INTERACTIVE DIGITAL ART: EVOLUTION, TECHNOLOGY AND CHALLENGES

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Abstract. Interactive digital art is a rapidly evolving form of contemporary art that makes use of advanced technologies to create an interactive experience between the artwork and the viewer. This study aims to analyze the evolution of this form of art from the 1960s until the present day, examining its key principles and the technologies employed. The article not only discusses the technical and ethical considerations of interactive art but also delves into the challenges of preserving it, which have become increasingly significant with the advancement of digital technology.

Special attention is paid to the social role of interactive art in cultural communication and its influence on traditional artistic practices. The study emphasizes how interactive art changes the audience's perception, moving them from passive observation to active engagement. The article analyses how such interaction fosters deep cultural exchange and enhances the communicative experience, blurring the traditional boundaries between artists and audiences.

The purpose of this study is to examine the theoretical and practical implications of interactive art within contemporary cultural practice. Through an analysis of current projects and examples, as well as interviews with artists and curators, the author aims to identify the major challenges and opportunities presented by interactive art for modern art criticism and the cultural sector. This research offers a fresh perspective on the potential of art in the digital era and initiates a discussion on the future direction of artistic practice in light of global cultural transformation.

Keywords: Digital Art; Interactive Art; Digital Interactive Art; Contemporary Art.

Introduction. The technological revolution has had a significant impact on the development of various aspects of human life, and art has certainly undergone significant changes as a result. One particularly interesting, rapidly evolving, and captivating form of art is interactive digital art. This form of art combines artistic creativity with advanced technology, creating unique interactions between the artwork and the viewer.

The emergence and evolution of interactive art are closely linked to a number of influential figures and projects, as well as the rapid advancement of digital technology. These developments have led to the creation of a new and exciting form of artistic expression that continues to grow and evolve. Interactive digital art is becoming an increasingly significant and exciting part of the contemporary cultural landscape, attracting both artists and audiences. This trend is driven by several key factors:

Firstly, technological advancements and the rapid evolution of digital technologies have opened up new possibilities for creating and experiencing interactive works. Artists can now produce more complex and engaging pieces, which can be enjoyed by a wider audience.

Secondly, the role of the viewer has shifted in interactive art. Instead of being a passive observer, they become an active participant, contributing to the artistic process and transforming their experience into a more immersive and personal one. This shift in perspective has led to a paradigm change in the way we view art and its relationship with the public.

Thirdly, the expansion of art's boundaries has also played a significant role. Digital media allows artists to explore new forms and expressions, breaking free from traditional conventions and pushing the limits of what art can be. Interactive digital art blurs the lines between different art forms, incorporating elements of performance, installation, music, and media art. This contributes to the emergence of new genres and styles of artistic expression, opening up a wider range of possibilities for creative experimentation. It also enhances the sensory experience for all those involved in the creative process, enriching it with new dimensions.

The subject of this research is interactive digital art, which is a unifying element in modern trends in creativity and the latest technologies. This research focuses on analyzing the technological, social, and aesthetic aspects of this art form, as well as its impact on cultural communication and traditional forms of art.

The main focus of the study is on how interactive art affects the interaction between artwork and the audience, as well as the challenges and difficulties that arise in its creation, distribution, and preservation. These include technical issues such as technology obsolescence and ethical concerns regarding the use of personal data. Additionally, there are difficulties in preserving dynamic and interactive artworks.

The purpose of this paper is to examine interactive digital art, exploring its evolution, fundamental principles, and technologies employed. We will also address emerging issues and challenges in this field. A particular emphasis will be placed on the analysis of preservation and archiving interactive works, as this is one of the most pressing concerns in contemporary times.

To achieve this goal, we have the following objectives:

- To trace the historical development of interactive art: to study the key stages and moments that have influenced the formation of this art form.
- Identify the basic principles and characteristics of interactive art, considering what distinguishes it from traditional forms and what types and forms it can take.
- Analyze the technologies used in creating interactive works, including digital technologies.
- Consider the challenges faced by the field of interactive art.

Methods. To write this article, we used the following research methods:

- Analysis of literary sources, including key works and publications on interactive art, such as the works of K. Kwastek and modern research on the subject.
- Study of world examples of digital interactive art.
- Comparative analysis of different types of interactive art, examining their characteristics and the technologies used.

The hypothesis of the study is that interactive art, due to its unique ability to engage and interact with viewers, promotes deeper cultural exchange and interaction. However, it also presents significant technical and ethical challenges, which require new approaches in the fields of artificial creation and curation.

