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ANALYSIS OF THE CONVERGENCE BETWEEN ART AND TECHNOLOGY AT THE WRO BIENNALE:
Opportunities for Museums to Anticipate and Adapt to Emerging Practices

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ABSTRACT
The WRO Biennale in Wrocław exemplifies the evolution of media art, from visibly mechanical devices to immersive systems based on artificial intelligence, sensors and algorithms. Through a comparative analysis of the 2013, 2015, 2023 and 2025 editions, the study demonstrates how artworks transform the viewer into an active participant while exploring material, temporal and socio-political dimensions.
WRO functions as a critical laboratory, offering museums the opportunity to anticipate emerging artistic strategies, develop adaptive curatorial practices and design innovative approaches to mediation and conservation, integrating new technologies as expressive, conceptual and participatory tools.

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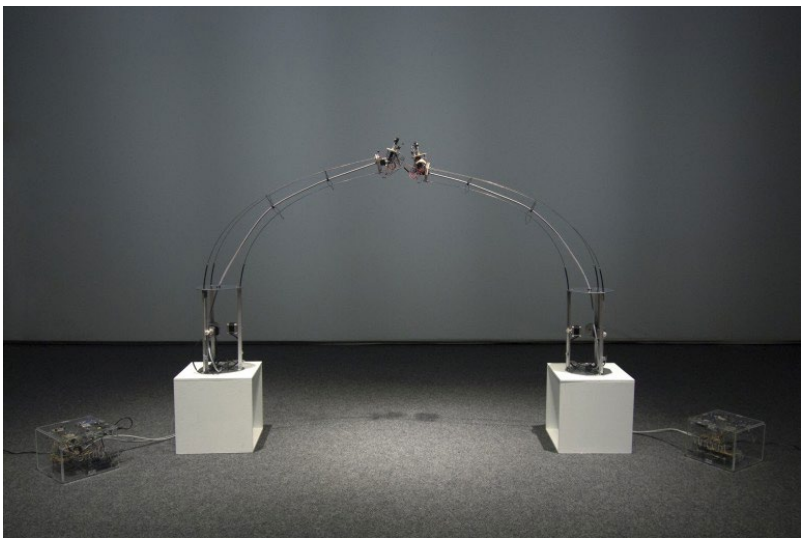
1. Introduction

Held every two years, the WRO Media Art Biennale has been held in the Polish city of Wrocław since 1989, representing the leading exhibition platform for new media art in Poland and one of the most significant international events in Central Europe. Edition after edition, the event showcases highly experimental artistic practices linked to emerging technologies, combining exhibitions with conferences and encounters between artists, scientists and audiences.

Visitors to the 2013 edition had the opportunity to experience *Vincent and Emily* (2012), an installation by artists Carolin Liebl and Nikolas Schmid-Pfähler (Fig. 1). The installation consists of two robots that interact in a conflictual manner, articulating a mechanical choreography that reflects the fragility and complexity of human relationships. Equipped with sound and motion sensors and driven by three motors, gears, racks and flexible metal shafts, the robots communicate solely through mechanical gestures and sounds emitted via loudspeakers. This interaction, structured around pre-programmed misunderstandings, projects onto the viewer the tensions inherent in affective relationships, while the technological materiality remains fully visible: motors, sensors, consoles and consumer hardware structure the perceptual experience through light, vibration and movement.

The work responds to contemporary reflections on the possibilities of mediated perception and technological interactivity in art, exploring the limits of human–machine communication through an approach centred on the tangible presence of technical apparatus. The installation highlights the visibility of technology and its analogy with human experience through recognisable mechanisms and the interplay between structure and conflict. These devices, which were undergoing rapid development during the 2010s, constituted a particular focus of interest for artistic collectives of the period, at a moment when post-Internet practices were beginning to shift attention away from traditional net art towards works that foregrounded the omnipresence of connectivity in everyday life, incorporating digital cameras, multi-screen environments, digital editing, web interfaces and consumer hardware as central materials of artistic experience (Martín Prada, 2017).

Figure 1. *Vincent and Emily.*

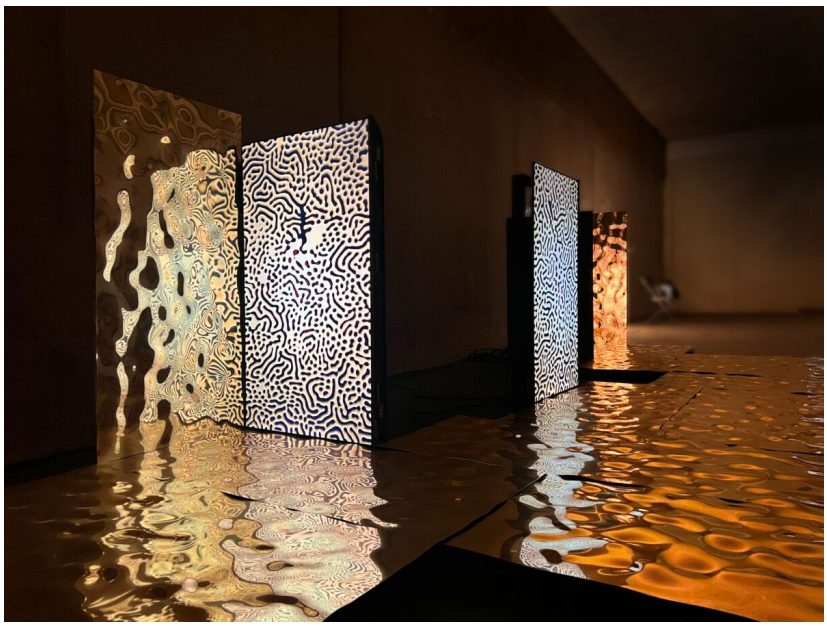


Vincent and Emily installation. Source: https://highlike.org
(https://highlike.org/carolin-liebl-nikolas-schmid-pfahler/)

Barely ten years later, at the same biennale, the installation *Proteus 4.1* (2024), conceived by Maria Smigielska and CompMonks, was presented (Fig. 2). This work represents a radical evolution in the conception of interactivity and technological mediation. It materialises an immersive digital environment through a modular architecture of screens, mirrors and gold-toned metal panels, transforming the exhibition space into a luminous and mutable ocean. Inspired by the Greek god Proteus—whose ability to foresee the future and reveal secrets is transfigured into the visitor's experience—the installation introduces a mode of interaction based on web applications with eye-tracking on mobile devices, integrating digital experience with physical spatiality and the distributed infrastructure of the Internet through the use of generative AI.

