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FROM PAST TO PRESENT: THE JOURNEY OF TECHNOLOGICAL THEATRE

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This document "From past to present: the journey of technological theatre" is an overview and non-exhaustive treatment of technological theater from the past to the present. It aims to outline the historical and theoretical context necessary for the development of ACuTe, a collaborative project between performing arts and technology.

ACuTe - Culture Testbeds for Performing Arts and New Technology, is an ambitious project dedicated to the modern developments of digital theatre, which unites 14 leading European theatres, universities and art organizations, including Ars Electronica, the European Theater Convention, and Europe's first Academy for Theater and Digitality. The project is co-funded by the Creative Europe programme.

This document is a scan report and tries to show the connections between modern developments and historical predecessors.

– Authors

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1. Introduction

In the context of the Work Package 2 of the project ACuTe – Culture Testbeds for Performing Arts and New Technology, we were researching the history and current practices on the interface between interactivity, performing art, and technology in Europe and abroad. We collected and analyzed data concerning technological innovation in theatre and benchmarked European and international models and practices for theatre and technology integration.

We relied on the theoretical background and drew practically from all five subsections of the theoretical framework of the Benchmarking Plan. As a result, we divided the Benchmark scan report into six (6) chapters:

- 1) History and the contemporary situation,
- 2) Taxonomies of digital theatre,
- 3) Digital technologies in offline performances: digital technologies on stage,
- 4) Telecommunication and performance: online art and mediated performative practice,

- 5) Technological advancements in performing arts: extended reality (XR) and sensor technologies,
- 6) Future visions.

In the first historical part, interwoven with contemporary projects, we tried to establish connections between modern innovations and historical predecessors. We listed digital theatre taxonomies. Parts 3 and 4 are dedicated to digital technologies on stage, offline environment, and telecommunication performance, online theatre, in its historical and contemporary meaning, respectively. Chapter 5 addresses the most radical innovations in the theatre environment that overlap with research projects. The sixth chapter, Future visions, can be understood as an AI-assisted sketch of future developments.

We mainly want to emphasize the close connection of modern developments with historical predecessors. We have pursued dominant themes. In this, we rely on the renowned media art researcher Erkki Huhtamo, who calls his method "*topos archaeology*" and treats the history of media technologies – media archeology – as a "*topos study*".

Here we trace the recurrence of regular elements and the underlying motives that drive the development of media culture.

These recurring motifs are the search for alternative and immersive environments, which is most clearly evident in today's VR applications,

but also in games, meetings, and performances over distances. We can consider these desires archaic, which have been realized thanks to technical progress.

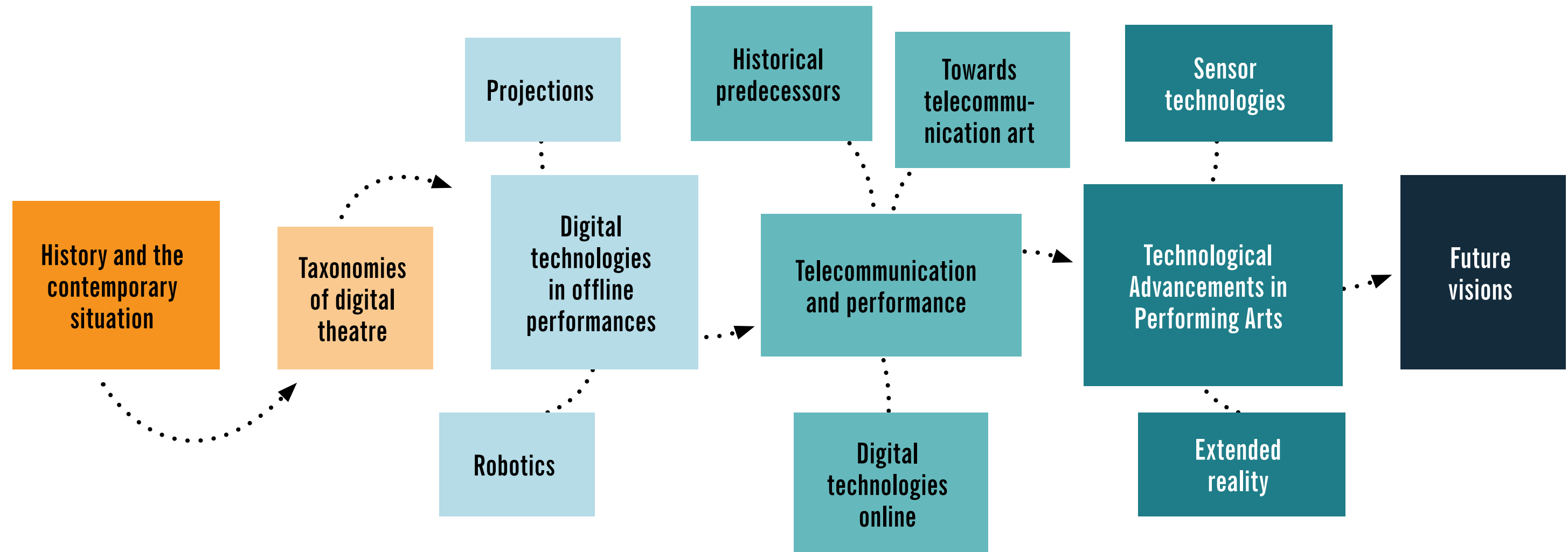


Image 1. Content overview.

2. HISTORY AND THE CONTEMPORARY SITUATION



2.1 The history and practices of virtual environments in art and theatre

Through the centuries, it has been the dream of artists to create a world close to reality. Examples of works of art or architectural environments where the viewer is offered to enter an artificial environment can be cited through several millennia.

The theatre sought to conquer viewers' senses with visual effects and substantive innovations. For centuries, the theatre space has functioned as a source of illusory reality and an environment to travel into imaginary worlds. We could say that the theatre has always been a virtual reality.

The German researcher Oliver Grau's research project is based on the thesis that the illusion of entering a virtual space is not as revolutionary as its campaigners claim. 2002 his book "*Virtual Art*" was published, where he searched for the centuries-old roots of immersive and virtual art.

The primary interest of Oliver Grau's research project [\[1\]](#) is the origin and history of simulation spaces where the experience of image

immersion can be experienced. Such can be found in the European tradition, private architecture, and spaces intended for the general public. The idea comes from the old days and also gathers vitality in the diving strategies of the new virtual art.

Another priority of Grau's research is the metamorphosis that has taken place in our understanding of images. The interface design methods and the possibilities of building interaction have had an explosive effect. Based on this, Grau collaborates with his colleagues in virtual art, e.g., Charlotte Davies, Monika Fleischmann, Maurice Benayoun, Crista Sommerer, and the research centers where they operate. These authors belong to the pantheon of interactive and virtual art, whose names have become well-known in the 90s.

Expanding the art of painting

Modern VR art rests on century-old roots. It is a desire to expand the art of painting, to make it spatial and the paintings three-dimensional.

Several authors can be mentioned here. Augustin Hirschvogel created city views in 1547, simultaneously showing Vienna from the south and the north. Hanns Kautenack painted Nuremberg in a 180-degree

parallel perspective. This led to the simultaneous depiction of four weather arcs in the 18th century: Emanuel Büchel's City View of Basel (1743-1747), J. Jakob Keller's View of Zurich (1778-1783), and H. Keller's circular view from different horizon perspectives in etching technique from the series "View from Mount Rigi" (1807). These artists may not even be well-known now, but they were in the business of combining disparate perspectives, as is also the case in VR environments.

Examples of precursors to VR spaces

We point to some examples that invited viewers into an illusory world. Oliver Grau gives an overview of this in the book "Virtual Art." [2] He points to examples of artificial illusory space that can be found in stately private townhouses and country villas, such as the wall paintings depicting cultic rituals in Pompeii's Villa dei Misteri, where the viewer could feel as if they were in a "virtual" world; the garden frescoes of the Villa Livia (ca. 20 AD); for Clement VI's chamber, the Chambre du Cerf in the papal palace in Avignon; for the Renaissance rooms of illusion -- Sala delle Prospettive in the Villa Farnesina in Rome; for the Sacro Monte di Varallo religious complex in northern Italy.

Historically, illusionistic designs have been used not only for personal fantasy but also for religious or political spectacles.

In 1486, the ever-expanding Ottoman Empire increasingly prevented pilgrimages to Palestine. Since the actual journey to Jerusalem was disrupted, the idea arose to create stops on the Jerusalem journey in their land. The Stations of the Cross were duplicated at the Sacro Monte in Varallo, northern Italy. [3] The author of this famous virtual installation was Gaudenzio Ferrari (1471–1546). His contemporaries admired him in the same order of magnitude as Raphael, Michelangelo, and Leonardo.

The imitation of Ferrari's pilgrimage was supported by the technology of the time and skilled craftsmanship. People could experience the life of Christ from Mary's Annunciation to Christ's birth, crucifixion, and resurrection. The goal was not to create an illusion of a modern Jerusalem, but a perfect rebirth of the holy places described in the Bible. The ascent of the hill was equivalent to a pilgrimage, and at the top of the hill, 11 pictures were passed until the Last Supper, and in 17 pictures, it was possible to experience dramatic events from the Garden of Gethsemane to the Crucifixion. You could also see Mary holding the body of Christ.

It was a Gesamtkunstwerk and mass media project. The observer faced the picture but was "pulled" into this situation. Such participation involved him physically and psychologically in events that had taken place long ago. In the case of Sacro Monte, it is about the beginnings of cinema and virtual theatre. The complex there consists of forty-five chapels and a small church.

But the most striking details, even today, are the windows and lattices through which the composition installed in the chapel can be viewed. Since the grids are of different shapes and the size of the openings varies, sometimes viewing is like peeking and sometimes "poking your head in" because the opening is large enough. Being half-faced in the territory of the installation space, the viewer undoubtedly has the experience of a picture-within-a-state; in any case, it can still be a part of it today. In this way, one "shot" from the life of Jesus is installed in each chapel, and since it can be viewed from different openings, the group presented in the scene becomes a convincing spatial experience.

To these examples can be added the creation of illusionistic space in Baroque art and architecture in the 16th century (Giulio Romano, Paolo Veronese, Andrea Mantegna's room or ceiling paintings), Andrea Pozzo's ceiling painting of Sant'Ignazio Church in Rome, etc.

