4

Intermedia Stages of Virtual Reality in the Twentieth Century: Art as Inspiration of Evolving Media

The desire *to be in the picture*, in both the metaphorical and nonmetaphorical sense, did not disappear with the panorama but lived on in the twentieth century. In this chapter, I shall follow the ways in which 360° images continued and entered developing new media and art trends. Further, I shall look at how visions or utopias, that is, the desire to produce art, interweave with actual attempts to realize new media for illusions.

In connection with its commission on the panorama, in 1800 the Institut de France suggested developing a smaller-scale apparatus, which would also create a panorama-type illusion and shut out distractions of the environment. The stereoscope, invented in 1838 by Charles Wheatstone and improved in 1843 by David Brewster,[1] was an apparatus that fulfilled these criteria. It utilizes our physiological ability to perceive depth of field: Two eyeglasses arranged as far apart as the eyes, the binocular parallax, allow the combination of two images taken from viewpoints a small distance apart. The stereoscopic view results from a system of mirrors and gives the observer an impression of space and depth. In 1862, Oliver W. Holmes and Joseph Bates began to market an inexpensive model of the stereoscope, and by 1870, it had become a standard piece of furniture in middle class homes. Modernized versions were available well into the twentieth century (fig. 4.1).[2]

Monet's Water Lilies Panorama in Giverny

It is perhaps surprising that modern painters intent on abstraction should have utilized image spaces encircling the observer to reduce the distance between image and observer. Claude Monet, for example, spent decades searching for ways to fuse the observer and the image. The triptychs, Iris, Saule pleureur, Agapanthus, and Nuages, painted between 1915 and 1917 and each measuring 12.75 m by 2 m, created "the illusion of a single continuous canvas":[3] a complete panoramic view of Monet's water lily lake (fig. 4.2). To begin with, Monet planned Nymphéas as a proper panorama for a garden rotunda lit only by daylight from the glass roof. However, its first public exhibition in 1927 was as eight series of images displayed in two rooms of an orangery at Giverny, the Musée Claude Monet.[4] Although this mode of display also aroused associations in contemporary visitors of being "submerged" in a lake,[5] Monet's original concept intended to avail itself of the far more effective illusion medium of the panorama. Monet's water lilies, floating on the wind-ruffled water that reflects the changing

Figure 4.1 Achromatic stereoscope. 90 × 120 cm, ca. 1860. Smith, Beck, and Beck, London. By kind permission of Gerhard Kemner.

colors of the sky, have lost almost all distinct contours. The artist's intention was to locate observers within the watery scene, not "submerging" them in water, but immersing them in an image space with an indeterminate perspective: *floating* above the water's surface, without distance, confronted on all sides by the 360° images.[6]

By 1904, Monet had already removed the banks of the lake, the imaginary viewpoint of external observers on *terra firma*, thus bringing the pond's surface closer. The fragmentary depiction fills the paintings entirely. Monet, who used to sit only 15 to 20 cm away from the canvas when painting, succeeds in transferring his own view to the observers. He forces them out of a secure inner distance, blurs the perspective, forms, and colors of the homogeneous images, obscures the familiar view of near and far, and encourages them to glide into the exclusiveness of a water landscape. The synthesis of natural environment and mental impression puts the