The patterns produced by a digitised ferrofluid, controlled by artificial intelligence algorithms, express the uncertainty inherent in the circulation of information and in human interaction, while also promoting attentiveness in the face of contemporary media saturation. In this context, AI does not merely fulfil a technical role but becomes an aesthetic mediator, articulating sensory experiences that transcend technological functionality and are situated within a critical register of contemporary artistic practice.

Figure 2. *Proteus 4.1.*



Installation by Mikael Håfström. Source: WRO 2025 (https://wro2025.wrocenter.pl/en/works/proteus/)

The contrast between both installations reveals, in the span of barely a decade, the transformations that have reshaped both the technical and conceptual dimensions of interactive art. While *Vincent and Emily* operates within a framework of visible and tangible mechanical materiality—where the viewer confronts the apparatus and its functioning directly—*Proteus 4.1* shifts attention towards the seamless integration of technology into perception and experience, demonstrating how artificial intelligence can intervene in aesthetic and conceptual construction without the need to be explicitly visible. Thus, the 2025 work reflects on a distinctly contemporary issue: artistic creation within an environment mediated and assisted by AI-based content generation tools, highlighting the capacity of these technologies to shape meaningful and sensorial experiences. By contrast, the 2013 work responded to contemporary concerns regarding technologically mediated perception in art and mechanical interaction, illustrating how, within just a decade, technological advances have radically reconfigured both the conceptual interests and formal possibilities of interactive and digital art, marking a decisive transition from technology as visible apparatus to technology as aesthetic and conceptual mediation.

The WRO Art and Technology Biennale may be conceived as a contemporary space of mediation and experimentation which, notwithstanding historical and contextual differences, recalls the function of the great international exhibitions of the nineteenth century. A paradigmatic example is provided by the exhibitions held in Paris, which played a crucial role in opening the first channels of exchange between Japanese art and Western culture. From the 1867 Exposition Universelle onwards, *ukiyo-e* prints began to circulate systematically across Europe, exerting a profound impact on artists, collectors and intellectuals in search of new sources of inspiration at a time when traditional academic models were becoming exhausted. This direct encounter with objects, techniques and visual systems external to the Western canon fostered the emergence of new aesthetic sensibilities and contributed decisively to the renewal of European art in the late nineteenth and early twentieth centuries (Martínez Mingarro, 2010).

These international exhibitions did not merely function as showcases of industrial and scientific progress; they already presented a hybrid and experimental artistic format that anticipated much of later artistic production. Within them, new modes of presenting, circulating and receiving art were explored—modes that would later become structurally integrated into the historical avant-gardes and into the modern redefinition of art. The international exhibition thus operated as a cultural laboratory

in which the technical, the aesthetic and the symbolic were interwoven, generating shifts that would only become fully visible in subsequent developments.

From this perspective, the WRO Biennale functions as a living laboratory of artistic and technological innovation: a space where emerging practices—still marginal within institutional museum frameworks—offer early indications of languages, methodologies and issues that may consolidate within technologically mediated art. Just as the reception of Japanese art transformed European sensibilities in the nineteenth century, the works exhibited at WRO make it possible to observe, in real time, processes of transformation that may progressively take shape within the artistic and cultural ecosystem. For museum institutions, such systematic observation offers the opportunity to understand emerging trends, explore new forms of mediation and sensorial experience, and design curatorial and educational strategies enriched by creativity, integrating art, technology and audiences within innovative cultural ecosystems.

2. Reconfiguring Museums: Mediation and Exhibition in the Face of Next-Generation Digital Art

Within the current digital reconfiguration of cultural practices, museum institutions face a set of dual challenges: on the one hand, those related to the internal use of next-generation technologies in their devices, processes and management systems; on the other, those arising from the need to adapt in order to effectively and contemporarily accommodate and disseminate works produced by contemporary creators. Far from being mere obstacles, these dimensions constitute potential opportunities to rethink curatorial and mediation strategies.

The incorporation of advanced technologies in museums extends beyond technical innovation, redefining curatorial paradigms and modes of aesthetic experience. Derda and Predescu (2025) highlight that visitor-oriented artificial intelligence systems foster dynamics of value co-creation and promote a more active relationship with cultural content. Complementarily, robotics and artificial intelligence applied to museum contexts enhance mediation and education, accompanying audiences in the exploration of heritage and generating more dynamic and accessible experiences (De Mello et al., 2024). Labella Martínez and García Lirio (2025) emphasise that the consolidation of works based on next-generation technologies—such as artificial intelligence, extended reality or virtual environments—requires a structural adaptation that goes beyond mere technological updating, affecting exhibition models, mediation and curatorial frameworks. These practices incorporate interaction, immersion, real-time content generation and active audience participation, demanding a critical revision of traditional exhibition logics. If institutions fail to respond critically, such works risk being reduced to exercises in technological spectacle, neutralising their aesthetic, political and reflective potential. As Groys (2016) argues, the contemporary museum is a space of friction between human and technological vision, where the cultural meaning of images, data and systems is continuously negotiated. This underscores the need to approach emerging technologies as cultural languages capable of enriching and transforming institutional practices.