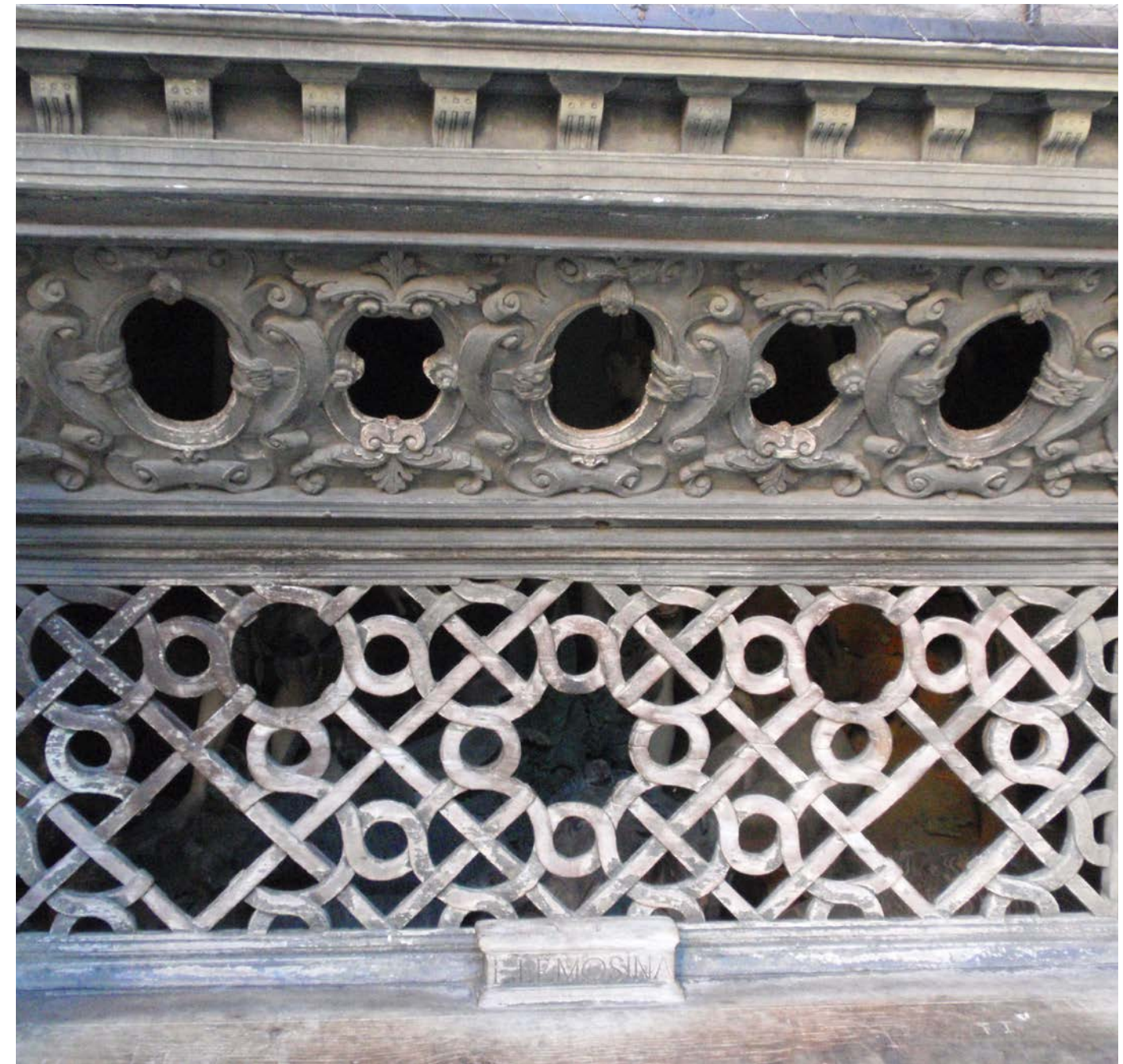


Image 2. The windows and lattices of Sacro Monte in Varallo, through which the compositions installed in the chapels can be viewed. Photo: Raivo Kelomees

The early examples of technical art, interactivity, and theatrical environment should be counted as the surprise fountains of the Baroque and Mannerist eras, as seen in Hellbrunn Castle in Salzburg or Peterhof in St. Petersburg. Their "interactivity" was entertaining, if it was there at all, or rather, nowadays they start to "surprise" by regularly starting up, and in the old days, it was a servant lurking in a bush or around a corner, who pressed the pump or turned the tap on the command of the ruler. But above all, water-powered mini-theatres, bells, and orchestras of birdsong are examples of the engineering art of the time. Today, however, visitors are politely warned about the sudden start of the fountains and advised to hide their cameras just in case. [4]

Panorama as a means of patriotic propaganda

The precursor to modern installation and theatrical painting was the panorama, which was a popular pastime in the 18th century. The panorama was invented by the Irishman Robert Barker in 1787. The panorama looked like a circular painting. The viewer stood in the middle, feeling as if they were participating in what was happening in the painting. The viewer had to move around to see everything. Popular panoramas were cityscapes and battle scenes. [5]

Paintings of battle scenes made up 30% of all panoramas. The client state expressed its joy of victory in this way. Heavy war losses were rarely depicted on panoramas. Many panoramas were made of the Napoleonic wars. In the territory of the former Soviet Union, there is the panorama of the Battle of Borodino, which probably still works today. The panorama of Sevastopol was opened in 1905 for the 50th anniversary of the city's defense in the Crimean War. A separate building was built for it.

Oliver Grau [6] writes that the most expensive and time-consuming panoramas in history have probably been the panorama of the Battle of Sedan created under the leadership of Anton von Werner. It depicted a critical battle of the Franco-Prussian War, which took place on September 1, 1870, under the fortress of Sedan between the French and the Germans. The situation in the battle at half past two was conveyed almost photo-realistically.

The panorama of the Battle of Sedan was opened on September 1, 1883, i.e., on the battle's anniversary. The opening was an important political and media event, which could be compared to Christo and Jeanne-Claude's packing of the Reichstag building in 1995; the public attention to the art event was unusually high.

The authenticity, illusionistic effect, and idealization of the panoramas were put to the service of official propaganda. The style of painting panoramas created an impression of the artist as an eyewitness, a chronicler - a person who can be trusted.

The panorama was an important tool in shaping official political and social history by visualizing contemporary political events. They were used to pedagogically express the official positions of power and to influence people psychologically.

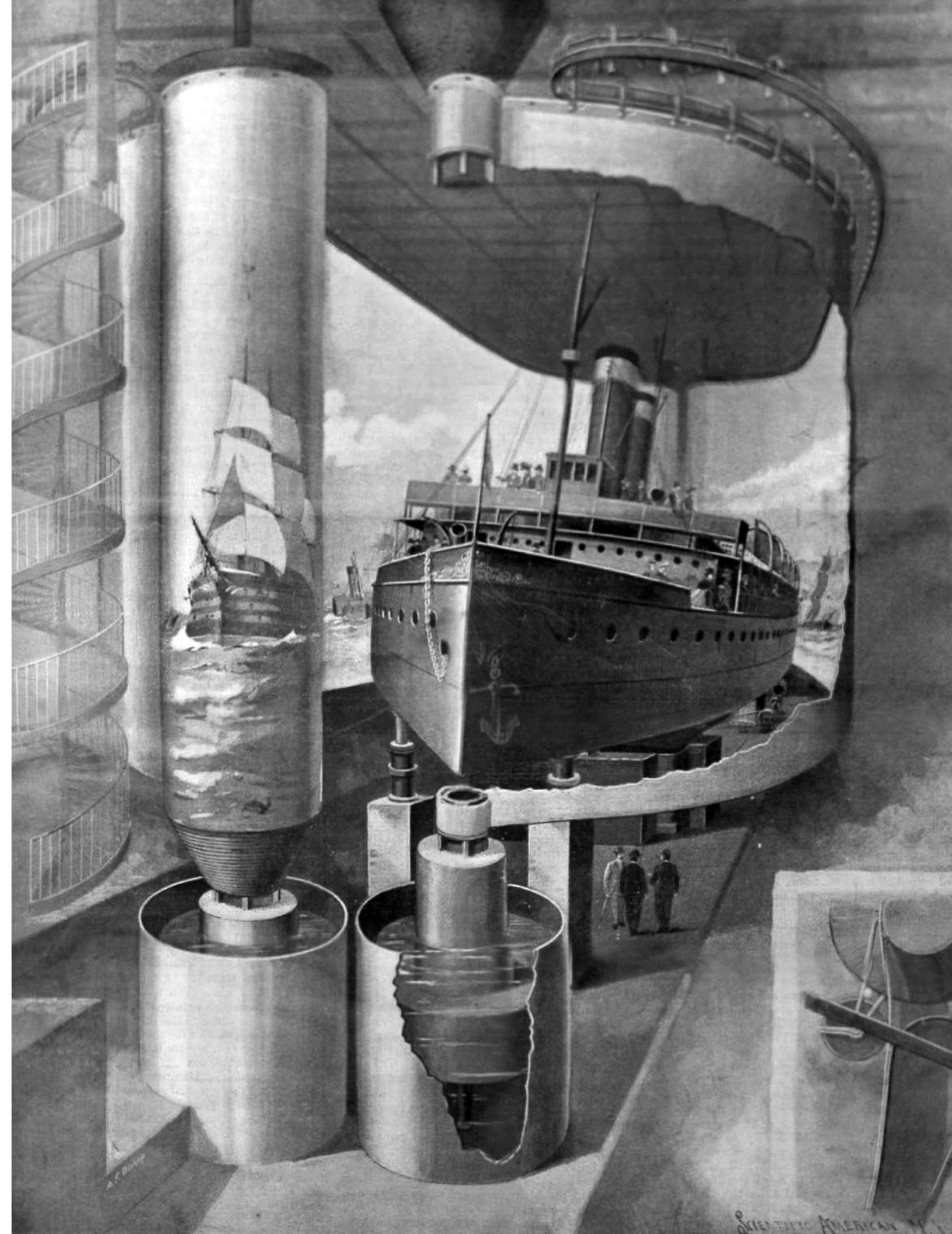
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- [2] Oliver Grau, *Virtual Art. From Illusion to Immersion*. The MIT Press, Cambridge, Massachusetts, London, 2002.
- [3] See also "Il Sacro Monte di Varallo," <https://www.sacromontedivarallo.org/wp/> (accessed May 25, 2023).
- [4] Hellbrunn, FAQ, <https://www.hellbrunn.at/en/info/faq> (accessed May 25, 2023).
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- [6] Oliver Grau, *Virtual Art*, 91–105.

2.2 19th century and beyond: immersive theatre environments and world's fair attractions

Theatre with immersion and technological requests belongs to the era of modernism. It is hardly believable that with the advent of new techniques, new image, and exposure technologies (such as photography, stereo photography, film, electric motors, etc.), they remain unused in theatre practice. It is hardly believable that ambitious and successful theatre directors or composers miss the opportunity to create new types of theatre buildings. Here we can mention Richard Wagner and his Gesamtkunstwerk concept, his work "The Artwork of the Future" (1849), which was a creative unification of multiple art forms: theatre, music, singing, dance, dramatic poetry, design, lighting, and visual art.

Image 3. Illustration of the Mareorama, from *Scientific American*, 1900 ([https://commons.wikimedia.org/wiki/File:Mareorama_\(Scientific_American\).jpg](https://commons.wikimedia.org/wiki/File:Mareorama_(Scientific_American).jpg))



Wagner's immersive requests were to build his theatre, which became the Bayreuth Festspielhaus (opened in 1876). It was designed in the shape of a fan, allowing a perfect view from all seats, avoiding distracting architectural details such as columns, balconies, etc. The viewer could only focus on what was happening on the stage. The orchestra pit was covered.

Wagner used several technical and artistic strategies, such as hypnotic repetitions of the leitmotif and long chords, to achieve an immersive experience.

Stereophotography can be considered the forerunner of virtual reality and immersive technologies. Media researcher Erkki Huhtamo writes about it as the first home media machine with which it is possible to "travel in an armchair." After its introduction at the 1851 World's Fair, it created a frenzy, causing stereosomania. Even Queen Victoria of England was fascinated by stereo photography.

In the 19th century, world exhibitions became places for the introduction of new technological wonders, and they have partly remained so even today. Here we recall Raoul Grimoin-Sanson's "Cinéorama," presented at the Paris World Exhibition in 1900, patented in 1897. It simulated a flight

with a hot air balloon. The spectators were located in a gondola and saw a panoramic view presented around them by twenty projectors. It was a combination of earlier panoramic painting and new cinema technology.