The following methods will be employed to test the hypothesis:

- Quantitative and qualitative analysis of contemporary interactive art projects to identify common patterns and characteristics.
- Comparative analysis of traditional and contemporary art forms to evaluate changes in cultural practices and communication.

The term "interactive art" refers to a type of art that involves the active participation of the audience, making them not only observers but also co-creators of the work. This definition of interactive art can be challenging to define, as interactivity itself has multiple meanings and levels of participation. For example, interactivity can range from simple button presses to more complex forms such as virtual reality or artificial intelligence. Additionally, with the rapid advancement of technology, it can be difficult to distinguish interactive art from other forms of digital media, making classification and definition even more challenging.

The basic principles and characteristics of interactive art include:

- Active participation of the viewer (the work is changed or supplemented due to the actions of the viewer);
- Dynamic structure (interactive works often change and evolve in real time);
- The use of technology (latest digital technologies such as sensors, virtual reality (VR), augmented reality (AR), and artificial intelligence (AI) are often used to create and maintain an interactive experience).

Results. The study revealed that interactive art has a rich and diverse history that dates back to the mid-20th century. In the 1960s, the first experiments with interactive elements began in art, in response to the desire for greater interaction between artists and viewers. Myron Krueger made a

significant contribution to the development of interactive art in the 1970s, laying the groundwork for its future growth.

In the 1990s, interactive art became increasingly important as an independent genre of media art, particularly after it was included in the Prix Ars Electronica competition. During this period, interactive installations were widely used in art galleries and museums, attracting a large audience and inspiring new forms of engagement.

Based on the research, a typology of interactive art was developed, encompassing the following key categories:

Interactive installation: Works that involve physical interaction with objects by viewers. Examples include touchpads, objects that respond to touch, and tactile sculptures.

Interactive performance: Performances in which the audience actively participates and influences the direction of the action. These performances may include elements of improvisation and interaction with the audience, creating a unique experience for each viewer.

Interactive media art: Projects that use digital and multimedia technologies to create immersive experiences. These may include audio-visual installations, virtual reality, augmented reality, and other forms that allow viewers to change audio and visual settings through their actions.

In the course of our research, we have identified several key challenges faced by artists and curators working with interactive art. These include technical issues such as the rapid obsolescence of technologies and the complexity of configuring and operating interactive installations. Additionally, there are ethical concerns regarding privacy, data security, and the preservation and archiving of interactive works.

Our study has shown that successful overcoming these challenges requires a careful approach to design and implementation, as well as considering all aspects of viewer interaction with the art. By taking these factors into account, artists and curators can create more effective and meaningful interactive experiences that engage audiences and contribute to the broader field of art and technology.

Discussion. Interactive art as a trend emerged at the intersection of artistic experimentation and technological innovation in the mid-20th century, tracing its origins back to the early attempts by artists to engage the viewer in the creation and perception of works.

Since the 1990s, interactive art has become an important concept in media arts, especially after its inclusion in the Prix Ars Electronica competition (Kwastek, 2013). However, the definition of this term has been a subject of debate among artists and critics. In 2004, the jury of the competition proposed a broader definition, removing the mandatory requirement of computer use and introducing the concept of "passive interaction". This reflects a trend towards blurring the boundaries between digital and analog forms of art.

One of the pioneers of interactive art is Jean Tinguely, who in 1960 presented his famous kinetic sculpture "Homage to New York" (photo 1). This sculpture, composed of many moving parts, was designed to disassemble and destroy itself during a performance. Viewers could interact with the work by watching as it was dismantled and destroyed, creating a unique and unpredictable experience.

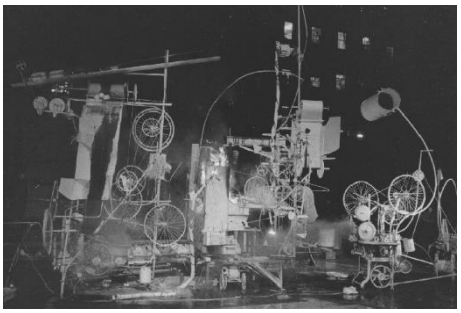

Photo 1. Jean Tinguely, "Homage to New York" (1960)

In the 1960s, Roy Ascott, a leading theorist and practitioner of interactive art, proposed the concept of interactive art in his work "Behaviorist Art and the Cybernetic Vision" (1966). He believed that art should not be a static object but a process, and he proposed using cybernetic systems to create interactive works.

At the same time, the first computer-generated artworks began to emerge. One example is "Senster" (1970), created by artist Edward Ihnatowicz (photo 2). "Senster" is a robot that reacts to sounds and movements, creating an interactive experience with the audience. This work demonstrates the potential of computer technology for creating interactive artworks.