In this context, particular attention should be given to the exploratory work of artists themselves, who experiment boldly with these tools. Their proposals generate creative and culturally relevant uses that institutions can adopt and reinterpret, becoming sources of innovation for redefining mediation, audience experience and the relationship between artwork and spectator. Many of these experiences take the form of interactive and immersive installations requiring active participation; others reinterpret environmental or network data, incorporating the algorithmic dimension as a constitutive material. These experiments introduce new conceptions of authorship, materiality, temporality and the status of the spectator, compelling institutions to engage urgently with the critical integration of emerging technologies.

Liz Gutiérrez (2020) emphasises how these technologies generate aesthetic experiences that transcend traditional perceptual frameworks, involving bodily, cognitive and affective participation. The technologically mediated experience ceases to be contemplative and instead becomes a relational space in which subjectivity is co-constructed. Puelles (2011, p. 297) notes that interaction and immersion challenge the traditional status of the spectator, who exists only through active participation, thereby blurring the boundaries between artwork, experience and reception.

Bishop (2025) argues that, beyond diagnoses of a digital attention crisis, it is crucial to analyse how spectatorial conditions are reorganised and how artists process, reject or reformulate these changes,

particularly in exhibition spaces combining artificial intelligence, augmented reality and hybrid environments. In a similar vein, Martín Prada (2024, p. 15) stresses that the challenge posed by technological systems lies not in their technical perfection but in their capacity to interrogate the world and the status of art; technology thus operates as a problem rather than an end. Adler (2024) identifies strategies that subvert hegemonic uses of these technologies, manipulating algorithms or distorting systems to open critical and experimental spaces. Martín Prada (2023, pp. 165–207) further argues that participation and immersion configure a new model of the spectator as an active co-creator of meaning. These transformations require institutions to adapt their exhibition, curatorial and conservation models to technologies in constant evolution. Although digital tools offer new possibilities for research, mediation and the dissemination of heritage (Irala Hortal, 2024), their integration generates tensions within structures still rooted in modern paradigms. The sustained incorporation of previously marginal technological forms points to shifts in processes of legitimation, museographic logics, conservation and mediation strategies.

The rapid growth of these strategies, intensified in the aftermath of the COVID-19 pandemic (Gao and Braud, 2023), highlights both their democratising potential and their conceptual limitations. To understand this context in depth, biennials emerge as privileged laboratories for analysing the impact of emerging technologies on contemporary artistic production. Unlike fairs or traditional museums, these events foster artistic experimentation and critical reflection, providing space for large-scale installations, hybrid projects and site-specific works that explore new forms of mediation and experience (Gardner and Green, 2016, p. 15). From the Venice Biennale (1895) to the present, biennials have expanded globally (Kolb et al., 2018; Tunali, 2017, p. 7), diversifying curatorial discourses, technological approaches and production strategies. Their transnational character allows the detection of structural transformations within the artistic ecosystem, traceable through flows of ideas, practices and technologies. Smith (2016) emphasises that, due to their dynamism and relative independence from direct commercial logic, they function as historiographical documents condensing the aesthetic, social and technological concerns of each period. In the field of next-generation technologies, biennials display particular permeability to experimentation with extended reality, artificial intelligence and virtual environments. Their intensive temporality and institutional autonomy facilitate conceptual and technical risk-taking, while their international visibility enables the evaluation of the impact of such practices across diverse audiences. The combination of qualitative and quantitative analysis of large datasets applied to these exhibition contexts—such as Manovich's (2020) Cultural Analytics—allows the biennial phenomenon to be understood as a complex cultural system, positioning these events as laboratories for experimenting with new forms of creation, mediation and aesthetic experience.

Among global art biennials, the WRO Art and Technology Biennale (Poland) stands out as a particularly valuable site for observing, measuring and contextualising these shifts. Unlike museums, biennials confront directly the challenges associated with exhibiting emerging works, managing audience response and developing strategies for public dissemination. WRO operates as a space of institutional experimentation where the limits of artistic language, the technical capacities of exhibition and the modes of reception within a networked visual culture are actively negotiated.

This study proposes a comparative and diachronic analysis of the 2013 and 2015 editions in relation to the more recent editions of 2023 and 2025, evaluating the evolution of discourses, technological tools, modes of interaction and mediation strategies. A shift can be observed from technologies oriented towards visualisation and basic interactivity to complex systems based on artificial intelligence, machine learning, immersive environments and autonomous algorithmic processes. This transformation repositions the spectator from an interactive user to an agent immersed in real-time systems capable of learning and adapting their behaviour. This approach engages with ongoing debates on attention in contemporary culture. As Bishop (2025) suggests, beyond the presumed crisis of digital attention, it is essential to examine how spectatorial conditions are reorganised and how artists process or reformulate these changes. At the WRO Biennale, these issues are intensified as audiences engage with sophisticated systems combining artificial intelligence, augmented reality and hybrid environments, requiring a reconsideration of modes of attention, comprehension and participation.

Consequently, cultural institutions can benefit from this type of comparative and diachronic analysis of artistic experimentation in order to anticipate trends, understand the impact of emerging technologies and develop more informed and resilient curatorial, mediation and conservation strategies. This approach enables not only the critical integration of artistic innovations but also the

construction of cultural ecosystems capable of adapting and evolving more effectively within the digital age.

3. Methodology

This study adopts a qualitative, comparative and longitudinal approach aimed at examining the structural transformations experienced by the WRO Biennale over more than a decade. The methodological objective is not limited to describing the progressive incorporation of emerging technologies within exhibition contexts, but seeks to identify continuities, shifts and ruptures in curatorial models, institutional mediation strategies and the configuration of contemporary aesthetic experience. From this perspective, the exhibition is understood as an epistemological device rather than merely a container of artworks, situating the study at the intersection of curatorial studies, critical museology and digital culture.