Also, Hugo d'Alesi' "Mareorama" at the 1900 World Exhibition allowed the audience a simulated sea voyage from Nice through Venice to Constantinople. During this, a 13 m high and 750 m long fabric depicting a seascape was unrolled in front of the spectators on the swaying ship. Its author, Hugo d'Alesi, spent a year on board a ship painting different landscape parts. It was written in the papers that hardly anyone can resist the temptation to enjoy a safe sea trip.

Erkki Huhtamo wrote: *"The steamer-platform rested on an elliptical pivot, supported by four hydraulic pistons, which allowed the boat to pitch and roll. ... The seven hundred spectators were free to stroll around, sit on deck chairs, and descend to a dining room. They observed the ship's crew in action, sensed the smell of tar, felt the salty sea breeze, witnessed smoke rising from the funnels, and heard the sounds of a steam whistle."* [1]

Huhtamo wrote that these simulations emphasized movement and dynamism. They used earlier ideas, but still, they weren't moving

panoramas. Artists, inventors, and entrepreneurs tried their best to hide the unoriginality of their ideas.

Reference

[1] Erkki Huhtamo, *Illusions in Motion. Media Archaeology of the Moving Panorama and Related Spectacles*. The MIT Press, Cambridge, Massachusetts, London, 2013, 314.

2.3 Avant-garde of the early 20th century: Futurism, Bauhaus

Futurism, which manifested itself in Italy in 1909, left a striking mark in embracing the technical world. Dixon writes [1] that the performance of Futurism has been neglected in theatre history, although several Futurist manifestos spoke more about theatre than visual art. In 1915 *The Futuristic Synthetic Theatre* was published. “Synthetic” meant that everything had to be scarce. The performance had to be squeezed into a few minutes, into a few words and gestures, innumerable situations, sensibilities, ideas, sensations, facts, and symbols.

The phrase “Time and Space died yesterday” in Marinetti’s manifesto can be seen as a prophecy of cyberspace. [2]

Futurism sought freedom from reality and tradition. Their manifesto calls for destroying museums, libraries, and all kinds of academies, but also a fight against moralism, feminism, and opportunistic and utilitarian cowardice. They see war as world hygiene. Beauty is only in the struggle. No work without an aggressive character can be a work of art. A roaring racing car is more beautiful than the Nike of Samothrace.

They tried to visualize the movement, the speed at which the effects of the moving film image can be guessed. They tried to introduce sound and movement into painting and sculpture. In Luigi Russolo’s painting “Dynamic Automobile” (1912–13), the car has turned into an abstract arrow. In Umberto Boccioni’s painting “The Street Enters the House” (1912), the street is partially visible through the female figure on the balcony in the foreground, which illustrates their “X-ray” method. The images were broken down into constituent parts due to movement or the influence of other images. Giacomo Balla’s painting “Abstract Speed + Sound” (1913–1914) is more of a non-representative abstract composition, where “sound” indicates the presence of an auditory dimension that the viewer should imagine. The musical is Giacomo

Balla's "Violinist's Hand or Violinist's Rhythm" (1912), with reproduced images of a violinist's hand.

These works express the desire to expand art, to cross boundaries, and to include sound and movement in visual art that was not there before. Moreover, Carlo Carra's manifesto "La pittura dei suoni, rumori, odori" (The Painting of Sounds, Noises and Smells, 1913) contains rather a synesthetic appeal to link visual forms: "... sounds, noises and smells can be concave, convex triangular, ellipsoidal, oblong, conical, spherical, spiral, etc." [3]

Filippo Tommaso Marinetti enthusiastically describes in 1921 in the "Manifesto of Tactilism" how he invented "tactilism" the previous year while swimming naked in Antignano. He tries to categorize different tactile experiences, in which one can again sense the synaesthetic, that the tactile experience is related to temperature or visibility. He also confirms that he made "tactile boards," which he presented to the audience at a conference dedicated to the art of touch. [4]

Anton Giulio and Arturo Bragaglia tried to record time with photography innovations "chronophotography" or "photographic dynamism." Various temporal moments were represented in the painting with a diversity



Image 4. Luigi Russolo's painting "Dinamismo di una Automobile" (1912-13). Musée National d'Art Moderne, Paris (https://commons.wikimedia.org/wiki/File:Luigi_Russolo_dynamism-of-a-car-1913.jpg)

of visuals, as we can see in Marcel Duchamp's painting "The Nude Descending the Stairs" (1911). The Futurists tried to visualize the movement, from which the film's effects can also be guessed. The undulation of the sound waves was depicted as concentric circles,

reminiscent of how they are depicted in cartoons. An attempt was made to translate what was perceived in one sensory modality into another modality, which is, after all, synesthesia.

Günter Berghaus has devoted an article to synesthesia in futuristic theatre ("Futurist Theatre as a Synaesthetic Experience, 2017). [5]

Berghaus notes that in his manifesto "La cromofonia: Il colore dei suoni" (Chromophony: The Color of Sounds, 1913), Enrico Prampolini tried to explain that all vibrational phenomena in the atmosphere can be received as chromatic stimuli. That sound and color should not be understood as isolated phenomena but are synesthetically related.

Dixon finds in Enrico Prampolini's 1915 manifesto "Futurist Scenography" "luminous stages and virtual bodies in exactly the forms that we now see them, almost a century later.

The stage is "...colorless electromechanical architecture, powerfully vitalized by chromatic emanations from a luminous source." [6]

Dixon sees earlier manifestations of interactivity in the activities of futurists: "Futurist innovations in the use of simultaneous, parallel action

on stage (which borrowed cinematic techniques) can equally be related to interactive theatre forms and performance CD-ROMs which present the user with options on what to choose to focus on and follow." [7] In Prampolini's manifesto "Futurist Scenography" (1915), Dixon also sees the non-tolerance of human actors. He writes that today we can see this in the emergence of Synthesians - these are artificial people on the screen. Prampolini's 1915 manifesto also addresses the futurist theatre's concern with interactivity, which has since become a central tenet of digital culture.

Marinetti's "The Variety Theatre Manifesto" (1913) proclaims collaboration with the audience: "The Variety Theatre is alone in seeking the audience's collaboration. It doesn't remain static like a stupid voyeur, but joins noisily in the action. . . communicating with the actors in surprising actions and bizarre dialogues." [8]

It would also be appropriate to refer to Ruth Markus's articles "Futurist Scenography: From Revolutionary Theory to Practice" [9] and "Light and Dynamism in Futurist Art and Scenography. The realization of Futurist theories in art and on stage." [10]

Among early 20th-century innovators, performance researcher Steve Dixon mentions Loïe Fuller, who created modern dance choreography in 1889 and used projectors and shadow effects, continuing to experiment until 1923 (died 1928).

Also, Vsevolod Meyerhold suggested breaking up the box-like stage to achieve a dynamic effect where there would be no difference between the different audience classes. Meyerhold also advocated the "cinematization" of the theatre.

According to Dixon, futurism lays the philosophical and conceptual foundation for contemporary digital performance; constructivism provides a mathematical model and formalistic methodology; other European avant-garde movements (Dada, surrealism, expressionism, and Bauhaus) offer plenty of artistic inspiration in terms of style and content. [\[11\]](#)

A complete turn away from the contingent proscenium can be seen in the theories of László Moholy-Nagy and the visions of other authors, such as Andreas Weininger's "Spherical Theatre," Farkas Molnár's "U-Theatre," Walter Gropius's "Total TheatreTheatre."

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- [2] Steve Dixon, *Digital performance*, 49.
- [3] Carlo Carra, *The Painting of Sound, Noises and Smells*, 1913, <https://www.unknown.nu/futurism/paintsoun d.html> (accessed June 12, 2023).
- [4] The Manifesto of Tactilism by FT Marinetti, 1921, http://peripher a lfocus.net/poems-told-by-touch/manifesto_of_tactilism.html (accessed June 12, 2023).
- [5] Günter Berghaus, "Futurist Theatre as a Synaesthetic Experience." In: *Prospective culturali fra intersezioni, developments and svolte disciplinary in Italia e in Ungheria*. Ed. by Ilona Fried. Conference organized by the Department of Italian Studies of the Faculty of Letters of the Eötvös Loránd University, Budapest, in collaboration with the Italian Institute of Culture in Budapest, 3-4 May 2017. Budapest: Ponte Alapítvány; Eötvös Loránd Tudományegyetem, Bölcsészettudományi Kar, Olasz Nyelv és Irodalom Tanszék, 2018, pp. 297–312.
- [6] Steve Dixon, *Digital performance*, 54.
- [7] Steve Dixon, *Digital performance*, 49.
- [8] Marinetti's *The Variety Theatre Manifesto*, 1913, <https://writingstudio2010.files.wordpress.com/2010/09/variety-stage.pdf>
- [9] Ruth Markus, "Futurist Scenography: From Revolutionary Theory to Practice", *Assaph 15, Studies in the Theatre*, Tel-Aviv University, 2000, (153–163).
- [10] Ruth Markus, "Light and Dynamism in Futurist Art and Scenography", *Assaph 9, Studies in Art History*, Tel-Aviv University, 2005. (First version published in *Scenography International*, 5, "Tradition and innovation", 2002).
- [11] Steve Dixon, *Digital performance*, 67.

2.4 Experiments with screen technology on stage and in exhibition space (1950s and later)

Here we present some categories where there is evident play between physical actors and the virtual screen content (from the 1950s to the present day). Examples are from the theatrical environment to the media and digital art environment:

1) Actors in physical space and screen-space are acting in collaboration or antagonism between each other.

During the 1950s and 1960s, multi-screen projections were met with excitement, and they later developed into immersive screen environments. The Czechoslovakian “Laterna Magika” staged during the 1958 World’s Fair in Brussels is worthy of mention, being described as a new media show and the first multimedia theatre. Director Alfréd Radok and scenographer Josef Svoboda collaborated to create a performance that combined ballet, theatre, film projection, and a sound environment.



Image 5. Czechoslovakia’s “Laterna Magika” at the World’s Fair in Brussels in 1958. (<http://www.medienkunstnetz.de/works/laterna-magika/images/2/>)

The activity/performance in the foreground was perfectly synchronised with multi-screen projection in the background to produce the interaction effect between the two. This gave the impression that the film had come to life and was reacting to the performance. [1]

There are plenty of related examples in contemporary technical and digital performances, for example, Tmema's (2003) "Messa di Voce," in which actors influence the visuals on the screen. [2] What previously required rehearsal and careful planning (mutual collaboration) is today achieved quite easily with the help of visual sensors and the use of programming.

To illustrate the imaginative movement between screens and reality, we may call on examples from visual art. A famous and often-used story is that of Pygmalion and Galathea, in which the sculptor falls in love with his creation and asks God to transform the artificial being into a living body. Interpretations include paintings by Louis Gauffier 1797, Ernest Normand 1881, Jean-Léon Gérôme 1890, and many others. This myth has also been used to illustrate interactive art. However, this phenomenon has two sides: reviving the non-living artwork and permitting the real spectator to enter the artificial environment.

Returning to "Laterna Magika," it is interesting that the success of the performance in Brussels paved the way for establishing a professional theatre in Prague bearing the name "Laterna Magika," which still exists today.

2) Viewers are influencing and directing the screen content: screen environments that surround viewers are gradually changed into environments shaped by users/viewers.