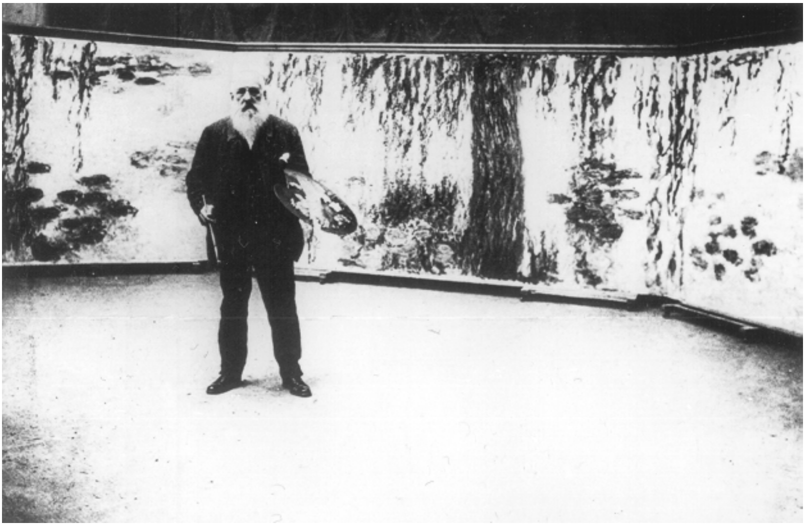


Figure 4.2 Claude Monet in Atelier 3 in Giverny, 1922. By kind permission of Karin Sagner-Düchting.

observer in a bird's-eye view position that overcomes the laws of gravity in the image space; in a certain sense, it is disembodiment. The linking of a nondistanced impressionist interpretation of a natural scene with the mechanisms of suggestion found in the image apparatus of the panorama suited the artist's intentions perfectly. Thus, one year after Monet's death and fifty years after his *Impression, soleil levant*, a late example of modern art reached the changed artistic landscape of the late 1920s, transported in a derivative of *the* mass medium for images of the nineteenth century.

Prampolini's Futurist Polydimensional Scenospace

In an entirely different social and aesthetic context, Enrico Prampolini (1894–1956), probably the most prominent member of the second generation of Futurists,[7] was also fascinated by the idea of using all available technical means to remove the boundary between observer and image space. In his manifesto on Futurist scenography (1915), the twenty-year-old Prampolini called for the immediate and radical removal of all static, painted scenery and its replacement by dynamic electromechanical scenic architecture of luminous plastic elements in motion. Prampolini was not interested in replicating natural elements of the world; he wished to dynamize the dramatic action on the stage, convinced that this would lead to corresponding effects on the minds of the audience. The actors, whose performance he assumed would be much more intense on such a dynamized stage, he later rejected entirely. It is interesting that Prampolini applies the fantasies of fusing different elements into one, typical of the Futurists, to the theater stage. Contemporaneously, Filippo Tommaso Marinetti was extending his theory to include cinema. In his Futurist Cinema Manifesto of 1916, Marinetti declares cinema to be the most dynamic of all human media of expression because of its ability to compound traditional forms of art and media. Futurist cinema will demolish the limitations and structures of literature through its images, through a realm of images augmented by appeals to the other senses deriving from other art forms.

Prampolini continued to work on his new concept for the theater, and in 1924, he proclaimed the polydimensional Futurist stage. The traditional, box-shaped horizontal stage, seen from one direction only and with a clearly delineated area for the audience's attention, was to give way to "spherical expansion." The stage would contain "new vertical, oblique, and polydimensional elements" that are set in motion electromechanically. These would enlarge the perspectival view of the horizontal, which, in concert with the light elements, would move "in simultaneous penetration toward a centrifugal irradiation of infinite visual and emotional angles of scenic action."[8] The distanced overview does not feature in this concept: Prampolini's goal is a paradoxical amalgam of a synthetic and dynamic image space, which creates a sharp contrast between strict contraction and absolute expansion in order to communicate spiritual moments of eternity.[9]

Prampolini was not the only one thinking in this direction. Although following different artistic and political goals, a short time later Bauhaus artists were also directing considerable efforts toward the union of stage and audience. The sociopolitical perspective is a different one, but notions of a totality are also found in the theories of László Moholy-Nagy, in Theater der Totalität, and in Walter Gropius's *Totaltheater* (1927), written for Erwin Piscator. In his essay, "Theater, Zirkus, Varieté," Moholy-Nagy wrote: "It is high time to develop activities, which will not allow the masses to remain mute spectators, which will not only move them inwardly but seize them, make them participate, and in the highest transports of ecstasy, allow them to enter the action on the stage."[10] He called for a new type of expanded stage including other media, which would level out the way theatrical space is organized, and the introduction of a system of separate, moveable surfaces fastened to a wire frame.[11] Moholy-Nagy reinterpreted certain ideas of Richard Wagner's: He reduced the importance of the spoken word and envisioned a synthesis of space, movement, sound, light, composition, and abstract artistic expression, enhanced by technical apparatus.