The research design follows the logic of a longitudinal multiple case study. Four editions of the biennale (2013, 2015, 2023 and 2025) were selected in order to establish a diachronic comparison between two distinct phases: an initial cycle (2013–2015), associated with the consolidation of video art, multimedia installations and early immersive experiences; and a second cycle (2023–2025), characterised by the integration of emerging technologies such as generative artificial intelligence, XR environments, robotics and digital interactive systems. The selection of these editions responds to the intention of comparing a stage prior to the full institutionalisation of digital practices with a later context marked by their conceptual and technical maturation. This temporal framing enables the examination of the biennale as an institutional laboratory in which technological innovation, artistic experimentation and the reconfiguration of cultural mediation devices converge, without aiming to provide an exhaustive overview of media art.

The study is not conceived as a systematic literature review, nor does it adopt evidence synthesis protocols typical of quantitative methodologies. Rather, it constitutes an empirical analysis of a defined artistic corpus, based on official biennale documentation—catalogues, curatorial archives, exhibition programmes and institutional audiovisual materials—and on the systematic examination of the works presented in each edition. This methodological precision is necessary to delimit the scope of the study and situate it within established practices of qualitative research in art history and curatorial studies, with an essentially exploratory and hypothesis-generating character.

The corpus analysed comprises 326 works included in the main curatorial programme of the selected editions. These include single-channel videos, interactive installations, technological performances, immersive environments, AI-based works and hybrid proposals combining physical and virtual media. The selection does not aim to cover the entirety of exhibited production, but rather to construct a sufficiently broad and diverse sample that enables the identification of diachronic patterns in the articulation between emerging technologies, exhibition devices and forms of audience experience.

To ensure procedural traceability, an analytical matrix was designed *ad hoc* to examine each work according to three interrelated dimensions: (1) authorial and contextual variables—authorship, geographical origin, year of production and institutional affiliation; (2) technological typology—video, interactive installation, virtual or augmented reality, artificial intelligence, robotics, generative systems or other hybrid formats; and (3) degree of interaction—from contemplative experiences to immersive, multisensory and participatory proposals. This approach makes it possible to evaluate not only technological innovation in a strict sense, but also mediation strategies and the construction of active aesthetic experiences, in line with transformations observed in audience attention and participation (Bishop, 2025; Liz Gutiérrez, 2020). Accordingly, the analysis shifts attention from the instrumental dimension of technology towards an understanding of how interactive devices reconfigure the spectator–artwork–institution relationship and generate new modes of perceptual and cognitive engagement.

In order to ensure comparability across the four editions, the classification system of the works was standardised through a limited set of stable typologies. All pieces were grouped into homogeneous categories—video installation/expanded cinema, audiovisual light and sound installation, kinetic/robotic installation, gesture-, camera- or sensor-based interactive installation, immersive/XR/VR installation, sound installation/sound sculpture, and performance or audiovisual concert (including variants of game art and essay film when integrated into spatial exhibition formats)—defined according to their technological materialities and their mode of articulation within the exhibition space. This classificatory framework enables the unification of criteria that in curatorial

practice often appear dispersed and facilitates systematic comparison of the constellation of technologies involved the mediation devices and the modes of experience activated in each biennial cycle.

The analytical procedure combined deductive and inductive coding. Deductive coding was based on technological, curatorial and mediation categories previously identified in the specialised literature on art and technology, allowing the establishment of a homogeneous comparative framework organised around the axis technology–mediation–outcome. In parallel, inductive coding enabled the identification of emerging patterns related to the transformation of the spectator's role, the performativity of the exhibition device and the increasing hybridisation between physical space and digital environments, as well as nuances not initially anticipated in the articulation between specific technologies, curatorial strategies and forms of experience. The results were systematised in comparative tables, facilitating the identification of structural trends across the two temporal cycles analysed.

The epistemological positioning of the study is grounded in the conception of the biennale as a space of institutional experimentation. From this perspective, the exhibition institution is not a passive recipient of technological innovation, but an active agent in processes of organisational learning and cultural reconfiguration. The observed practices provide indications of possible transformations in models of audience attention, forms of aesthetic participation and cultural mediation devices, whose scope will require further exploration in future research.

The methodological rigour of the study is supported by the explicit delimitation of the corpus, the formalisation of the analytical matrix and the coherence between the theoretical framework and the interpretative procedure. However, certain limitations inherent to the adopted approach must be acknowledged. The analysis is based primarily on institutional documentation and does not include systematic interviews with curators or artists, which could enrich future research through ethnographic or testimonial approaches. Furthermore, the rapid pace of technological evolution implies that the conclusions should be understood as situated analyses within a specific historical context, open to revision as new practices and dispositifs become consolidated. Overall, the methodology developed allows the WRO Biennale to be examined as an institutional laboratory in which the relationships between art, technology and cultural mediation are negotiated, offering a coherent and formalised analytical framework that enhances procedural transparency and aligns with established standards in museological research.

4. Objectives

The primary objective of this study is to analyse the evolution of emerging technologies within the artistic ecosystem of the WRO Biennale, assessing how these transformations impact the production, mediation and reception of artworks.

Through a diachronic comparative analysis of the 2013, 2015, 2023 and 2025 editions, the study seeks to identify continuous and correlated patterns in the use of advanced technologies, examining the consolidation of strategies, the emergence of new tools and the conceptual shifts within artistic practice. The Biennale is thus considered not merely as an exhibition space, but as a critical laboratory, responsive to technological change and to the experimental possibilities it enables.