The 1967 EXPO in Montreal featured the most important participation film in the history of interactive cinema: Radúz Činčera's "Kinoautomat" or theatrical cinema, where viewers were able to change the plot direction of the movie by pushing a red or green button on their seat. Historically speaking, it is the most important experiment of this type to which researchers are constantly returning. [3] For our discussion, the salient point is that viewers could participate in decisions about the directions of the cinematic story. This category could contain the majority of interactive artworks in which something happens between the viewer/user and the moving image. Radúz Činčera's "Kinoautomat" is one of the earliest examples of interactive cinema.

3) Viewers or actors are "in the image": viewers or actors are corporeally in the image or influencing it directly.

Here we can start with several examples, including Tmema's previously mentioned "Messa di Voce" (2003), most of Paul Sermon's telematic work ("Telematic Dreaming," 1992; "Telematic Vision", 1992, etc.),

Myron Krueger's "responsive environments" from the 1970s, and Dan Graham's installations using a delayed image. Also included would be installations of the 1970s by Bruce Nauman, Peter Campus, and Peter Weibel, Jeffrey Shaw's "Video Narcissus" (1987), and many others.

Experimentation with screen and performance was evident in the 1960s, raising the question of whether earlier experiments like "Laterna Magika" influenced later artworks. We can talk rather about a trend made possible by technology. For instance, in Robert Whitman's screen-based performance "Prune Flat" (1965), a woman in white was mimicking the movements of a woman represented on screen. Whitman was arguably the first who brought film projection into sculptural environments with his "Shower" (1964), in which a naked body was projected onto a shower curtain. Whitman mentioned that he was influenced by childhood memories of the clown Emmett Kelly's performance in which he tried to sweep up a searchlight that would move or get smaller. [4] Similar techniques of connecting physical objects with images could be encountered in Tony Oursler's works from the 1990s until now. [5] Also, Nam June Paik, in collaboration with Charlotte Moormann, realised many versions of a piece in which Moormann was connected to working television monitors, or she played the "cello" formed by three television monitors.

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2.5 Digital theatre and immersive installations in the 1990s and later

The digital performance researcher Steve Dixon [1] discusses the British theatrical group Moving Being which, as a multimedia and theatrical collective, staged performances in the 60s and 70s in the UK. The group was created as a collaboration between actors, dancers, and musicians with the help of film and video. Dixon's group Chameleons was devoted to stage performances using screens and projections – the Chameleons multimedia performance research company was created in 1994 at the University of Salford in the UK.

In their 1994 project “Chameleons: The Dark Perversity of Chameleons,” five actors in their bedrooms were situated on stage. Televisions in the same room reflected their dreams and hallucinations. Every actor had a system of movements – four physical movements which were repeated and borrowed from each other. The subsequent (1996) project “Chameleons 2 – Theatre In A Movie Screen” featured actors moving between screen and stage – the screen was supplied with windows and doors through which actors could pass. An interactive CD-ROM of the performance was produced, serving as documentation and a

meta-analysis of the performance. Even more complicated was the performance “Chameleons 3 – Net Congestion” (2000), in which the audience gave instructions to the actors via the Internet. According to Dixon (at a presentation made at DRHA2015 in Dublin), this attempt was unsuccessful and remained only in the form of an experiment.

The experience of “Chameleons 2” is comparable with the Estonian performance “Estonian Games. The Wedding” at the Von Krahl Theatre, staged practically simultaneously in 1996 in Tallinn. The screen was used similarly: the screen functioned as a character, co-actor, and a surface through which actors and the choir could move. It was touched, opened, and closed directly and physically and was equally an object, a mediator of distant reality, and a participant in the narrative.

A discrete categorization could emerge here, which would investigate interactive dance environments in which the goal is to develop specific hardware and software to facilitate the creation of devices (shoes, clothes, etc.) that permit dancers to influence sounds or the visual environment around them. This category of digital theatre and “cyberformance” would include several groups such as Troika Ranch, [2] Dumb Type [3], and others. [4]

Special attention should be directed to visual environments where the goal is not only to immerse the viewer in a multisensorial environment but also to influence the viewer kinesthetically, vibro-acoustically, and unconsciously. The goal here is not only to involve the senses in the perceptive act but rather to involve the whole body – since physical reactions are important to the perception of art, these reactions themselves could become the artistic goal. An illustration of this is the group Granular Synthesis (the Austrian artistic duo Ulf Langheinrich and Kurt Hentschläger) who created several multiscreen, acoustically marginal, and physically challenging environments during the 1990s in which the viewer was surrounded by four (or many more) screens with approximate sizes of 3 x 4 meters showing visuals with low-frequency sound that induced physical discomfort. [5]

Ryoji Ikeda's projects "Supersymmetry" (2015), "The Planck Universe [micro]" (2013), and "Test Pattern [n°5]" (2013) are also worthy of note. These projects truly challenge the viewer's perceptive ability and physical tolerance.

One contemporary direction lies with virtual environments such as the CAVE or VR-Cube in which the viewer is surrounded by stereoscopic images, which give a feeling of immersion. Examples like this shift the

notion of multi-screen environments to the extreme. This is particularly true of the six-sided CAVE (VR-Cube) at the Royal Institute of Technology in Stockholm. Here the viewer is surrounded by six walls covering 360 degrees, one of them being the floor. The environment is used for design and technology research and a few artistic and architectural projects (Teresa Wennberg realised several). [6] The impressions produced are so powerful that audiences in the cube grab each other's clothes to keep their balance while "flying" over architectural representations – it is well-known that to maintain balance, we need adequate visual feedback from the environment around us.

Tactile and proprioceptive interaction

Regarding physical image environments, there is a long history of conceptual, entertainment, and research activity aimed at inventing spaces with the ultimate immersive potentiality. Our interest lies in observing those artworks and their contextual elements based on tactile and proprioceptive interaction. Concerning corporeal feedback affecting changes connected with the presentation of content, an example is Orit Kruglanski's (2000) poetic and interactive multimedia project "As Much As You Love Me," which deals with the issue of guilt. [7] As an additional physical interface, a so-called force-feedback

mouse is placed on a steel plate, and on-screen non-apologies are displayed encrypted as symbols accompanied by the words “don’t forgive me,” etc.

Many historical and classic projects of digital art could be mentioned here in which corporeal contact with the artwork takes place, for example, Lynn Hershman Leeson’s “Deep Contact” (1984), Monika Fleischmann’s “Liquid Views” (1992), Christa Sommerer and Laurent Mignonneau’s “Interactive Plant Growing” (1992) and “A-Volve” (1994), Thecla Schiphorst’s “Bodymaps: Artifacts of Touch” (1996) as well as many others. These projects are distinct from ordinary hand-controlled projects that use a mouse or button-based device because they make interacting with the content much more physical. In Hershman Leeson’s project, the user can touch an image of a woman’s body using their hand – something considered extraordinary during the 1980s when the project was done.

In other projects, sensors and electrical conductors react to the user’s actions or force. As a result, there is not only a tactile but a haptic relation to the content of the artwork. Erkki Huhtamo, for example, distinguishes between tactile and haptic feedback. Nevertheless, the terms are used synonymously. Tactile is associated with physical touch,

whereas haptic involves physically perceptible feedback (vibration, shock, etc.). Haptic is, in Huhtamo’s interpretation, connected with a much bigger physical engagement. [8]

The viewer’s collaboration occurs manually and involves the upper body and physical behavior – the viewer can experience different tactile and multisensorial sensations, such as touching plants or water.

Immersive environments and biofeedback

In the following examples, the viewer’s bodily or physiological information influences his behavior in the room or relation to the installation objects. It is important here that the viewer’s biological information is recorded by the corresponding sensors (such as Heart Rate Variability, HRV, Galvanic Skin Response, GSR, etc.)

In discussing projects involving perception via the whole body, we can find a sequence of examples in which the artwork’s environment perceptually embraces the viewer. The artist TeZ (2008) does this in his work “Optofonica Capsule”: the viewer places their head inside a capsule which gives an experience of “tactile sound” combined with audiovisual sensations. Vibrations are transferred through

the floor where the viewer stands, and which is connected to the audio environment.

The performative environment “Ilinx” by Chris Salter, TeZ, and Valerie Lamontagne (2014) offers its audience an intensive visual, auditive, and tangible experience. Participants wear specially designed equipment and clothes fitted with sensors. The performance lasts around twenty minutes, during which the audience experience sound, visuals, and vibrations, producing a total corporeal experience radically different from typical everyday experiences.

In this context, we would like to mention Pia Tikka’s (2008) Ph.D. thesis and her “Enactive Cinema” project shown in Kiasma, Helsinki, in 2005. [9] In this piece, the cinematic narrative of an interactive movie entitled “Obsession” was manipulated through participants’ heart rates and skin conductivity.

Finally, in this category, we would like to point to Sean Montgomery’s (2010) installations “Emergence biofeedback art installation,” “Vital Threads Biofeedback Apparel” (2011), and “Telephone Rewired” (2013), all of which employ biofeedback and achieve attractive and entertaining results. [10]

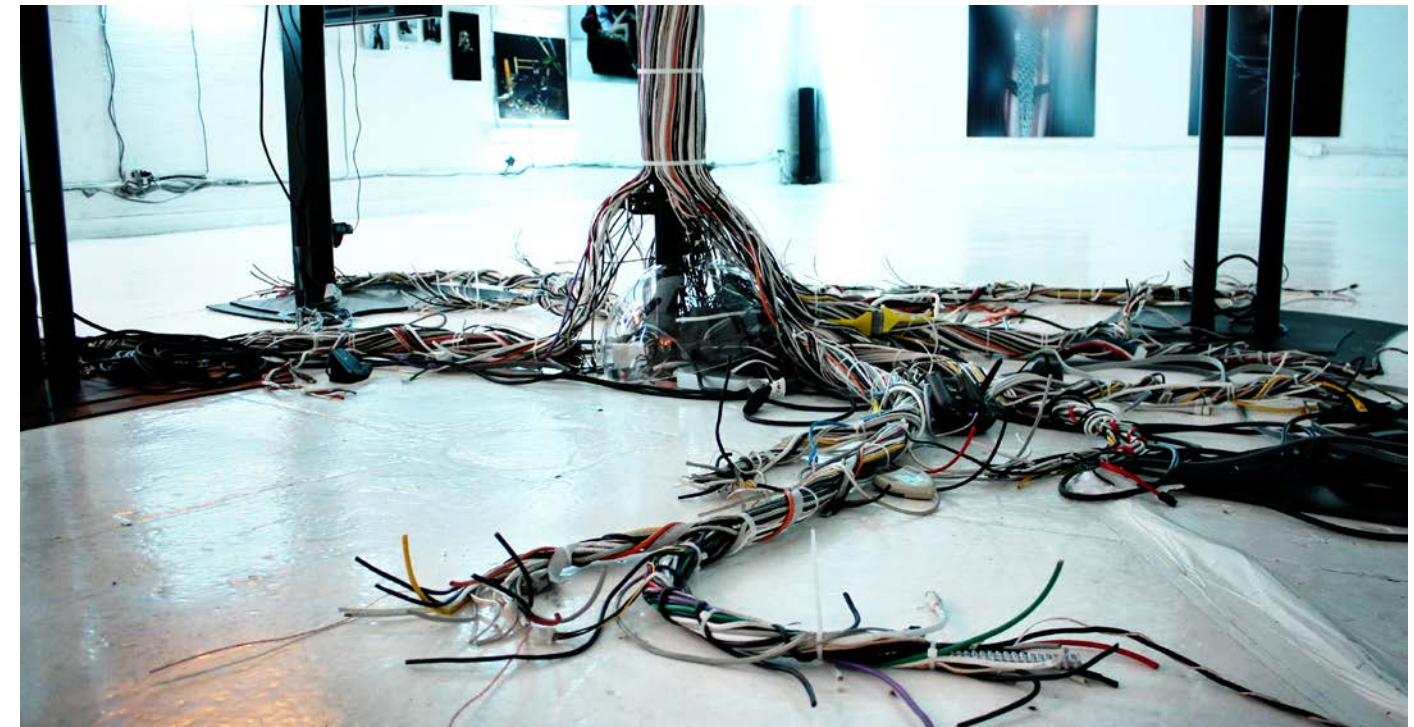


Image 6. *Emergence*, 2010, Sean Montgomery, Diego Rioja, Mustafa Bağdatlı, wires cables circuits connectors, 315 x 400 x 400cm. Copyright: Sean Montgomery.