In 1919, Kurt Schwitters, who inspired the Dadaists, also conjured up visions to eradicate barriers with a multimedia work of art: "I demand Merz theater. I demand the complete mobilization of all artistic forces to create the *Gesamtkunstwerk*. I demand the principle of equal rights for all materials, equal rights for able-bodied people, idiots, whistling wire netting, and thought-pumps. I demand inclusion of all materials, from double-track welders to three-quarter size violins. I demand conscientious modernization of technology until complete implementation of molten melting-togetherness. . . . I demand revision of all the world's theaters according to the Merz idea."[12]

The Futurist conception of a *spazioscenico polidimensionale futurista* centered on blending observer and mechanodynamic image space. Prampolini was convinced that this would open up "new worlds for theatrical magic and technique."[13] The more powerful the suggestive potential of the seemingly *living* theatrical images became, the more logical it seemed to the Futurists that the actor was a useless element in the action. For since the Renaissance, the actor on the traditional stage of a theater represents a relative viewpoint, the spectator's opposite number, and this endangers the immediacy of the new images and their efficacy. Prampolini's position on the actor is much more radical than, for example, Gordon Craig's of a few years earlier; he even regards actors as "dangerous for the future of theater"[14] because of their unpredictability and ability to interpret: "I consider the intervention of the actor in the theater, the element of interpretation, to be one of the most absurd compromises for art in the theater."[15] Without going into detail here, it does seem remarkable that the core motivation of Prampolini's ideas for the theater is religious and spiritual; every spectacle was, for him, a *mechanical rite* of the eternal transcendence of matter, a magical revelation of a spiritual and scientific mystery.[16] Prampolini saw the theater as "a panoramic synthesis of action, a perfectly mystical rite of spiritual dynamism. A period of time for the spiritual abstraction of the new, future religion,"[17] and he translated Futurism's well-known visions of merging humans with machines into a state of permanent dynamism on stage. He wanted to amalgamate this image, now mechanized and "totalized," with the spectator. Without actors, it would be possible to revolutionize the spectators' perception and direct their thoughts toward a spiritual state, which would prepare the ground for a new religion. To this end, Futurist scenospace theater creates a virtual and dynamic sphere from which the spectator cannot escape.

Film: Visions of Extending the Cinema Screen and Beyond

It is now more than seventy years ago that Rudolf Arnheim set out to classify film as art, armed with an entire catalog of aesthetic concepts.[18] After the intense debate on cinema[19] and writings by Walter Benjamin,[20] Erwin Panofsky,[21] and others published shortly afterward, this appeared to mark a pause for reflection and thoughtful review after the turbulent early days of this young medium, which had been largely spectacular. From the limiting frame of the screen, the absence of the space-time continuum, movement of the camera, to slow motion and and many other parameters besides, Arnheim (who studied art history in Berlin) fans out his aesthetic vocabulary of film. Although the artistically creative subject is threatened with near-liquidation by the complexity of organizing the machinery of film production, Arnheim interprets the medium as being free for artistic utilization. In his view, the time was past when film was under the influence of its precursor media—diorama, panorama, pleorama, mareorama, and so on—which meant first and foremost illusion and immersion. Arnheim emphasizes the difference between filmic reality and human perception primarily in order to better analyze the directors' possibilities for artistic intervention, yet the career of cinema as an image medium began because it appeared capable of fulfilling the unkept promises of its suggestive precursors, whose effects and affects no longer had the power to captivate the urban mass audiences.[22] The consciously reflected universe of images was penetrated by the visuality and particular nature of the film and first scientific studies presented their findings. Just as today the dynamic images produced with the aid of high-performance computers are regarded as a turning point in the evolution of images and a challenge to theorists, at that time film was perceived as a dramatic and decisive event. To approach a fuller understanding, however, is possible only through