Within this framework, the selected works move beyond passive contemplation to configure an ecosystem of bidirectional interaction. Visitors are no longer limited to observation; rather, they engage with algorithmic systems, sensory devices and immersive environments that respond to their presence, movement or even biometric signals. This shift in focus from object to experience transforms the spectator into an active agent, a co-creator of meaning through technical, cognitive and emotional participation, in line with the approaches articulated by Adler (2024) and Martín Prada (2023, 2024).

Furthermore, the selection of technologically driven works allows for the mapping of a critical transition towards an aesthetics of immateriality, in which the use of artificial intelligence, augmented reality and generative projections articulates new expressive possibilities. Artists explore the fragility of the digital as an autonomous language, incorporating temporal, interactive and algorithmic dimensions that demand a reflective engagement from both institutions and audiences.

Taken together, this methodological and objective framework aims to strengthen the understanding of the Biennale as an institutional laboratory, providing tools for museums and art centres to anticipate trends, interpret emerging practices and develop curatorial, mediation and conservation strategies capable of responding critically to the challenges of the digital age.

5. Results Analysis

The comparative analysis of two editions of the WRO Art and Technology Biennale from the 2010s (2013 and 2015) and two from the 2020s (2023 and 2025) reveals a progressive transformation in both artistic discourses and the technological materialities mobilised within the exhibition context. Over this period, a clear shift can be observed from a new media paradigm still strongly linked to digital video, expanded cinema and basic electronics towards an ecosystem dominated by installation in a broad sense, understood as a hybrid device in which image, sound, body, space and technology converge. This evolution cannot be explained solely by technical developments or the incorporation of more advanced tools but reflects a gradual reconfiguration of how technology is conceived, displayed and experienced within the exhibition space.

5.1. 2013: Visible Technology and the Materiality of the Medium

In the 2013 edition, an audiovisual paradigm clearly centred on digital video, multi-channel projection and glitch aesthetics predominates, while robotics and the manipulation of video game engines still appear as emerging lines within the exhibition context. A representative example is the installation *Test Five*, which reformulates the cameraless film by Józef Robakowski into five video channels, shifting the traditional materiality of projected light and film towards the logic of the monitor: white dots on a black background that visualise luminous energy now conditioned by pixels, resolution and screen surface.

Works such as *RGB Lookbook* explore chromatic saturation and the visual culture of fashion video blogs through five synchronised channels, RGB coding and intensive editing, highlighting how the digital camera and the multi-screen system operate as raw material for a veritable "carnival" of image consumption. In parallel, pieces such as *Uso*|*Menos* employ sine wave generators to vibrate objects in front of the camera, revealing electronic sound not only as an acoustic phenomenon but as a physical force capable of visually shaping matter. Game art and machinima emerge in works such as *The Plastic Garden*, which hacks *Call of Duty: Black Ops* to reinscribe nuclear imagery, emphasising the game engine, three-dimensional maps and digital textures as malleable and reprogrammable materials.

The robotic installation *Vincent and Emily*, mentioned at the beginning of this article, is fully situated within this horizon. Three motors, racks, flexible metal shafts, and sound and motion sensors articulate a pair of machines whose conflictual choreography transforms gears, vibration and structure into a metaphor for affective relationships. In this edition, technology is presented explicitly as a visible apparatus—camera, monitor, projector, motor or console—and materiality is concentrated in light, metal, moving objects and consumer hardware, without concealing the mechanisms that sustain the aesthetic experience.

Table 1. Classification of works in 2013

Type of work	Approx. no. of works	Dominant technologies / materialities
Video installation / expanded cinema	60	Digital cameras, multi-screen, projection, digital editing, glitch.
Audio-visual installation (lighting/sound)	32	Projectors, tone generators, lighting systems, moving objects.
Game art / machinima	11	Video game engines, real-time capture, game interfaces.
Kinetic installation / robotics	32	Motors, metal/lightweight structures, microcontrollers, basic control systems

Source: Author's own elaboration (2026).

The analysis of the typologies presented in Table 1 reinforces this interpretation. The clear predominance of video installation and expanded cinema, with an approximate total of sixty works, positions digital audiovisual media as the structural core of the edition. This is complemented by a significant number of installations based on light and sound projection, consolidating an interest in the physical dimension of the electronic signal. In contrast to this dominant cluster, game art and relational robotic installations appear in smaller numbers yet are conceptually significant in that they introduce—still in an incipient manner—issues related to machine agency, interaction and technological performativity. Overall, the distribution of typologies reveals a biennial still anchored in the exploration of medium and device, while already opening towards shifts that anticipate subsequent developments.

5.2. 2015: Electronics, Networks and the Materiality of Infrastructure

In the 2015 edition, the WRO Biennale maintains video and electronics as central axes of the exhibition discourse yet introduces a significant shift: attention is now directed towards the infrastructure of the Internet and the visibility of data networks as aesthetic and political material. Technology no longer appears solely as an interface or a device for image production but is instead conceived as a distributed system with physical, architectural and territorial presence.

The installation *SIMULACRA* by Karina Smigla-Bobinski (Fig. 3) clearly exemplifies this concern with perception and media materiality. Through an experimental opto-physical project, the work establishes a bridge between technology and the philosophy of vision, inviting the viewer to reflect on the relationship between image, reality and consciousness. The installation experience transforms perception into an active process: the movements of the audience, their interaction with the space, and the relationship between external and internal images reveal how virtuality and reality are configured as perceptual constructions. Technology thus ceases to function as a mere instrument and instead emerges as a mediator of sensory experience, where sensors, light and optical devices operate as materials capable of transforming the spectator's consciousness and imagination.