All the mentioned projects are physical installations in a space that the viewer enters or where the viewer’s behavior in that environment determines the performance of the artwork. Chris Salter, TeZ, and Valerie Lamontagne’s project create a fully immersive environment where the viewer is separated from the usual perception of the outside world; the viewer is an actor in a self-created scenario. Adapting all these attractive installations to a theatre or stage environment would not be much of a challenge without a suitable script.

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2.6 “New aesthetics” and post-digital performance: blending of the virtual and the real (2010 and later)

Four terms should be discussed here that are related to each other. They express the penetration of digital culture into all areas of life and illustrate digital normality: post-digital, post-internet, “New Aesthetic,” and “post-digital performance.”

Post-digital

Florian Cramer wrote about post-digital in 2014: “The prefix ‘post’ should not be understood here in the same sense as postmodernism and post-histoire...”. [1] This means that post-digital is not after digital; it is also during it. He also writes: “... the term ‘post-digital’ in its simplest sense describes the messy state of media, arts, and design after their digitisation... But post-digital is also “anti-new media.” Cramer: “... post-digital stands in direct opposition to the very notion of ‘new media.’” [2] Post-digital eliminates the distinction between “new” and “old” media in theory and practice. Post-digital means moving away

from the fascination with digital technology as it was at the beginning of the digital age; it means making a critical sense of digitality and understanding its social, cultural, and political dimensions.

Post-internet

Post-digital parallels the post-internet phenomenon. It is about turning to diverse physical materiality in artistic practice.

There is also an ironic hypothesis: that the whole post-internet art movement can be viewed as a reaction against the specially skilled, cognitive demands of technical art and simultaneously accommodate the system of contemporary art: producing physical artifacts. [3]

The term post-internet was first used by Marisa Olson in 2006. As the editor of the net portal Rhizome, she held quite an influential position. While producing her projects, she saw post-internet as the phenomenon of 'internet-engaged art,' or net-influenced visual art. Olson's updated view on post-internet (in 2014) was: "Today, I use the term more broadly to think about the social conditions of life in network culture."

[4] Christiane Paul has expressed his critical view of the phenomenon: "While I don't like the term post-internet, I don't think it has hurt the mainstream art world. Post-internet works fare much better on the art market than 'new media art' per se. Still, I think this success can be attributed more to the fact that it largely takes the form of objects rather than the post-internet discussion." [5] Since there is also the phenomenon of "internet art" in the art world, there is an assumption that post-internet art is related to it, but this is still problematic.

From post-internet works, Cory Arcangel's "Super Mario Clouds" (2002) is cited, where he removes all elements of the well-known video game Super Mario except for the blue sky background and the drifting clouds; Amalia Ulman's "Excellences & Perfections" (2014), was a social media-directed project in which Ulman played the role of a stereotypical Instagram trendsetter, exploring fake identities, self-image, and the influence of the medium in today's society. Katja Novitskova, who in 2010 published "Post Internet Survival Guide: How to Survive in the Internet Age", should be mentioned. Novitskova's message concerns the attitude towards the digital age, the techno-biological reality, and the possible future worlds.

New Aesthetic

James Bridle initiated the concept of the New Aesthetic on his blog (<https://new-aesthetic.tumblr.com>) in 2011, where he started gathering images and things that seemed to identify a new future aesthetic. The term describes the increasing presence in the physical world of such visual phenomena rooted in digital technology and the internet. James Bridle has explored the mixing of the effects of the digital environment with tangible reality, giving examples of objects by Shawn Smith and Douglas Coupland. They are sculptural and made as if from pixels, real cubes. Bruce Sterling wrote: "The New Aesthetic concerns itself with 'an eruption of the digital into the physical.'" [6] New aesthetics and visual language spring from the digital environment, glitch art, pixelation, data moshing, and generative algorithms.

Post-digital performance

The "post-digital performance" concept emerged in the 2010s and refers to blending the virtual and the real in artistic practices. Technological advances and the widespread use of digital tools and platforms often facilitate this blending. The term "New Aesthetic" is related to this.

Post-digital performance is naturally hybrid, using objects and technology from the physical and digital worlds. The lines between the virtual and the real are blurred. Post-digital performances use projections, interactive media, virtual reality (VR) and augmented reality (AR) devices, and other immersive technologies to create a unique and multisensory experience for the audience.

Examples of post-digital performance include both theatrical performances and participatory installations where the viewer becomes a part of the art environment, for example:

Marshmallow Laser Feast: A London-based collective that combines art, technology, and science to create immersive experiences using VR, AR, and interactive installations. Their project *Evolver* is a collective virtual reality experience that drops audiences deep inside the landscape of the body, following the flow of oxygen through our branching ecosystem, to a single 'breathing' cell. Through this transcendental narrative, it becomes clear that breath sparks life and connects us to the natural world through the cycle of respiration. [7]

Ryoji Ikeda: A Japanese artist known for audiovisual installations exploring the intersections of sound, data, and perception intersections.

Memo Akten: A Turkish-born artist and AI researcher who creates interactive installations and performances that explore the relationship between humans and machines.

The Creators Project: A platform and collective that showcases artists' work pushing the boundaries of technology and creativity, often featuring projects that blend the virtual and the real.

TeamLab: An international collective of artists founded in 2001 in Tokyo. Digital environments are created where the viewer, surrounded by dynamic and interactive visuals, is absorbed into the musical environment.

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3. TAXONOMIES OF DIGITAL THEATRE

3. Taxonomies of digital theatre

While the usage of digital technologies in theatre has been extensively examined, there is no comprehensive taxonomy to categorize these uses effectively. Scholars have proposed diverse frameworks, but these often intersect and lack universal agreement due to the complex integration of digital elements with traditional theatre. Consequently, the categorization of digital theatre remains a multifaceted and evolving field of study, with no definitive, all-encompassing classification scheme established to date.

The various taxonomies offered by Katie Hawthorne [1] , Burnett [2] , and Elena Pérez [3] underline the dynamic interplay of digital technologies in the realm of theatre. We can map this multilayered interaction into three principal categories: digital technologies in offline performances, digital technologies in online performances, and audience engagement/co-creation.

In the first category, digital technologies in offline performances, Perez’s idea of multimedia theatre and Burnett’s concept of space intensification intertwine. This involves using digital technologies like

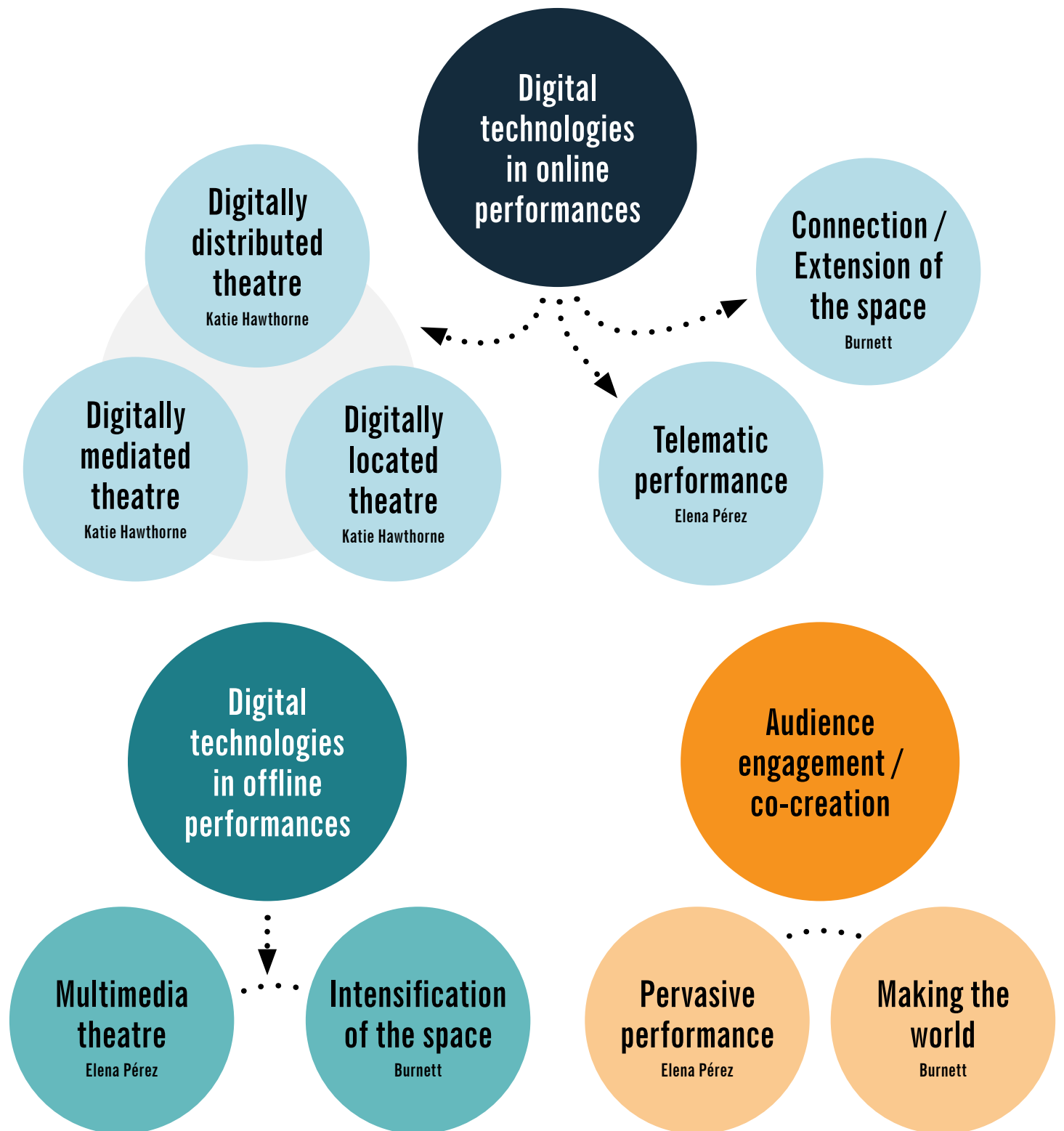


Image 7. Schema of taxonomies by Katie Hawthorne, Burnett, and Elena Pérez.

film, video, or computer-generated visuals to enrich the visually defined theatrical space and the audience's experience. It encompasses aspects of projection technologies, sound, and interaction and may include artificial actors.