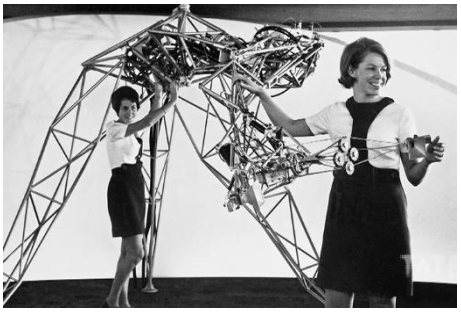

Photo 2. Edward Ihnatowicz, "Senster" (1970)

Technological innovations have undoubtedly played a significant role in the evolution of interactive art, beginning with the initial experiments involving computers in the 1970s. This period saw the emergence of the first personal computers, which presented new possibilities for artists. Myron Krueger was the first to systematically explore the possibilities of digital technology for interactive art. He introduced the term "artificial reality" to describe a new art form. In the 1970s, Krueger created interactive environments like Psychic Space and Maze in order to explore the rules and conventions of interactive experiences. His work laid the groundwork for a movement that had a significant impact on culture and the arts over time (Kwastek, 2013). His "Videoplace" project (1975) enabled viewers to interact with virtual objects on screen through the use of video cameras and monitors, made possible by the development of computer hardware and video capture systems (photo 3). Krueger believed interactive art should offer viewers the opportunity for active participation and control, a departure from the traditional, passive approach to art.

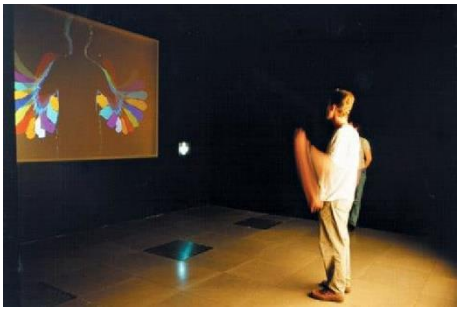

Photo 3. Myron Krueger, "Videoplace" (1975)

These early experiments laid the foundation for the further development of interactive art and became an inspiration for many artists of subsequent generations. They showed that art can be not only an object of contemplation, but also a process of active interaction, involving the viewer in the creation and perception of the work.

In the 1990s, the Internet and multimedia technologies began to actively influence interactive art. With the development of the global network, artists gained access to new tools and platforms for creating and distributing their works.

"The Legendary City" was a virtual bike ride through the city where buildings and streets were replaced with text (photo 4). Viewers could navigate the virtual city by reading text and creating their own stories. This project was one of the first to use virtual reality actively to create an interactive experience.

Photo 4. Jeffrey Shaw, "The Legitimate City" (1989)

"Pulse Room" by Rafael Lozano-Hemmer is an interactive light installation that uses light bulbs that blink to the rhythm of the audience's heartbeats (photo 5). When visitors touch a sensor, their pulse is sent to the bulbs, creating a unique visual rhythm. The piece emphasizes the individual involvement of the audience and generates unique lighting patterns.

Photo 5. Rafael Lozano-Hemmer, "Pulse Room" (2006)

In the 2000s, mobile technology and sensors became an important element of interactive art. Artists began using mobile devices and GPS to create new forms of interaction with audiences.

"Artvertiser" by Julian Oliver is a project that uses augmented reality to replace advertisements with digital works of art on the streets (photo 6). Viewers can use special devices to see advertisements replaced with artistic objects, allowing them to rethink public spaces and their content. This form of art has become possible due to the development of mobile technology and augmented reality software.

Photo 6. Julian Oliver, "Artvertiser" (2008)

"Hello World!" is an interactive installation consisting of multiple screens broadcasting videos from various blogs and social networks (photo 7). Viewers can interact with this visual "wall of noise" by exploring the personal stories and experiences of people from all over the world.

Photo 7. Christopher Baker, "Hello World! or: How I Learned to Stop Listening and Love the Noise" (2008)

In the 2010s, virtual reality (VR) and augmented reality (AR) technologies began to be actively used in interactive art. These technologies made it possible to create multidimensional and interactive works that interact with reality.

"Foresta Lumina" is a night light installation in the forest where viewers can walk along a trail and interact with various light and sound effects (photo 8). This project combines elements of nature and technology to create a special magical atmosphere.