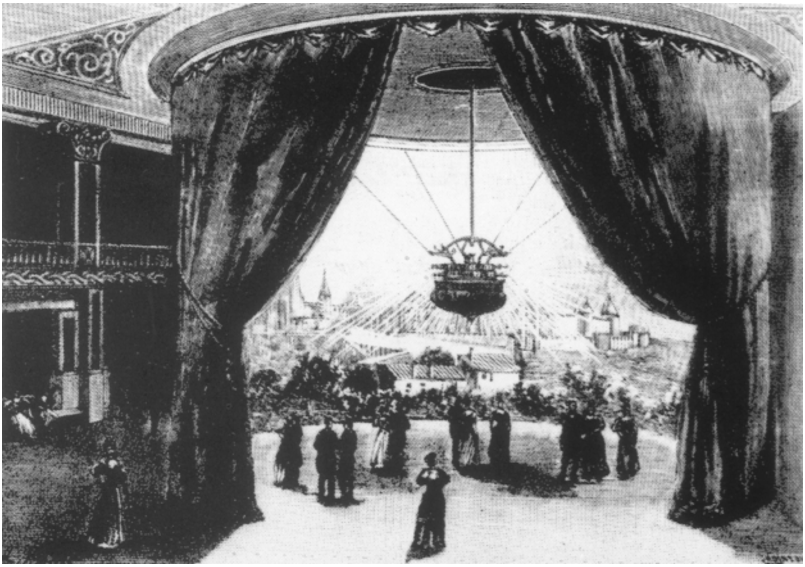


Figure 4.3 View of Charles A. Chase's *Stereopticon,* 1896. In *Hopkins Magic.* By kind permission of Silvia Bordini.

the relativization of a historical appraisal. Arnheim was fully aware of this, when, nearly a centenarian, he stated: "In pondering the future we are tempted to limit our attention to the curiosity about the inventions and discoveries awaiting us. This, however, would be narrow-minded. What is needed is a wider view encompassing the coming rewards in the context of the treasures left us by past experiences, possessions, and insights."[23]

Many and diverse were the ways in which the film became the successor to the mass medium for images that was the panorama. Much less well known are the developments that culminated in this new medium. In 1894, the stereopticon was presented to the public, an apparatus that used sixteen slide projectors working in rapid succession to project circular pictures (fig. 4.3). For a short time, the panorama united with the new technology of cinematography in the *Cinéorama* (fig. 4.4). First presented at the 1900 World Exhibition in Paris, it was a hybrid medium: Ten 70mm films were projected simultaneously to form a connected 360° image.[24] In fact, the walls of older panorama rotundas were often whitewashed and used as presentation spaces for the new cinematic version.[25]

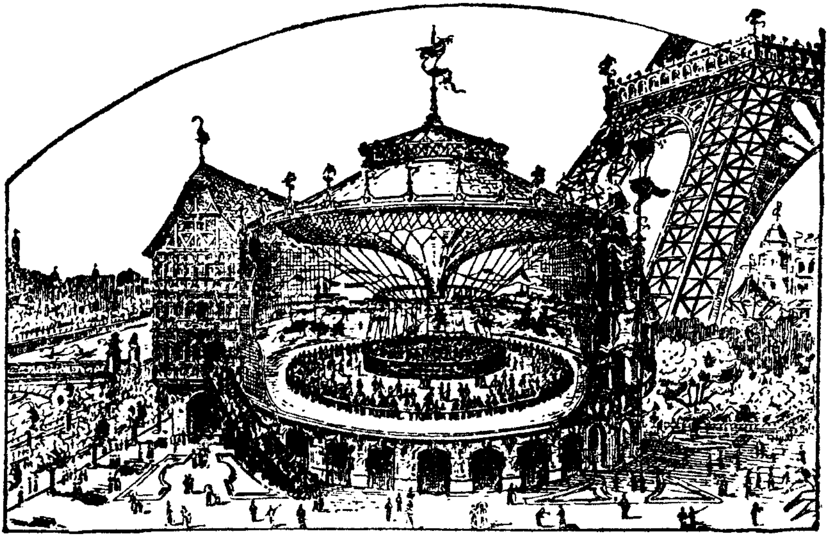


Figure 4.4 The *Cinéorama* at the 1900 World Exhibition in Paris. Cinematographic panorama, constructor: Raoul Grimoin-Sanson. Pen-and-ink drawing in *Le Cinema,* by G. A. Auriol et al. By kind permission of Georg Olms Verlag.

