and mixed reality and differences of between them, especially when it comes to

artistic use, will likely be left out for separate discussion. We are more interested in how the art world used, iterated upon and ultimately accepted the freedom and new forms of expression allowed by virtual, augmented and mixed reality technologies. As most notable and expressive works and more importantly scientific research of these works have appeared in the 21<sup>st</sup> century, we will limit our overview of art-specific papers to this time period. Papers reviewed in this article are divided into four different categories, each with its own general research goal that most of the articles inside the same group share between themselves: virtual museums or galleries and preservation of cultural heritage, artworks and immersive typography, education, behavioral research on the basis of viewer-artwork interactions. With first three categories being well understood, when it comes to the usefulness of research results and experiments themselves, fourth one is exceptionally useful as relatively easy and universal way to “predict” viewer behavior in different circumstances for both gallery owners and artists (gallery layouts, lighting, artwork composition, color contrast between artworks, etc).

**Key words:** virtual reality, augmented reality, virtual gallery, historiography, immersive art history

**Introduction.** Virtual reality art has become, in a way, one of the most exciting and novel ways of expressing an artist's own thoughts, while giving viewers new experiences that themselves could be considered art. As usage of virtual reality (VR) in games and therapeutic experiences, which themselves mostly resemble games, gave way to creation of visual art forms, so the researchers noticed this new phenomenon and started closely studying it.

**Problem statement.** Theoretical research of VR technologies started in 1950s, usually Morton Heilig’s article from 1955 “The Cinema of the Future” is used as a reference

point for early VR research, with his own prototype of multi-sensory theater, that in fact was what we now would call “arcade machine” with the ambitious goal of providing realistic driving experience similar to that of real life motorbike. Second milestone is Ivan Sutherland’s work at University of Utah, which culminated in creation of a fully-functional prototype of head mounted display (HMD) connected to electromechanical setup tracking movements of the user to present test 3D models accurately from every potential viewing angle. Practical creation of sufficiently advanced and comfortable for prolonged use VR units can be traced back to the 1990s, but tech of that time still was not advanced enough to allow viewing of artworks, much less creation of one using VR tools only.

**Analyses of recent research and publications.** The problem of the article can be considered unexplored, since only certain aspects are studied in a small number of articles, even foreign ones. For domestic science, this question is new.

**The purpose of this article** is to create an actionable, albeit non-extensive, review of scientific papers throughout the 21<sup>st</sup> century, that touch on the usage of VR in art and design projects and can be used as a basis for research into how VR as art technique has evolved and was accepted to various degrees by artists.

**Results.** State of both experimental and consumer-grade commercial VR tech improved after that and by mid 2000s store-bought VR goggles and tracking setup were enough to play games and watch movies compatible with the new technology. Art exhibits could now be made relatively easily, provided that tools for that are available at artist’s or gallery’s disposal (mainly this means that one of game engines had to be used and it itself had to be compatible with chosen VR gear) and they could be interactive to some degree, moreover - they could be experienced from the comfort of one’s own home. Creation of art however was and in some ways still is a kind of semi-

uncharted territory in a sense of it being underutilized, despite artists technically having access to open-source “creative environments” and editors made specifically for VR.

A lot of previous discussions and articles on the topic of VR or AR, especially in fields of art and artistic education, usually focus on technical aspects like technologies and workflows needed/employed in the creation of specific environments or artwork.