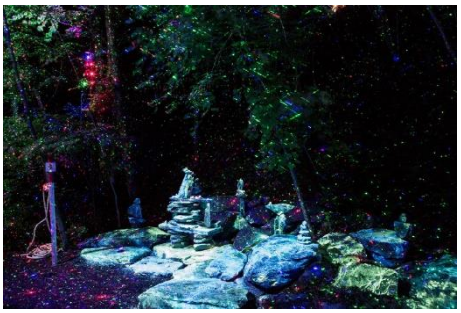

Photo 8. Canadian studio Moment Factory, "Foresta Lumina" (2014)

Recently, artificial intelligence (AI) and big data analysis have become new tools for creating interactive art. The König Galerie project, Machine Hallucinations (2019), uses AI to analyze and transform huge amounts of data from the internet into unique, impressive visual and sound works that are like sculptures (photo 9). Viewers can interact with this digital world by exploring its structure and content.

Photo 9. König Galerie, "Machine Hallucinations" (2019)

These key artists and projects showcase the variety of approaches and technologies used in interactive art. Each of them has made a significant contribution to the development of this direction, opening up new opportunities for viewers to interact with art and expanding the boundaries of artistic expression.

When it comes to interactive art, a question arises: how can viewers or participants feel free to choose their actions when their outcome is determined by the author of this installation? This issue is further complicated by different perspectives: the participant experiences the fictional world as a continuous present, focused on an unknown future, while the designer creates the world from a timeless

perspective, considering events or elements without regard to their temporal order. This allows designers to structure plots and events in a way that corresponds to the desired effect or purpose of the story, without being constrained by a linear sequence (Ryan, 2001). It is important for viewers to find a balance between deeply immersing themselves in a work and maintaining a certain distance from it. This allows them not only to experience the physical interaction with the work but also to engage in critical thinking. This approach to critical interactive art encourages a deeper understanding of art by analyzing the grammar of interactions, rather than simply experiencing its intensity or emotional impact (Simanowski, 2011).

Interactive art manifests itself in various forms, each using unique methods and technologies to engage viewers.

One of the most striking forms is the interactive installation. A good example is "The Night Cafe" by Borrowed Light Studios (photo 10), which immerses visitors into the world of Vincent Van Gogh's painting. Inside the virtual space, viewers can freely move around and interact with various elements, as if they were really in the famous cafe. This project uses VR technology to create an immersive experience that allows people to explore a well-known work of art in a new way.

Photo 10. Borrowed Light Studios, «The Night Cafe» (2016г.)

Another impressive interactive installation is "As We Are" by Matthew Mohr. A huge interactive head 14 feet high is placed in a public space and projects the faces of the audience (photo 11). Using 3D scanning and projection technology, the faces of people who scan their images are projected onto the installation, creating a unique public artwork that interacts with the wider audience.

Photo 11. Matthew Mohr, "As We Are" (2018)

The next form is interactive performance, which also continues to evolve, creating new forms of interaction with the audience. "Dear Angelica", a project from Oculus Story Studio, uses VR to immerse viewers in a story told through drawings and animations (photo 12). The audience can move through the scenes and interact with plot elements, allowing them to actively participate in the narrative's development. The project shows how VR can create a new narrative format in which viewers become an integral part of the story.

Photo 12. Oculus Story Studio, "Dear Angelica" (2016)

Interactive media art also continues to evolve, offering new ways of interacting with and perceiving art. The "Learning to See: Gloomy Sunday" project by Memo Akten uses artificial intelligence to analyze and generate images based on viewer moods and emotions (photo 13). Viewers enter their emotional states, and AI creates visual representations of these emotions. This use of AI in creating personalized visual works highlights the potential of technology in art.

Photo 13. Memo Akten, "Learning to See: Gloomy Sunday" (2017)

Another example of interactive media art is "Artificial Nature" by Haru Ji and Graham Wakefield (photo 14). In this interactive digital installation, viewers can control virtual natural elements such as water, trees, and animals, creating their own digital ecosystems. The project uses interactive technologies to create simulations of natural ecosystems, allowing viewers to interact with and change the virtual environment in real time.

Photo 14. Haru Ji and Graham Wakefield, "Artificial Nature" (2007)

Conclusion. The future of interactive art largely depends on the development of technology and social change. Artificial intelligence and machine learning are likely to play a key role, allowing the creation of works that adapt and respond to the actions of viewers in real time, creating personalized and intelligent experiences. Virtual and augmented reality may well expand the possibilities of interactive art even more qualitatively. These technologies can be used to create more immersive and interactive works of art accessible to a wide audience through mobile devices and VR. Social media and digital platforms already play an important role in the dissemination and interaction with interactive art, and in the future they are likely to occupy a key place in communication with all participants in the processes related to art. The creation of virtual galleries and online exhibitions will allow us to interact

with art remotely. As the MoMA and the Louvre museums have already done in response to the COVID-19 pandemic, this will allow people to enjoy art from anywhere in the world.