Figure 3. *SIMULACRA.*

SIMULACRA installation. Source: WRO 2015
(https://wro2015.wrocenter.pl/site/works/simulacra/)

A further group of works deepens this logic by focusing on the architectural materiality of the network. An essay film traverses various data centres located in Art Deco skyscrapers in New York, documenting façades, cabling, ventilation systems and security devices. In this context, technology is no longer presented as an immaterial flow, but as building, cooling systems, copper and optical fibre. Digital cinema here operates as a tool of critical indexing of an otherwise invisible infrastructure, rendering perceptible the physical substrate that sustains global connectivity.

Network culture and online video are also thematised in works that remix aesthetics associated with blogs, tutorials and web interfaces, emphasising the digital camera, streaming and compression as material conditions of the contemporary image. These pieces underscore that digital visuality is shaped by technical protocols, formats and economies of attention that determine both the production and circulation of images.

Sound electronics likewise acquires a specific weight in installations where sine waves and noise interact with physical objects. Loudspeakers embedded within structures, resonant surfaces and exposed cabling become vibrating sculptures, in which the electronic signal—beyond its symbolic representation—manifests as a material force capable of activating and transforming space. In parallel, relational robotics, inheriting from works such as *Vincent and Emily*, remains quantitatively marginal but conceptually significant, consolidating a vocabulary based on motors, metal structures and basic control systems that introduces the notion of "other bodies" within the exhibition ecosystem. Based on these observations, the 2015 edition may be synthesised as follows:

Table 2. Classification of works in 2015

Type of work	Approx. no. of works	Dominant technologies / materials
Video installation / expanded cinema	35	Multiple monitors, HD projection, multi-layer editing, expanded montage.
Essay film / documentary on infrastructure	3–4	Digital filming, direct sound, architectural documentation of data centres or other infrastructure.
Sound installation/sound sculpture	12	Wave generators, loudspeakers, resonant objects, electronic processing.
Kinetic/robotic installation	12	Motors, metal structures, mechanical or electronic control systems.

Source: Author's own elaboration (2026).

The distribution of typologies presented in Table 2 allows these dynamics to be synthesised. Multichannel video installation continues to occupy a central position, with approximately thirty-five works, confirming the persistence of audiovisual media as the dominant support. However, the emergence of essay film focused on digital infrastructures, although limited in number, is significant due to its critical dimension and its capacity to shift attention towards the material substrates of the network. Electronic sound installations and robotic or kinetic proposals display a relatively balanced presence, indicating a growing interest in the physical, vibrational and spatial dimensions of technology. Overall, the 2015 edition marks a clear transition: from technology as a visible device towards technology as infrastructure, anticipating concerns that will intensify in subsequent editions.

5.3. 2023: Embodied Prototypes, Sensitive Kinetics and Immersive Interfaces

In the 2023–2024 phase, the WRO Biennale consolidates three principal technological strands that anticipate the developments of 2025: robotics and small-scale kinetic installations, virtual reality as a full-body instrument, and haptic interfaces mediated through gesture and camera. The installation *FLOCK OF* (premiered in 2023) constitutes a paradigmatic example of the first strand: a school of levitating mechanical fish that transforms into a flock of birds, relying on motors, lightweight structures and programmed control systems to construct a "supernatural nature" in which mechanics emerges as a sensitive material.

In parallel, *The Dancing Princess* by Shota Yamauchi explores the relationship between humans and technology through corporeality and sensory perception. Through gesture, costume and virtual environments, the performers—Tomasz Żurek, Dasha Bogdan and Sofiia Onishchenko—stage a conflictual and affective interaction between humans and technology, integrating video, virtual reality, motion capture and interactive modelling.

In this context, technical media are no longer mere supports but materials that directly shape the form of the work, where the tension between physical presence and technological mediation generates complex meanings concerning addiction, pleasure and the distance between body and machine.

Research into mediated haptic interfaces also occupies a prominent position. The installation *Stay in Touch* by Maryna Khrypun and Valerie Karpan offers an audio-tactile experience that transcends visual perception, incorporating visually impaired audiences and fostering empathy through the exploration of others' memories and perceptions of urban and domestic space. Haptic sensors, interactive systems and auditory and tactile stimuli allow physical contact and interaction to become temporally displaced media events, highlighting the political and affective dimension of technology, particularly in contexts of displacement and the reconfiguration of home.

Small-scale robotic installation, inheriting from works such as *Vincent and Emily*, coexists with these proposals, consolidating a language of motors, lightweight structures and microcontrollers as expressive materials that engage with user experience. Computer vision interfaces and gesture tracking,

together with DIY devices, motion sensors and interactive projection, complete an experimental ecosystem in which technical materiality is articulated with corporeality, sensory immersion and affective interaction, forming a laboratory of prototypes that anticipates the evolution towards more complex systems and AI-based algorithms in the 2025 edition.

Figure 4. *The Dancing Princess.*

Installation: *The Dancing Princess*. Source: WRO 2023
(https://wro2023.wrocenter.pl/en/works/the-dancing-princess/)

These approaches coexist with small-scale robotics—heir to earlier works such as *Vincent and Emily*—and with interactive installations based on computer vision and gesture tracking. In these works, DIY hardware, motion sensors and microcontrollers take on a central role, reinforcing an aesthetic of provisionality and experimentation. Technology is presented as a system in process, closer to a prototype than to a finished product.

Table 3. Classification of works in 2023

Type of work (standardised)	Approx. no. of works	Dominant technologies / materials
Kinetic / robotic installation	12	Motors, metal/lightweight structures, microcontroller control.
Immersive installation / XR / VR	7	VR headsets, tracking, 3D graphics engines, spatial audio.
Interactive installation (gesture, camera, sensors)	26	Cameras, basic computer vision, projection, real-time sound generation
Performance/audiovisual concert (using DIY hardware)	3	Synthesizers, physical interfaces, real-time projection, DIY hardware.

Source: Author's own elaboration (2026).