**Virtual Museums and Galleries.** As odd as it sounds to an observer of the artistic world’s trends and evolution, what came first in the realm of virtual experience was not the act of creation of artworks themselves but exhibits and restoration of digital spaces. In part this was done because it was a lot simpler and easier to put a 3D model of a building recreated by traditional means and then scanned or already modeled in professional software as “true to original” shape, rather than create new art in a fully interactive environment. Early VR was geared more for video-game-like experience, which meant that any gallery could create, ideally an online, version of itself and let visitors from all over the world have access to their collections. An article from 2013 titled “The Herbert Virtual Museum” (2013) describes one of the first attempts to create a virtual exhibit using real museum’s halls as a backdrop [9]. However we have to adjust our expectation of how this virtual museum itself looks like as if it was a computer game from 2013 and not a fully immersive “realistic” environment, where potential visitors get roughly the same perceived value from their virtual visit as they would in real life. In fact what Petridis and team describe is closer to a set of games than fully immersive VR, not discounting the fact that even a “simple” job of recreating town square faithful to original still takes a lot of work and experience.

Another article, this time from 2023 [8] is a continuation and new iteration of the previous research (we intentionally skip

years between these two publications because while technology made significant progress, actual implementation did not experience significant change), this time however authors are more concerned with technical side of things rather than a discussion about potential “product” or “activity” types that users could engage in. Proposed VR assistants could, if designed with specific audiences in mind, prove beneficial in helping both museums and educational institutions (which not infrequently have their own museums and galleries) to show their exhibits in greater detail. For example technological museums could show intricate works of early automobiles, allow for “actionable” cut-away models as extra learning examples or create environments where more experimentally inclined audiences would have the chance to tweak historic machines to their liking. Art exhibits could be set up in much the same way as before, but with the added benefit of showing step by step creation process for each of the works on display. Historic sites can be augmented with AR/VR to show their previous iterations. System proposed by the team does not have too high or costly requirements (Intel Core i5-4590 or AMD FX 8350, Radeon RX 480 or NVIDIA GeForce GTX 1060, HDMI 1.4, DisplayPort 1.2, USB 2.0 and Windows 7/8.1/10), which makes it easier to adopt as one of educational tools. However Unreal Engine 4 (UE4) used in their experiment or otherwise suggested as an editor and physics engine, may and frequently is not the best choice for such projects as due to its internal complexity it frequently suffers from lack of optimization and system requirements for personal computers that will act as editing stations far exceed those of “player’s” computer.

Another potential way of integrating VR and AR into galleries was described in 2023 as well [2] as a research into more practical ways of explaining intricate workings or general role of exhibits that are frequently behind glass panels and are inaccessible for visitors. AR, as one of proposed solutions to

enhancing already present material's quality and facilitating easier and deeper understanding of certain topics, is more flexible than VR and more dependent on personal choice as visitors are free to use it if they decide to and are not tethered to computers or need to wear VR goggles. Satisfaction from such an enhanced visit was proven to be higher than the traditional non-AR one. These results largely depend on the quality of the exhibit itself and of AR content in particular.

Complete and through approach to the use of VR to preserve historic sites and allow non-intrusive study was described in detail in 2019 [3] as a part of their work on recreating the complex of Santa Maria delle Grazie, in Milan as one cohesive and true to original digital environment. Their use of new technologies is what could be considered an example of both digital preservation of historic sites and creation of realistic architectural environments for educational or gaming purposes.

This technique is discussed further in a paper titled "A Gaming Approach for Cultural Heritage Knowledge and Dissemination" [7]. Their paper follows several different approaches to gamified museum visits through the means of VR as well as techniques for both static and procedural (real-time) asset creation or application. Combined, these papers could serve as a description of a general framework for creation of virtual environments from real-life scans (by "virtual environment" we mean a digital environment that could be visited and interacted with using an ordinary computer with mouse and keyboard, gaming console, VR gear set or even smartphone). The only problem inhibiting wide adoption of these spaces (besides the cost of the gear and development resources) is inadequate level of detail born from a need to optimize models and textures as much as possible. More detailed assets require more powerful graphical processors and the underlying game engine often has its own limitations as to how much complexity it can deal with.