Interactive art continues to evolve, using the latest technologies and adapting to social changes. It not only transforms traditional art forms, but also creates new ways of interaction and communication. The future of interactive art promises to be exciting, with even greater opportunities for audience engagement and participation, making art accessible and meaningful to a wide audience.

In interactive art, there are various rules that play an important role in determining how participants interact with the artwork. These rules can be divided into three categories: explicit, implicit, and unwritten.

Explicit rules refer to the technical and operational aspects of interacting with the artwork, such as how to use specific tools or techniques. Implicit rules are more difficult to define, as they relate to norms of etiquette and behavior that depend on how participants interpret their roles in the interaction. These implicit rules can be influenced by cultural or social factors.

Unwritten rules are those that are not explicitly stated, but are understood by all participants. These can include things like expectations about how to behave or what is considered appropriate or inappropriate in the context of the artwork.

Unwritten rules define the expected behavior of participants in a given scenario. For instance, if participants are playing the role of scientists in a lab, they should wear lab coats and conduct experiments with chemicals. If they are viewers, their goal is to understand the work's structure and content and explore how the different elements relate to each other. Those passionate about technology may want to explore the technical aspects by experimenting with sound zones and devices. Viewers who happened to be there by chance should try not to draw attention to themselves or interfere with others while observing from the sidelines.

These rules form the basis of how participants experience their activities. The artist allows these boundaries to be flexible, enabling participants to switch between different roles and perspectives on perception. The core of interactive art lies in the collision of these various perspectives, creating a more complex and enriching experience for the viewer (Ricardo, 2009).

Interactive art, despite its innovation and the involvement of the viewer, faces a number of problems and challenges. One of the main problems is the preservation and archiving of interactive works. Technical aspects, such as the obsolescence of hardware and software, make long-term storage and reproduction of such works difficult. In addition, the viewer's interaction with the work is often unique and unpredictable, which adds complexity to documenting and preserving the original intent of the author. Do not forget about the human factor, which plays an important role at all stages of the life cycle of interactive art.

Interactive art, located at the intersection of artistic creativity and advanced technologies, faces a number of problems and challenges.

One of the main technical problems of interactive art is the rapid obsolescence of technology. The hardware and software used to create interactive works may become unavailable several years after the creation of the work. This leads to the need for regular migration of data to new media and updating of the technologies used. An important solution to this problem is to use open standards and formats that are easier to adapt and update.

The complexity of setting up and operating interactive systems is also a significant obstacle. Such works often require complex setup and constant maintenance. The solution may be the development of modular and scalable systems that can be easily adapted to various operating conditions. The reliability and stability of interactive systems are also crucial, as technical failures can disrupt the viewer experience. To minimize risks, careful testing and use of high-quality equipment is necessary, as well as the introduction of backup systems and contingency plans. Interactive art, especially that which uses personal data from viewers, raises important ethical questions. Artists and curators who collect data about viewers must consider their right to privacy and obtain consent before using biometric and behavioral data. Informing the viewer about data collection and obtaining consent is an essential part of this process. Ensuring the security of collected data and preventing unauthorized use is also crucial. Using encryption and secure storage methods and restricting access only to authorized individuals will help protect viewer privacy.

The main challenge is preserving and archiving interactive works.

One of the most serious problems with interactive art is preserving and archiving works, which is associated with their technological and conceptual complexity. Preserving interactive works requires maintaining operability of technologies used, which are rapidly becoming obsolete. An important step in this direction is documenting all technical aspects of a work, creating virtual copies, and using emulators to recreate outdated systems.

The conceptual aspects of interactive works also present a challenge. Interactive works often depend on the participation of the audience, which makes them unique and difficult to reproduce. Recording interactions and documenting the process of creating and operating a work, as well as creating instructions and manuals for future curators and restorers, will help preserve the original intent of the author and the unique aspects of interaction.

Interactive art, despite its innovative capabilities and the ability to involve viewers in the process of creating and perceiving works, faces many problems and challenges. Technical difficulties, such as the rapid obsolescence of technologies and the complexity of setting up interactive systems, ethical issues related to rights to use audience data, etc., are all problems that need to be addressed. The main challenge is preserving and archiving interactive works, which requires an integrated approach including documentation, data migration, and the use of open standards. With the help of modern technology, strategies, and methods, as well as active collaboration between artists, technologists, and research institutions, these challenges can be overcome. Interactive art is continuing to evolve, utilizing the latest technologies to adapt to social changes and create new ways of interacting and communicating. The future of interactive art promises to be exciting, with even greater opportunities for audience engagement and participation. This will make art accessible and meaningful to a wider audience.

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