In the second category, digital technologies in online performances, Burnett's concept of space connection/extension and Perez's telematic performance converge. This is where Hawthorne's notion of digitally aided theatre also fits (Katie Hawthorne's categorization of digital theatre underscores three key modes of engagement with digital technologies: *digitally distributed, digitally mediated, and digitally located theatre*), as this category is defined by using digital technologies to bridge physical gaps, enabling theatre performances to occur in and extend to remote digital spaces, including online platforms, chatrooms, and telecommunication technology.

The final category, audience engagement/co-creation with the audience, comprises Perez's *pervasive performance* and Burnett's concept of "making the world." Here, the theatre environment becomes a platform for participant experience and production. Pervasive performance as a mixed-media event engages audiences in participatory events by integrating gameplay, media, and performance. This also involves

leveraging digital media to create immersive experiences, stimulating participant involvement.

In conclusion, the evolving utilization of digital technologies in online and offline theatre shows a promising trend toward creating more engaging and immersive experiences for audiences, whether remote or present in the physical theatre space. This interweaving of technology and artistry contributes to the innovative transformation of the theatre environment, shaping it into an intensively interactive and participant-centric space.

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**4. DIGITAL TECHNOLOGIES
IN OFFLINE PERFORMANCES:
DIGITAL TECHNOLOGIES
ON STAGE**

4.1 Robotics on stage and in theatre performances

When talking about robots and creature-mimicking mechanisms on stage and in the context of performances, we should start with the Heron of Alexandria mechanical devices, which preceded the technical revolution by more than a millennium. His aeolipile (*Hero's engine*) was powered by steam. In "Pneumatics," he describes the wind-powered organ. Heron also designed mechanisms for the theatre. Heron's findings are considered the beginning of cybernetics research.

Automata were precursors to mechanical theatre and robotics. Made in the 18th century, these mechanical dolls entertained the wealthy but also showed the ingenuity of the masters. Among them were dancers, acrobats, and instrumentalists. Similar devices could be seen on other continents besides Europe; Japanese Karakuri's history goes back to the 7th century. Automata is "a machine or control mechanism designed to automatically follow a predetermined sequence of operations or respond to encoded instructions." [1] One of the most famous masters is the French watchmaker Jacques de Vaucanson. His duck was able to drink, eat and chew. Pierre Jaquet-Droz, writer (1774), musician,

and draftsman, made them all in thousands of copies. They are still on display in Switzerland at the Neuchâtel History Museum.

Hungarian engineer and inventor Wolfgang de Kempelen attracted attention with *Chess player* (Mechanical Turk), which he introduced to Empress Maria Theresa in 1769. It was a fraudulent project; inside this automaton sat a real person who knew how to play chess and controlled the puppet. This machine was demonstrated for 84 years until the secret was revealed. He played against Napoleon and Benjamin Franklin and visited most European courts. Kempelen also designed manually operated speech machines.

19th-century visual and theatrical entertainment formats include moving panoramas: cycloramas, myrioramas, cosmoramas, etc. The various mechanical theatre formats, such as *the eidophysicon* created by the French painter Philip James de Louthembourg (1781), are notable. It could be considered a scientific theatre of natural phenomena, the reconstructions of which are still being created today. [2]

Edison's "The Talking Doll" (1890), which Edison himself called a "little monster" and which also played a short phonograph, is recalled here. It was a failed commercial venture. [3] We owe the term "robot" to Karel

Čapek's play "RUR (Rossum's Universal Robots)," published in November 1920. The real author of "Robot" is Karel's brother Josef, a painter. [4]

In modern performances with mechanical characters (robots), the visual appearance of the equipment can range from schematic to imitating living creatures. Creative fields where an artificial being is used include digital installation art, public actions, and conventional theatre environments where one of the characters on the stage is an artificial creature.

Speaking of robotic installations, Garnet Hertz's "Cockroach Controlled Mobile Robot #2" (2005) [5] illustrates the attitude in contemporary creative practice. The project is externally installation and performative but internally exploratory and an attempt to introduce biomimetic ideas, being the subject of future applications in military robotics and why not also in the field of art.

Nam June Paik made *Robot K-456* (1964-1996). He staged the performance "First Accident of the Twenty-First Century" on a New York street where a robot was the victim of a car accident.

Petra Gemeinboeck & Rob Saunders's "Accomplice" (2013) could be mentioned among the installation projects. The installation transforms

the traditional relationship between the audience and artwork such that visitors to the space become performers for the machine. [6]

Mari Velonaki's "Fish – Bird" (2014) robotic installation also deserves a mention. [7] Viewers can move between two motorized wheelchairs that print notes indicating intimate proximity to each other as if communicating. One can conclude that the work demonstrates that we do not need identifiably human actors as guarantors of meaning and intimacy. This example illustrates that pursuing anthropo-mimetic resemblance in robotic performances does not always mean the transmission of meanings. In this way, Velonaki deconstructs robotics. [8]

In connection with this work, we can mention earlier projects that belong to the classics of digital art. Norman White's "Helpless Robot" (1987-96) asked visitors to take him elsewhere. Simon Penny's "Petit Mal" (1993-96) reacted to gallery visitors by chasing them and moving away. His goal was to create a completely autonomous work of art that would perceive space, respond to people, and give the impression of intelligence. [9] Ken Rinaldo's "Autopoiesis" (2000) also reacted to the presence of the audience. The viewer was in a constantly changing performative space, surrounded as it were by "hands" that wanted to touch the viewers. [10]

Several production projects are based on the work of authors who are dedicated researchers and whose works are in the context of production projects and digital art exhibitions and festivals. This can be said for Louis-Philippe Demers, Bill Vorn, and also Stelarc.

Demers has defended his doctoral thesis on his experiments. [11] Demers/Vorn's most extreme, participatory performance, "Inferno," pushes the boundaries of robotic performance quite far, as viewers are placed in exoskeletons, where the movements of a few dozen volunteers are controlled and synchronized to techno-industrial music.

In the 1990s, Stelarc pushed the boundaries of art events by staging robotic performances. His "Exoskeleton" (1997) is a six-legged walking robot powered by 19 pneumatic actuators and controlled by Stelarc with the movements of his arms. Stelarc's projects are on the border of art forms: robotic performance, body art, and telecommunication art. Work like "Third Ear" was born in cooperation with professional plastic surgeons.

The name of Hiroshi Ishiguro, who has presented his android at festivals but has collaborated with theatre professionals, has been attracting attention in digital art and theatre circles for years. Oriza Hirata's

Sayonara II (2011) gave birth to *robot-human theatre*, where Ishiguro got the perfect opportunity to experiment with his robots.

Stefan Kaegi's "Uncanny Valley" discusses the strangeness of humanoid robots by bringing an android to the stage. On stage, a robot actor performs as the animatronic twin of screenwriter Thomas Melle. [12]

Marco Donnarumma's practical and research activities are noteworthy. He has added a body part controlled by artificial intelligence to his stage characters, one of which he plays himself.

In his work "The AI Prostheses" (2020), he writes: "Through combined research on movement, dramaturgy, sound, and technological engineering, each of the works in the cycle combines human bodies, robotic hardware, machine learning software, and microorganisms into a particular 'configuration'." [13]

Dries Verhoeven's "Happiness" was a performance in a unique building resembling a public toilet and pharmacy hybrid. Visitors interacted with a humanoid robot, discussing drugs to manipulate emotional reality by altering brain chemicals. The work explored the convergence

of robotics and pharmacology, allowing for the reclamation or transcendence of our human state through synthetic substances. [14] Robotics on stage and in the exhibition environment is an open chapter. Technology is developing and offers more and more opportunities to create autonomously functioning devices. It is impossible to fully cover existing theatre production or research projects dedicated to robotics. However, we can see that although perfectly functioning stage androids have not yet been created, schematic solutions also offer opportunities for rich conceptual experiments. Here, one can only agree with what Eckersall, Grehan & Scheer wrote earlier [15] that human-like actors do not always guarantee meaning and intimacy.

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4.2 Evolution of projected imagery and interactivity in theatre

The advent of projection technology can be traced back to the 17th century with the emergence of the Magic Lantern. This early image projection system used a light source to project hand-painted or photographic glass slides onto a screen or wall. This primitive yet fascinating device, consisting of a light source, lenses, and a mechanism for slide transition, can be considered a precursor to modern projectors. [\[1\]](#)

The 19th century saw the introduction of a remarkable visual illusion technique – Pepper’s Ghost. Named after English scientist John Henry Pepper, this method manipulated light and reflection using a semi-transparent, angled sheet of glass or plastic to create ghostly apparitions. Pepper’s Ghost technique has since been adapted in various contexts, including stage performances, “holographic” displays, and theme park attractions. [\[2\]](#)

The integration of film into theatre can be traced back to 1904, not long after the invention of cinema. This innovation profoundly influenced

theatrical performances, sparking debates between advocates for a ‘poor theatre’ that prioritized actors and performances and proponents for a theatre enhanced by technology. [\[3\]](#) Aristotle’s argument for managing visual aspects in tragedies by stage technicians, not playwrights, further fueled this discourse.

The 1950s and 1960s saw the exciting emergence of multi-screen projections that eventually transformed into immersive environments, exemplified by the groundbreaking Czechoslovakian multimedia production “Laterna Magika,” which debuted at the 1958 World’s Fair in Brussels, where director Alfréd Radok and scenographer Josef Svoboda created an innovative blend of ballet, theatre, film projection, and sound.

The late 20th century witnessed a seismic shift in projection design with the advent of digital technology. Facilitated by the increased availability of personal computers and advancements in processing speeds, digital projectors, computer-generated imagery, and sophisticated software ushered in an era of detailed and dynamic projection mapping. This leap in technological capabilities broadened the horizons of theatre companies, including those that previously lacked the financial means to utilize complex technical possibilities.

Interactivity was another groundbreaking addition to the theatre. Developments in motion tracking and interactive technology enabled performers' movements to manipulate projected images in real-time. This category, often called digital theatre or "cyber-performance," encompassed groups like Troika Ranch or Dumb Type. Another example of this approach is "Mortal Engine" by Chunky Move (2008), a performance where aesthetics and kinetics interacted through the computational expertise of Frieder Weiss. Hiroaki Umeda's "Intentional Particle" (2015) further showcased the convergence of interactive projections, real-time camera tracking, and generative visuals, creating a captivating experience for audiences.

The 21st century saw many artists initiate extensive experimentation with video mapping, highlighting its potential as an essential tool in contemporary digital art and design. In this flow of the digital revolution, projection mapping emerged as a powerful tool for storytelling, creating immersive experiences and generating illusionary effects beyond the physical restrictions of the target structure. These projections could be cast onto objects as complex as industrial landscapes or as intricate as small indoor objects and theatrical stages, transforming them into unique display surfaces.