**Art and Typography.** While we have, in a way, adopted VR as part of our computer games experience and started experimenting with its use as a way to show and preserve art pieces, one aspect that is relatively elusive still is creation of artworks solely in VR. One of main problems, more for artists than researchers, is control over the environment and certain limitations of what could reasonably be made in VR space, using only VR gear. Most of what we can see in games or in examples provided in previous section of an article, is made using either of the game engines capable of creating VR-ready levels: Godot, Unity or Unreal Engine. Environments are first made in a “static” editor from premade meshes, scanned objects and textures and only then experienced by visitor or player. This allows creators to make art exhibitions but not create art itself in real time.

One of fairly detailed research papers delivering into matters of specific expression techniques and more specifically — typography, is a 2021 work titled “Virtual Reality Art and Immersive Experimental Typography” [10]. In it we can see only three examples of interactive experiences, created almost entirely from, for and in a way by the means of different letters, numbers, fonts and hand-drawn ornaments. While they do indeed create an experience that no other static “real-life” showroom could ever accomplish, two out of them may have been made by traditional means rather than fully created inside a VR environment (at the very least we do not have explicit confirmation of tools used). They are of exceptional quality and serve as suitably good research samples, one of which was made by Uyan Dur themselves, “in order to create a writing-based VR Artwork and explore the potential of VR in terms of experimental typography”. What sets this experiment apart from the rest is that it was created almost entirely within Tilt Brush — a Google-developed and for some time Google-hosted VR art creation platform. Created “memory spheres” were later

imported into Unity to be used as parts of one cohesive VR environment. While their paper gives some insight into how these spheres were created, it rightfully avoids all of the specifics of how Tilt Brush operates and what exactly it does “under the hood”. Problem with studying pure made-in-VR art forms lies in the simple fact of VR not being used actively enough and mostly remaining a novelty, however VR and to a larger extent AR opened new venues for research of viewer interaction with art pieces along with potential enhancements of already existing artworks.

One of such art installations is discussed in paper by Kristof Crolla and Garvin Goepel [5]. Work in question was commissioned by Hong Kong Museum of Art as part of their own project titled “Redefining Reality”. Actual sculpture, accessible in open space rather than gallery halls, is made from bent steel pipes later colored bright red and is a captivating work of art by itself, but what sets it apart is extensive use of AR. Paper discusses the process of creating AR component of the installation in fairly great detail, sufficient to reproduce similar experiment on the grounds of another institution, be it museum, university or library. However we must note that one of the most frequent issues with AR is not that of ease of use, but rather the need to make and download separate app. This is not helped by viewing area being much smaller, plus the entire AR component’s complexity and as a result — user engagement, relies on the power of ordinary smartphone’s CPU and GPU, which further limits what artists can express through AR alone.

**Art Education, Theory and Practice.** When it comes to another aspect of artistic world — education, we can employ VR more than AR to help in studying theoretical disciplines (art history as an example) and practical (perspective or 3D modeling in real-time, though the latter may need extra software) with potentially greater student engagement, productivity and understanding of topics being studied.



This idea was put to the test in real universities with real students as participants, which of course is a requirement to gather as realistic data as possible [4]. Their findings support the theory of VR and oddly enough even AR being highly effective at inciting interest in students, with VR being slightly more useful, enjoyable and easy to use (these are subjective claims made by experiment participants). These results may be skewed by previous experience or lack thereof as participants who have/had played VR/AR games, worked on VR/AR projects either in spare time or in any professional capacity and participants who have not had any prior engagement with these technologies, the perceived value and “interest” for such lessons will vary greatly. Nevertheless, in general, lessons with any kind of (well designed) interactive elements are received better than those without such additions.

We must note that augmented reality of any kind is more suitable for lectures, although there were attempts to employ mixed reality as part of the process, with easiest way to achieve sufficient mixed reality setting being to utilize full-scale virtual reality setup and replicate real-life environment in it through the means of photogrammetry, 3D scan or even using placeholder objects. Virtual reality is perhaps the best candidate for educational environments because it is essentially detached from the real world and can replicate Louvre halls as easily as university lecture classrooms.