Table 3 allows this configuration to be synthesised. The relatively small number of kinetic and robotic installations contrasts with their conceptual weight, while VR-based and immersive installations, such as *The Dancing Princess*, introduce a qualitative shift in the relationship between body, gesture and sensory space. Gesture-, touch- and deferred-perception-based installations, exemplified by *Stay in Touch*, together with audiovisual performances using DIY hardware, complete an ecosystem in which the emphasis lies on system behaviour, affective interaction and direct embodied experience.

Overall, the 2023 edition functions as a threshold: technology is no longer centred on large-scale data infrastructures or the visibility of the network, but on mechanical bodies, VR headsets, haptic sensors and consumer-grade cameras. This shift towards the corporeal, the kinetic and the sensory prepares the ground for the 2025 edition, where these explorations will be articulated within more consolidated discourses on agency, perception and the co-evolution of humans and technical systems.

5.4. 2025: Algorithmic Ecologies, Sensitive Matter and Reprogrammable Bodies

The 2025 edition marks a qualitative leap in the recent trajectory of the WRO Biennale, not so much through the introduction of radically new technologies as through the way these are articulated within a dense landscape of relations between data, matter, body and territory. Unlike 2023, where a prototypical logic predominated, in 2025 the works are presented as complex and discursively mature systems, in which AI algorithms, vibration and microwave sensors, environmental databases and organic materials coexist with haptic interfaces and vibratory architectures.

AI-based works move beyond technical fascination towards a critical reflection on the regimes of classification and meaning that structure machine vision. *Kenosofía* employs image classifiers trained to "name" everything captured by the camera, rendering visible not only the materiality of the device—lens, sensor, screen—but also the epistemic violence embedded in labelling systems and the operational ontologies of AI. In a complementary manner, *La biblioteca febril* (*The Feverish Library*) draws on a language model trained exclusively on texts by Jorge Luis Borges, generating textual drifts that foreground the model itself as malleable matter, susceptible to delirium, repetition and excess. In both cases, AI does not appear as a transparent tool, but as a cultural device charged with assumptions, limits and latent imaginaries.

This attention to data systems extends to works such as *Patrones de activación (Activation Patterns)*, where scientific datasets on natural phenomena are processed algorithmically to generate images and sound. The piece simultaneously exposes the poetic potential and reductive violence of the processes of translation and labelling required for nature to become legible to machine learning systems. Data thus emerges as a form of abstract matter, subject to operations of extraction, cleaning and normalisation.

The material dimension is intensified through installations that render visible otherwise imperceptible physical forces. *Proteus 4.1* combines ferrofluid, electromagnets and projection to sculpt magnetic fields in real time; the mutable, glossy black fluid functions as an ambiguous material evoking both oil and blood, articulating energetic, bodily and extractivist imaginaries. Here, magnetism ceases to be an abstract phenomenon and becomes a sculptural gesture and a choreography of forces.

The ecocultural axis acquires particular density in several works engaging with waste, soil and geological temporalities. *Green Grey Black Brown* uses found footage from plastic factories in southern China, accompanied by a slowed-down soundtrack, to construct a form of petro-capitalist science fiction in which oil and plastic operate as landscape, atmosphere and character. In a different register, *El Museo de la Tierra Comestible (The Museum of Edible Earth) and El compost como superalimento (Compost as Superfood)* introduce soil, edible earth and fermentation processes as artistic materials, exploring practices of geophagy and speculating on possible future tastes. Soil, dust and compost acquire here a status equivalent to projection or sound, blurring the boundaries between installation, archive and sensory experiment.

The work *Fósil (Fossil)* deepens this superposition of temporal scales by articulating coal with fern imprints from the Carboniferous period and a sound composition generated through the friction of bones, flint, granite and sand. The piece connects the geological, the organic and the electronic, producing an experience in which the deep time of the Earth intertwines with contemporary technologies of sound capture and amplification.

Within the domain of sensors and invisible infrastructures, several installations shift attention towards energies and signals permeating everyday space. *Temblor (Tremor)* captures vibrations from the WRO Art Center building—produced by trams and geological activity—and translates them into sound and light passing through a reclaimed optical glass block, transforming architecture into a resonant instrument. *Scan* employs a set of rotating antennas to collect signals in the microwave range (Wi-Fi, Bluetooth, satellites, radar) and transform them into a sonic experience, rendering audible a saturated yet normally imperceptible electromagnetic environment. The city also appears as an electrical organism in the drift *Hacia la electrofónica (Towards Electrophonics)* which compiles recordings of transformers, cash machines and ventilation systems, revealing electricity as a kind of sonic skin of urban space.

Mediated corporeality reaches a turning point in this edition. In *NON-BODY*, a digitally controlled acoustic-mechanical apparatus is connected to the dancer's body through prostheses and cables, anticipating movement and translating it into sound. The relationship between human body and machine becomes ambiguous: neither extension nor mere tool, the device acts as an agent co-producing

gesture. Works such as *Tacto del tacto (The Touch of Touch), Sin oír (Without Hearing) and Haptisizer* reconfigure touch and hearing through conductive paint, headphones, signal delay and collective contact, proposing skin and anatomy as reprogrammable and socially shared surfaces. *Piano de línea de puntos (Dotted-Line Piano)* culminates this shift by transforming virtual reality into a full-body instrument: VR ceases to illustrate an experience and instead becomes a compositional medium in which gesture, sound and visual environment form an inseparable continuum.

Table 4. Classification of Work in 2025

Type of work (standardised)	Approx. No. of Works	Dominant technologies / materials
Audiovisual / spatial installation	15–20	Video projection, architectural structures, lighting, multi-channel sound.
Interactive installation (gesture, haptic, sensors)	8–12	Touch sensors, conductive paint, eye-tracking, web interfaces, AI, lightweight VR.
Sound installation / sound sculpture	6–8	Microwave antennas, vibration sensors, computer-controlled organ, loudspeakers.
Video installation (incl. found footage)	5–7	Digital video, industrial found footage, rhythmic montage, multi-channel.
Performance / audiovisual concert	5–7	Live electronics, processing, generative visuals, experimental instruments.