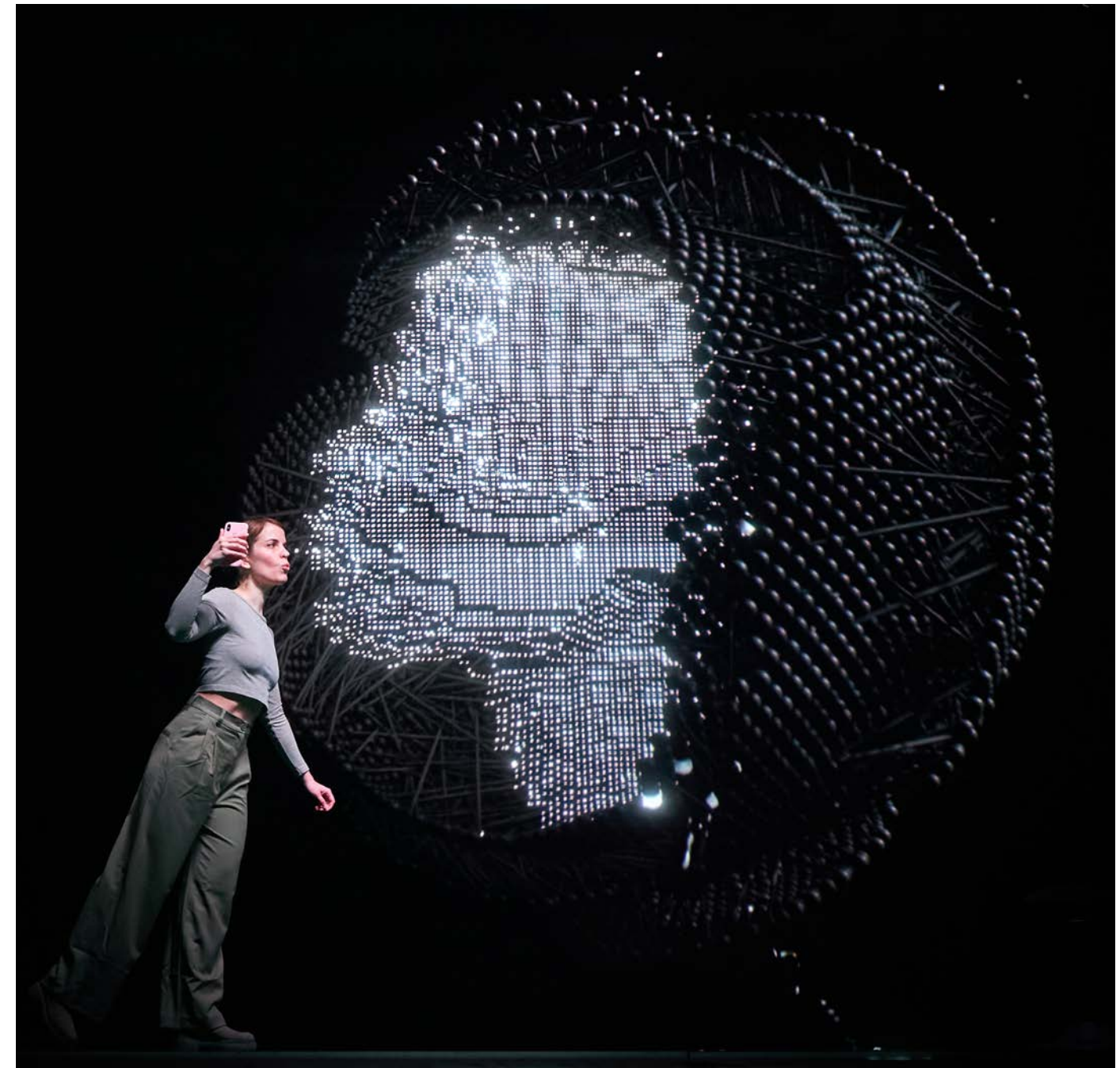


Image 8. *SH4DOW* by Mikael Fock.

The emergence of software frameworks, such as QLab, Notch, MadMapper, and TouchDesigner, significantly accelerated the evolution of theatrical projections. These platforms provided user-friendly interfaces facilitating complex sequences orchestrating visual, audio, and interactive cues. Moreover, they supported real-time video processing, intricate animation, 3D mapping, and interactive engagement with performers and audiences.

Contemporary performances such as "DÖKK" by FuseWorks and "SH4DOW" – An AI Performance in 3D by Mikael Fock epitomize the transformative impact of technological advancements in performing arts. "DÖKK" combined real-time performance with various interactive technologies to create a unique experience for each performance. "SH4DOW," an AI-centric performance, showcased a special "4D Box" stage – a modern version of Pepper's Ghost technology – allowing mixed-reality illusions, highlighting the advanced interplay between performer and machine.

In conclusion, the evolution of projection technology in theatre reflects the continuous interplay between art and technology, from the simplicity of Magic Lantern to the complex interactivity of today's digital technologies.

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**5. TELECOMMUNICATION
AND PERFORMANCE:
ONLINE ART AND MEDIATED
PERFORMATIVE PRACTICES**

5.1 Historical predecessors

Fairy tales and myths express the dream of being present across distances. Technical development has provided the means to reach beyond real distances. If we recall the optical telegraph of the 18th century, important messages for governance were conveyed through it. Distant vision technology was photography and stereo photography. The imaging technologies of the 19th century brought distant sea battles, shipwrecks, geysers, and volcanic eruptions to people. Imaging technology gave the viewer the ability to see into the distance.

Several inventions remained fictional, such as the *telephonoscope* attributed to Edison, which can be considered an early concept of the videophone and television, can be seen in George du Maurier's 1878 cartoons. The invention of the telephone by Alexander Graham Bell in 1876 enabled the emergence of the *electrophone* and *theatrophone* a few years later.

Alexander Bain's *phototelegraph* (1843), which scanned the original line by line, should be classified in the history of telecommunications.

In 1863, Italian physicist Giovanni Caselli sent pictures between Paris and Lyon with a *pantelegraph*. These were early fax machines.

The Theatrophone network in Paris was introduced in 1881 by Clément Ader at the International Exposition of Electricity. It made listening to performances and concerts possible without being in the opera house. The Théâtrophone Company provided service to subscribers. The company placed coin-operated theatrophones in hotels, cafes, and clubs. The company went out of business in 1932 as radio broadcasts and the phonograph supplanted the old medium.

This example reveals the normalization of the remote theatre experience more than 100 years ago and the fate of all innovative technologies: they are supplanted by even more modern ones.

Radio, the "new media" of the first decades of the 20th century, launched euphoric visions of the future. In 1921, the Russian futurist Velimir Hlebnikov proposed to turn the radio into a "spiritual sun of the country," which was supposed to unite people and the country, heal the sick with hypnosis and increase labor productivity. Bertolt Brecht wrote in 1932 that the radio must be changed from a broadcasting device to a communication device, not only for receiving but also for sending.

In the 1930s, Italian futurists (Filippo Tommaso Marinetti and Pino Masnata) fantasized about a metal body that would be made alive by faraway mechanical impulses. Marinetti wanted to increase the sensitivity of the body using radiophony. It was hypothesized that the senses of touch, taste, and smell could be amplified to the point where stimuli could be received from great distances. [1]

László Moholy-Nagy's "Telephone Paintings" (1922) are cited as a forerunner of telecommunication art. He ordered the same painting in three different sizes from the sign factory. He wrote: "... I had the factory's color chart before me, and I sketched my paintings on graph paper. At the other end of the telephone, the factory supervisor had the same kind of paper divided into squares. ..." [2]

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5.2 Towards telecommunication art

The late 1960s saw several exhibitions that introduced the use of computers in the exhibition environment: 1968's "The Machine: As Seen at the End of the Mechanical Age," organized by Pontus Hultén at the Museum of Modern Art in New York; "Cybernetic Serendipity", 1968, curated by Jasia Reichardt; 1969 "Art by Telephone" at the Museum of Contemporary Art Chicago; 1970 "Software, Information Technology: Its New Meaning for Art" curated by Jack Burnham at the Jewish Museum in New York.

A peculiar format in the 1960s and 70s was the provocations and interventions of artists on television. They could be understood as tele-actions. These are works of communication carried out across distances, with electronic audiovisual means, a kind of performative proposal. Video artists interpreted television as a dominant medium, against which the artists came out with their decollages and "viewer-provoking" actions.

In 1969, Nam June Paik's video "Electronic Opera No. 1" contained written instructions "close your eyes" and "open your eyes" appearing

on the screen from time to time, which should require active reception. The viewer was involved in the performance and made aware of their consumer behavior. It was another attempt to break the normative pressure of the mass media and give it back its communicative function. [1]

In 1973, Hans Ortlieb conducted a 30-minute program on Austrian television to overcome the alienation barrier between the viewer and the TV, in which he asked the viewers to turn the TV on and off in time with their breathing rate.

1975 Kit Galloway and Sherrie Rabinowitz founded “Aesthetic Research in Telecommunications.” Their Satellite Arts Project ’77 was the performance “A Space With No Geographical Boundaries.” Their goal was: “To demonstrate (for the first time) that several performing artists, all of whom would be separated by oceans and geography, could appear and perform together in the same live image (The image as a place).” [2] At that time, satellite communication was the only way to transmit television images over long distances.

The artists performed several telecollaborative dances and performances, exploring new future art forms. In 1982, within

the framework of the ART-COM laboratory, students, based on performance, tried to learn and comment on their experiences “living in” a composite-image space. The students tried to complete common tasks and performed theatre sketches imitating life situations with their fellow students in another campus area.

Galloway and Rabinowitz’s best-known project was “Hole in Space,” a 3-day public communication sculpture between New York and Los Angeles in November 1980. Residents of both cities began to use the unexpected communication channel spontaneously, talking, singing, and gesticulating with each other. [3]

Galloway and Rabinowitz’s “art and communication event” “Electronic Café” (1984) has gone down in the history of communicative art. Five restaurants in Los Angeles during the 1984 Olympics created an opportunity to interact with texts, drawings, photographs, and poems. *Low-scan* television equipment, computer terminals, printers, and video cameras were helpful. The fact that the restaurant owners set aside tables for this was a great welcome. [4] They exchanged each other’s pictures, performed in front of the cameras, and wrote poetry.

The use of satellite links during the 6th Documenta in Kassel, Germany, is worth mentioning.

Douglas Davis's performance "The Last Nine Minutes" was performed at the exhibition's opening on June 24, 1977. Performances by Nam June Paik and Joseph Beuys preceded him.

Roy Ascott's "La Plissure du Texte" (The Pleating of the Text) was executed in 1983 during the Electra exhibition organized by Frank Popper for the Museum of Modern Art in Paris. The Ascott project was an asynchronous fairy tale written by different authors worldwide using the IP Sharp time-sharing system: participants logged on with portable terminals and posted their contributions, made from the perspective of the role or identity they selected from a repertoire of fairy tales.

The 1980s can be considered the time of the development of telecommunication projects. The aesthetic specificity of communication art, which is related to its technical nature, affects the creation and reception of the work more than before. The specialty lies in creating an event instead of a material object: a real-time network of human relationships without geographical limitations, new temporal-spatial

relationships, and interactivity designed by the artist, which enables creative communication. [5]

Eduardo Kac wrote: "Telecommunications art, on the whole, is, perhaps, a culmination of the reduction of the role of the art object in the aesthetic experience..." [6]

To describe the manifestations in the 1990s and later, we mention three prominent artists who have contributed to telecommunication art and whose works are characteristically performative: Stelarc, Paul Sermon, and Rafael Lozano-Hemmer.

Stelarc's "Fractal Flesh" (1995-1998) [7] took place at the "Telepolis" event in Paris, and users could move Stelarc's real body through the Internet while being in Helsinki (Media Lab, University of Design), Amsterdam (Conference "Doors of Perception") and Luxembourg. Users in different European countries could give small electric shocks to the muscles via the Internet, which caused Stelarc to make involuntary movements, thus manipulating the artist's body and seeing the result on the computer screen. Stelarc's later performances include prosthetics, robotics, VR, and AI.