The history of the World Exhibitions has not yet been written, but these mammoth trade fairs are closely linked with the development of new media of illusion. Even a cursory glance reveals their concerted attempts to provide the millions of visitors with images that conjured up visions of the future. In this respect, Paris 1900,[26] with the giant panorama, *Le Tour du Monde*, dioramas of colonies, panoramas of Madagascar and the Congo, Cinéorama, and mareoramas, was no different than the New York World Exhibition in 1939. Under the motto "Building the world of tomorrow," new designs for urban development were on show as large walk-in models; inside the exhibition symbol, a sphere measuring 60 m in diameter, visitors could enter a cityscape entitled "Democracy." However, the real expression of the American vision was created by Norman Bel Geddes and sponsored by Chrysler: the Futurama. It depicted a journey through an automobile-friendly city of 1960, thus offering a simple direction for consumer optimism after the recent Great Depression (figs. 4.5 and 4.6). Thousands of model cars flowed along a freeway—later, the stereotyped image of urbanity par excellence—past high-rise buildings stretching as far as the eye could see and occupying the horizon. The visitors sat in

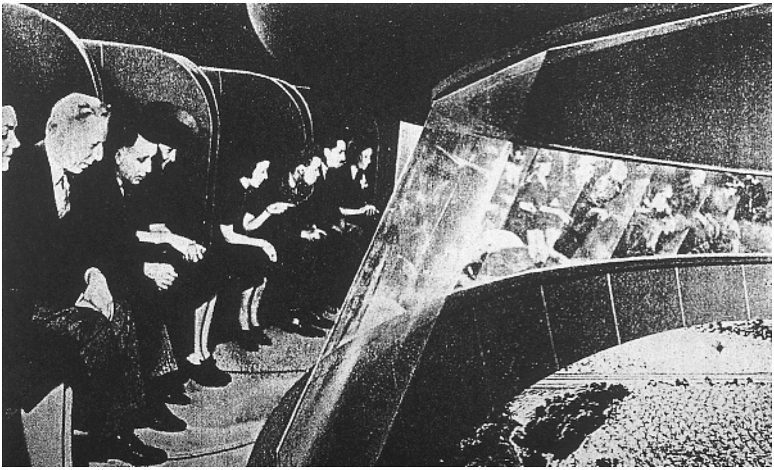
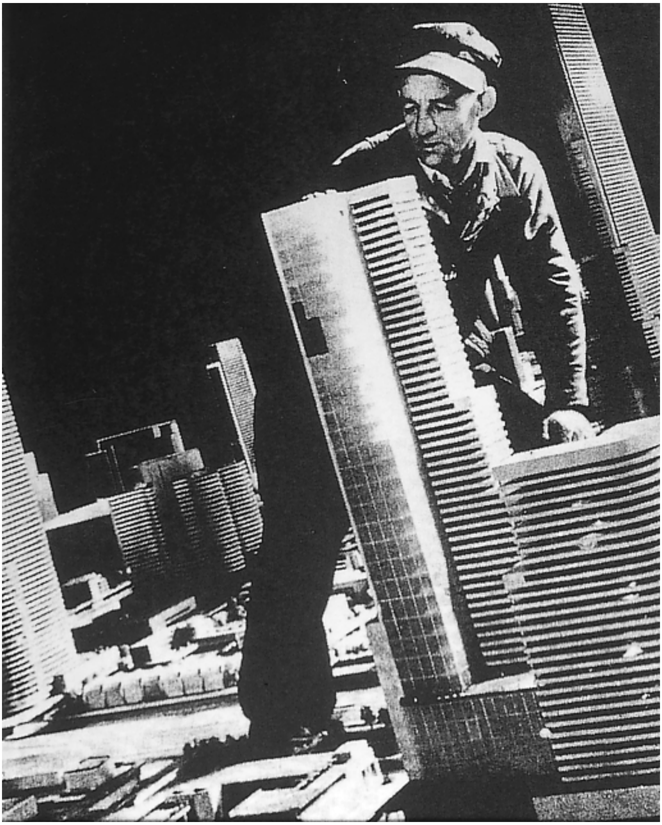