Source: Author's own elaboration (2026).

Table 4 confirms the centrality of installation—including site-specific proposals—as the dominant format, followed by a significant group of interactive and haptic installations integrating sensors, AI and lightweight VR. Sculptural and sound-based installations, together with video installations based on industrial found footage, reinforce a materialist and critical reading of technology. Finally, performances and audiovisual concerts consolidate a space of live experimentation in which electronics, body and environment are co-constituted.

Overall, the 2025 edition may be read as a mature synthesis of the transformations observed since 2013: from the visibility of the technical apparatus to complex ecologies of data, matter and bodies. Technology is no longer merely a medium or infrastructure, but a sensitive territory, an extractive archive and a space of negotiation between the human, the non-human and the machinic.

6. Conclusions

The comparative and diachronic analysis of the 2013, 2015, 2023 and 2025 editions of the WRO Art and Technology Biennale provides museums with a privileged field of observation for identifying emerging trends that may acquire increasing relevance. This evolution cannot be reduced to a simple succession of technical innovations; rather, it reveals a structural shift in artistic discourses, in the materialities activated, and in the position of the spectator within the exhibition device.

In the 2013 edition, technology is presented explicitly as a visible and recognisable apparatus: cameras, projectors, monitors, motors, consoles and microcontrollers constitute both the technical support and the aesthetic material of the works. The experience is articulated around light, glitch, sonic vibration and mechanical movement, configuring a new media paradigm still centred on the transparency of the medium and on direct interactivity between user and device. The spectator is confronted with the functioning of the machine and its tangible materiality, within a logic that privileges the visibility of the technical process.

By 2015, while the predominance of digital video and sound electronics persists, a significant shift can be observed towards network infrastructure as an object of aesthetic reflection. Data centres, mapping services, cabling, telecommunication architectures and data flows begin to emerge as conceptual and visual materials. Technology ceases to be merely an interface and becomes a distributed system, revealing its architectural, political and territorial dimensions. This shift anticipates a critical awareness of the "hidden" materiality of the digital and of the physical conditions underpinning network culture.

The 2023 edition functions as a transitional laboratory. Attention shifts towards kinetics, soft robotics, virtual reality and interfaces based on gesture and camera. VR headsets, tracking systems, mechanical bodies and sensors structure immersive experiences that emphasise the embodied and performative dimension of interaction. However, although system behaviour becomes central, data and

algorithms are not yet explicitly foregrounded as discursive protagonists. Technology is primarily experienced as an environment for action and as a sensory extension of the body.

In 2025, a decisive qualitative leap occurs. Technology is configured as a complex environmental and material system in which artificial intelligence algorithms, microwave sensors, architectural vibration capture, environmental databases and organic materials—soil, compost, fossils and industrial plastics—are articulated in an interdependent manner. AI ceases to operate as an invisible tool and becomes a critical object, revealing its classificatory logics, biases and its capacity to produce meaning. The human body is inscribed within these systems through prostheses, haptic devices and full-body virtual reality experiences, dissolving the boundaries between organism, machine and environment.

This evolution enables the construction of a coherent narrative describing the transition from a "media art" centred on the apparatus to an art of material, algorithmic and ecological systems, in which curatorial interest shifts from the exhibition of devices towards the mediation of complex sensory experiences. Works no longer merely display technology; rather, they produce immersive, relational and critical environments that interrogate the political, ecological and perceptual conditions generated by contemporary technical systems.

From this perspective, the WRO Biennale is confirmed as a leading critical laboratory, comparable—despite historical differences—to the great international exhibitions of the nineteenth century. Its value lies not only in the presentation of experimental works, but in its capacity to anticipate languages, methodologies and issues that will progressively be assimilated into the museum ecosystem. The systematic observation of these transformations offers cultural institutions a privileged tool for understanding the development of emerging technologies and their creative uses in the artistic field.

The study thus provides a useful framework for museums and art centres seeking to critically integrate artificial intelligence, robotics, virtual reality, sensors and hybrid environments. Specifically, it enables them to:

1. Anticipate technological and discursive trends based on artistic practices already tested in experimental contexts.
2. Rethink curatorial strategies oriented towards experience, participation and sensory mediation.
3. Design conservation and documentation models sensitive to the processual, algorithmic and materially unstable nature of these works.
4. Develop educational programmes that approach technology not as spectacle, but as a cultural, political and aesthetic language.

Ultimately, the analysis of the WRO Biennale demonstrates that technological art biennials not only reflect the state of contemporary art but also function as spaces of institutional learning. Their study allows museum institutions to advance with greater knowledge and responsibility in the integration of emerging technologies, fostering a more critical, creative and reflective relationship between art, technology and audiences in the digital age.

7. Statement on the Use of Artificial Intelligence

In accordance with current recommendations on transparency and the responsible use of artificial intelligence systems in academic research (Marescotti, 2023), the tool ChatGPT was used in the preparation of this article in an instrumental and supervised manner. Its use was strictly limited to tasks of stylistic revision—aimed at improving the cohesion, clarity and fluency of the text—and to the preliminary verification of data extracted from the official websites of each edition of the WRO Biennale. At no point did it replace the critical analysis, historiographical interpretation or final writing of the content.

The tool thus functioned as a technical aid intended to optimise the author's manual work, with all information systematically cross-checked and validated by the author. In this sense, the use of AI is conceived as an auxiliary resource comparable to other digital tools commonly employed in contemporary research, reinforcing analytical rigour without undermining authorship, intellectual responsibility or the ethical principles governing academic practice.

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