One of Paul Sermon's most famous works, "Telematic Dreaming" (1992), is a telematic video installation that connected two rooms with beds. On the bed was a living image of a partner who could be thousands of kilometers away. The clear projection of another person who can react almost in real time to the viewer's movement in bed was very convincing. Sermon said his goal was to broaden the user's senses: there was no way to touch a virtual bedmate. [8] "Telematic Dreaming" triggers the performative action of the viewers; they lie on the beds and "harass" the images projected on each other's beds. Sermon's activity is consistent and rich; the performative element is always present in his works. [9]

Networked performance and interactivity have been discussed by Johannes Birringer using the terms "networked dance" and "distributed choreography." [10]

Lozano-Hemmer's name and works are considered synonymous with the concept of "relational architecture." The artist prefers this wording as opposed to "interactivity", and he also prefers the idea of "connected architecture" to virtual reality and virtual architecture. [11]

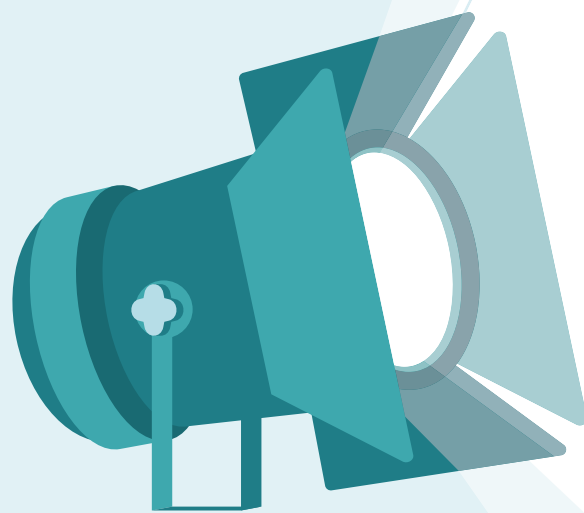
"Vectorial Elevation" used Mexico City's central Zocalo square and an internet site. Eighteen searchlights were placed on the roofs of the buildings around the square, the light beams of which were visible for more than 15 kilometers.

Eight hundred thousand website visitors from four continents could design their beam configurations. They made light sculptures displayed from 6:00 p.m. to 6:00 a.m. from December 26 to January 7, 1999–2000. Thus, the project involved robotic floodlights, the internet, the architectural environment, and users' participation worldwide. The physically present observers were passive, but the web surfers were active – Lozano-Hemmer proposed the term *telecreation* to describe the process. Lozano-Hemmer did similar projects in Lyon and Dublin. [12]

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5.3 Digital technologies in online performances: from stage to screen

Digital technology in the performance arts industry has proven to be a revolutionary game changer. Part of it is transitioning from the physical stage to virtual platforms. This chapter explores this transformative shift, its contributing factors, and its impact on the theatrical landscape.

In 2006, the Metropolitan Opera introduced *The Met: Live in HD*, a series of performance transmissions shown live in high-definition movie theatres worldwide, followed by National Theatre Live (NT Live) launching its digital cinema broadcasts in 2009. These pioneering initiatives brought global audiences closer to the stage, sparking a rising interest in digital theatre.

Recognizing the potential of this shift, performing arts institutions worldwide acknowledged the need for comprehensive digital strategies. Simon Mellor emphasized that for such strategies to be effective, they needed to be endorsed by leadership, prioritize user and audience data for decision-making, and involve individuals responsible for strategic planning and progress evaluation. [1]

The onset of the COVID-19 pandemic in 2020 illuminated the necessity for a digital strategy in the performing arts. The ETC study "Digital Theatre – Digital Strategies and Business Models in European Theatre" [2] revealed staggering increases in digital ticket sales and roles in European theatres, with a significant percentage of theatres agreeing on the positive impact of digital theatre on staff skill development.

Integrating digital technology into the performing arts introduced new challenges and opportunities, such as the need for high-quality streaming platforms, adequate education and training, increased funding, and audience engagement strategies. These needs and opportunities have given rise to different forms of digitally aided theatre, as suggested by Kathie Hawthorne [3], which can be categorized into three subsets: digitally distributed theatre, digitally mediated theatre, and digitally located theatre.

Digitally distributed theatre involves broadcasting performances from their original locations to remote audiences. It challenges traditional notions of time, space, and duration in theatre and redefines the concept of liveness. In addition to the previously mentioned, The Met and NT Live, projects promoting digital theatre are Digital Theatre

(UK) and Prospero - Extended Theatre, which spotlights the fusion of film and theatre aesthetics.

Digitally mediated theatre enhances the audience's experience during a performance using digital technologies. It includes using smartphones, tablets, apps, and hybrid theatrical experiences that combine live performances with virtual or augmented reality elements. Edith Kaldor's interactive live performance "Parallel Life" (2021) is a notable example, even though it happened in the streets, not in a classical theatre setting.

Digitally located theatre comprises performances specifically designed to occur in digital-first environments. Platforms like Zoom and social media sites like Instagram, Facebook, and TikTok became unconventional spaces for artists to connect with audiences. An example is Paul Sermon's "Collaborative Solutions for the Performing Arts: A Telepresence Stage" [4], which pioneered a new approach to collaboration for remote performers.

Additionally, social media performances could also be considered as digitally located theatres. Marion Siéfert's Instagram Live performance "_jeanne_dark_" (2020), Rimini Protokol's Zoom performance "Call Cutta at Home" [5], and Liis Vares' streamed desktop performance "Kõik Loeb/The reader" (2020) are significant instances of such innovation.

The COVID-19 pandemic has created a fertile ground for digitally aided performances. Theatres have come to recognize the necessity of digital modernization, artists have come to appreciate the new possibilities offered by digitally mediated performing arts, and audiences have come to realize the novel and awe-inspiring theatrical experiences they can enjoy without having to venture outside their homes.

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6. TECHNOLOGICAL ADVANCEMENTS IN PERFORMING ARTS: EXTENDED REALITY (XR) AND SENSOR TECHNOLOGIES

6. Technological advancements in performing arts: extended reality (XR) and sensor technologies

The field of performing arts is experiencing a technological renaissance with the introduction of Extended Reality (XR), encapsulating Virtual Reality (VR), Mixed Reality (MR), and Augmented Reality (AR). These innovations reshape the domain, create immersive experiences, and provide unique artistic possibilities.

At its core, theatre has always been a form of Virtual Reality; it creates a fictional world through acting, narratives, spatial design, costumes, light, and sound manipulation. Integrating VR, MR, and AR in immersive theatre reimagining storytelling by eliminating physical limitations, expanding audience reach, and enhancing performance accessibility. Still, the adaptation presents challenges, demanding comprehensive technological understanding, adaptability, and exceptional improvisational skills from creators and performers.

Immersive theatre experiences like "All Kinds of Limbo" (2020) by Raffy Bushman and Nubiya Brandon, and "Dream" (2020) by The Royal

Shakespeare Company are setting a precedent in digital theatre, blending traditional performing arts with VR and gaming technology. Simultaneously, projects like "In the Eyes of the Animal" by Marshmallow Laser Feast, and "Frankenstein" (2019) by the National Youth Theatre of Great Britain are pioneering the use of VR headsets, providing audiences with a unique perspective.

The use of browser-based VR platforms like Mozilla HUBS, A-Frame, or Spatial.io is also gaining popularity, facilitating the creation of social VR spaces and simple performative environments accessible through a web browser. Also, the Theatre of Virtual Reality - Cyberrauber aims to bridge the realms of theatre and VR.

Parallel with the advancements in XR technology, sensor technologies are also coming to the forefront. Sensor technologies used in theatre can be divided into two major categories: 1) external analysis of performer or audience movement and 2) internal physiological processes of performers or audience members during a performance.

In the previously discussed solutions in interactive projections, camera sensors were primarily used to analyze the 2D image, extracting the necessary data that was subsequently mapped onto MIDI or OSC protocols to control various video effects, soundscapes, and lighting

modifications. The evolution of 3D cameras (Kinect, iPhone, and iPad) and motion capture (MoCap) systems such as Rokoko, Xsens, Perception Neuron, Manus, etc., allows creators to blend physical bodies with virtual avatars and create hybrid performances. Integrating generated environments using game engines like Unity or Unreal Engine adds a new dimension to these performances.

But thanks to the notable growth of the field of physiological computing, the interaction possibilities in theatre have tremendously expanded. Artists have historically used physiological data, such as heart rates, electrodermal activity (EDA), and electroencephalogram (EEG) measurements, in their works. This approach gained momentum in the 1960s and became more prominent in interactive theatre since the 1990s.

BCI (brain-computer-interface) artworks have seen significant growth post-2009, facilitated by the emergence of low-cost EEG BCI devices like Emotiv EPOC, Emotiv Insight, Muse, and NeuroSky Mindwave. [1] Artists have primarily used these devices for digitally mediated outcomes, resulting in many immersive works straddling virtual and augmented reality, such as "Hidden Rooms" and "The Mnemonic Body" by Allan Dunning.

Furthermore, physiological sensors measuring electrodermal activity have inspired audience-focused experiments in theatre. These non-intrusive sensors enable the exploration of quantifiable audience engagement data during performances. For instance, Taavet Jansen and Aleksander Väljamäe's "Neurochoreography No. 5" project visualized real-time audience EDA signals, where spectators' arousal was mapped to sound-design loudness during the performance. [2]

In conclusion, the union of XR and sensor technologies in performing arts presents an exciting and pioneering shift. Integrating these advanced technologies expands creative possibilities and enhances audience engagement and experience, promising a new era in performing arts.

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7. FUTURE VISIONS



7. Future visions

To clarify future visions, we turned to artificial intelligence (Chat GPT (Model GPT-4)) and made a request: "Write me 5 bullet points how digital technologies will enhance performing arts within the next 10 years:"

These 5 subdivisions were as follows:

- 1) Immersive and Interactive Experiences (Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) technology),
- 2) AI and Machine Learning in Creativity,
- 3) Blockchain and NFTs for Digital Rights Management,
- 4) Remote Collaboration and Performance,
- 5) Enhanced Accessibility and Inclusivity.

Understandably, text generators are not completely reliable. Somehow, we discussed these five topics above. Accessibility and inclusion are included in online performances, carried out numerous times during COVID-19.

The main purpose of the previous was to place contemporary developments in a historical context. If we look at virtual reality, inclusion, or the use of remote technologies, they all have earlier artistic, technological, and cultural antecedents. We can also see cultural "ripples" around digitality: it is no longer novel and is intersected with traditional practices or materials. We see this in "post-digital" developments.

It is important to note that the presentation here is not final or exhaustive. It does not deal with important theatre areas such as sound, lighting, etc. They, too, are influenced by digital technology. Many technologically demanding theatre phenomena remain at the level of experimental or research projects; they do not become mainstream. In that sense, what is presented here also maps the brightest manifestations that have caught the authors' attention.

ACuTe

ACuTe, co-funded by the Creative Europe programme, is a pioneering digital theatre project across Europe. Project aims to transform the way theatre and performing arts are created and presented using emerging technology and new forms of cultural collaboration and competence development. The project involves a collaboration of 14 leading theatres, universities, and creative arts organizations, including Ars Electronica, the European Theatre Convention, and Europe's first Academy for Theatre and Digitality. These organizations, from 10 different European countries, will work together to develop new approaches and models for testing new technology, leading to audience development, co-creation, and capacity development within the performing arts and theatre industry.

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