**Viewer engagement research.** Another venue where VR may be of use to researchers is the study of behavioral patterns, in our case these will be interactions with certain art and/or design works. One of the markers of how viewers perceive and, in a way, engage with the product, be it user interface (UI), artwork on canvas or a room, are gaze patterns. Historically artists employed many tools, some of which are intuitively understood, like contrast, shape, lines to guide the viewer’s eye towards the areas of the sculpture, drawing or

painting, that artist thought of important. The same applies to the design of interfaces where certain pieces or areas are more important and should be made easier to access or notice. When it comes to environments, especially designed with specific goals in mind, examples of such environments may be a room, garden, gallery, concert hall or installation. In theory, VR could help to tailor the gallery visitor's response according to what authors of artwork(s) intended to accomplish. In part this may be through the study of virtual prototypes, made before the actual installation is made and assembled. This however poses a question of whether the results obtained through VR will be similar to what is experienced in real life? If they are indeed similar, then how much?

To answer these questions we have at the very least one thorough experiment, described in a 2021 paper "Similarity of gaze patterns across physical and virtual versions of an installation artwork" [6]. The experiment was done a little bit differently than the theorized use of VR – Instead of creating a real installation from a VR prototype, the team copied the existing one inside a VR program. The piece chosen for the experiment was a room of Mondrian's design, a physical version of which was created by Heimo Zobernig. Participants were divided into two groups, one of which first had unlimited time to familiarize themselves with real room (term "unlimited" time is used here very loosely to signify there being no hard limits imposed on time spend) and then were presented with VR copy of the same room, the other group had reversed order of interactions. While we traditionally expect VR environments to be worse than their real counterparts, here it had "actual" furniture like a cupboard, instead of a symbolic rectangle on a wall. This factor influenced visitor's attention to certain parts of the room, albeit very insignificantly, so observed gaze patterns were mostly dependent on other factors like color and its intensity. Location also played no significant role in changes, if

any, of the visitor's behavior, except for obvious change in movements as VR "spawned" their avatars in the center of the room instead of let them enter where the door should have been (although this could have been accommodate if the level was made slightly larger and had exterior environments added). Results of the experiment prove that not only there is small difference between patterns, but also that roughly the same areas of the artwork, in this case a room, were interesting to different participants, regardless of the order they were presented with the VR copy of the room. As such, the use of virtual environments either as stand-ins for real galleries or to test out prototypes of designs, installations, sculptures and potentially even regular 2D works is certainly possible and in some cases recommended, even if artist's or their client's subjective view of this practice is less than favorable.

Concerning potential role of such technologies as parts of real-life education programs, we have active virtual gallery used to showcase chosen artworks made by a group of students [1] and however the practice was not "picked up" by university at large or other educational institutions, it proved to be a reasonable alternative to live project reports, progress checks and exhibitions. One noticeable problem with such showcases, especially ones where participants photograph their works themselves, is that of consistent image quality. Subjective quality of the artworks showcased may be on the same level, but improper camera angle, lighting, image compression and even resolution of camera's sensor can and frequently do contribute to general difficulty when working on such virtual environments. Setting optimization and design challenges aside, the more similar inconsistencies are made on what is essentially the asset preparation stage, the harder it will be to create a truly immersive experience, especially if it is supposed to be what we can consider "true VR" – a fully interactive 3D environment experienced through VR goggles. If students are to be involved

in similar projects, they should all follow consistent rules regardless if their work is created in traditional techniques or digital, 3D or 2D, for example, the paper suggests using online galleries as interactive showcase of graduate projects (which is a good idea in regards to visual arts disciplines), in which case all students would have to adhere not only to formal work's minimal requirements (size, techniques, materials, etc) but gallery's technical specifications to ensure as consistent quality across images as possible (which translates to potentially less bias in grading, should these photos be used for it).

**Conclusions.** Virtual and augmented reality and to some extent mixed reality are becoming more widespread in art world both as tools for artists and galleries alike, however not only definitions of what is considered VR and to some extent AR are different, the use of “pure VR” as tool for creating artworks is substantially less common than for purely demonstrative purposes. When it comes to research on VR/AR in art-related areas, it reflects the general state of how these technologies are used throughout art and design fields, with archival, educational and research uses being much more prevalent overall. Part of the issue with the apparent lack of articles and publications about projects created in VR (not just for viewing in VR but entirely made in it) is the rather small number of such projects at all, which is not helped by relatively harder access to VR gear and editors. Despite this, modern researchers have a rather complete picture and substantial amount of previously made materials on which they can base their own theoretical and/or practical research projects, with fields and industries related to culture, art and entertainments being ones that would benefit from such research the most. Worth noting that some concepts discussed in this article and referenced materials can appear to be mentioned out of order chronologically but in fact they are usually well known and widely used in adjacent fields like game development or computer-graphic effects imagery by the time

they are brought into education, archeology, art and similar fields.

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**ТЕХНОЛОГІЇ ВІРТУАЛЬНОЇ ТА ДОПОВНЕНОЇ  
РЕАЛЬНОСТІ В ОБРАЗОТВОРЧОМУ МИСТЕЦТВІ  
ПЕРШОЇ ПОЛОВИНИ ХХІ СТОЛІТТЯ:  
ІСТОРИОГРАФІЧНИЙ ОГЛЯД**

**Анотація.** У статті проаналізовано історію досліджень VR/AR у сфері мистецтва та дизайну в наукових публікаціях ХХІ ст. Використання віртуальних просторів для презентації творів мистецтва та підвищення зацікавленості відвідувачів не є чимось новим у культурному просторі, з цим експериментували багато людей. VR також дедалі частіше, хоча все ще залишаючись радше експериментальною новинкою, використовується як інструмент для викладання та/або вивчення мистецтва та історії, рідше – технічних дисциплін, як інженерія чи фізика. Проте досліджень, орієнтованих виключно на мистецтво, досить мало, частково через те, що прикладів використання VR/AR у мистецьких та дизайнерських проектах не так багато, принаймні поки що, проте існує низка різноманітних експериментів — від суміжних із психологією до тих, що знаходяться на межі мистецтва та ІТ. Для цілей цієї статті питання відмінності між «справжньою VR» (цілком 3D-інтерактивним світом, який можна відвідати за допомогою VR-обладнання), віртуальними середовищами, які не потребують VR-обладнання, та різними типами штучної і змішаної реальності, а також відмінності між ними, особливо коли йдеться про художнє використання, швидше за все, будуть

залишені для окремого обговорення. У фокусі даної статті питання, як світ мистецтва використовував, розвивав і, зрештою, прийняв свободу і нові форми самовираження, дозволені технологіями віртуальної, доповненої і змішаної реальності. Оскільки найбільш помітні та експресивні твори і, що важливіше, наукові дослідження цих творів з'явилися у ХХІ ст., ми обмежимо наш огляд робіт, присвячених мистецтву, цим періодом. Роботи, розглянуті в цій статті, поділяються на чотири різні категорії, кожна з яких має власну загальну дослідницьку мету, яку більшість статей всередині однієї групи поділяють між собою: віртуальні музеї або галереї та збереження культурної спадщини, мистецькі твори та імерсивна типографіка, освіта, поведінкові дослідження на основі взаємодії глядача з твором мистецтва. Якщо перші три категорії добре зрозумілі, коли йдеться про корисність результатів досліджень і самих експериментів, то четверта є надзвичайно корисною як відносно простий і універсальний спосіб «передбачити» поведінку глядача за різних обставин як для власників галерей, так і для художників (планування галереї, освітлення, композиція творів мистецтва, кольоровий контраст між творами тощо).

**Ключові слова:** віртуальна реальність, доповнена реальність, віртуальна галерея, історіографія, імерсивне мистецтвознавство

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