Figure 4.5 *Futurama*, 1939 World's Fair, New York. In *The World of Tomorrow*, ed. L. Zim, M. Lerner, and H. Rolfes, 1988, p. 112. By kind permission of Herbert Rolfes.

darkened cabins, arranged in a circle and hanging several meters above this model world. At the World Exhibition in Osaka of 1970, which attracted a record number of visitors, the Pepsi Cola pavilion presented a playful artificial sphere that addressed the senses with dry ice, interactive laser effects, stroboscopes, and music. The result was a confusion of the senses that approached synaesthesia. Colors and sounds mix, shapes have taste, you can describe the color, shape, and flavor of someone's voice or music, the sound of which looks like "shards of glass." A technopoetic composition designed by the legendary group Experiments in Art and Technology (EAT), it revamped the appearance of something now familiar to urban societies around the world: the polysensory environment of the discotheque. The vision of a media society informed the World Exhibition EXPO 2000 in Hannover. Both the pavilions of corporations, such as Bertelsmann's 100 million mark *Planet m*,[27] and national pavilions, such as Germany's[28] (fig. 4.7), took the visitors to bright worlds full of multimedia images, often accessed by dark tunnels filled with low-pitched sound. In the "longest cinema in the world," Jean Nouvel used dramatic light effects, spatial sound, and powerful emotional and nostalgic images to create an apotheosis of *Mobility*.[29] The long, dark passageways between the incalculably moving images also produced a feeling of immersion, not so much in an explicit image space but rather a lasting feeling of



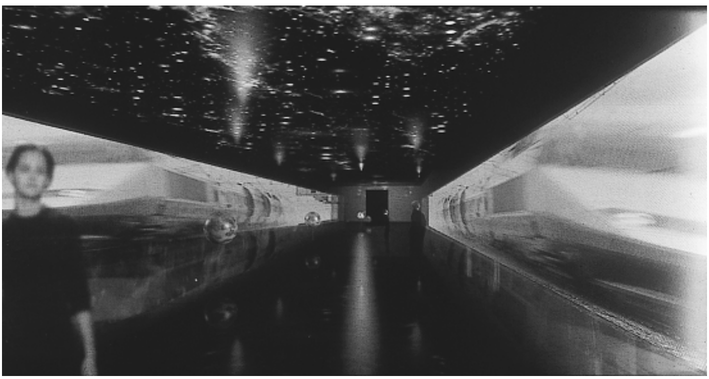


Figure 4.6 *Futurama*, 1939 World's Fair, New York. Interior, worker with model of a building from the Vision of a City, 1960. By kind permission of Herbert Rolfes.

Figure 4.7 Expo Hannover 2000. Themenpark: *Mobilität*; architect: Jean Nouvel.

suggestive image spaces. The scenography adhered closely to the concepts of EXPO 2000's management. In a theoretical article on scenography published before the Hannover exhibition opened, Martin Roth, director of the theme park, stated that in Hannover, the content of the visualizations is characterized by a relationship of competition to their modeling by new projection techniques. Referring to Buckminster Fuller, Disney, and El Lissitzky, among others, he wrote: "It is within this tension that the true dynamic and dramaturgical momentum of the exhibition is realized."[30] The architectonic designs of the pavilions' interiors, where materiality, complexity, and expression are barely recognizable, retreat behind the surfaces used for projecting worlds of images. The visitors find themselves in dark caves, which—like IMAX cinemas or virtual art installations—transport meaning only through moving pictures. The architectonic structure is merely a vehicle for the images, and this allowed variability in what could be shown. Each World Exhibition has introduced new image experiences to the public using the most advanced media technology of the day. Their aim is to create a credible and irresistible vision of the future, and this can be achieved most readily by employing large format images that enclose the visitor.

Today, contemporary accounts of first film shows by those pioneers of cinematography, August and Louis Lumière, read like a blend of legends, anecdotes, and sensational journalism. *Arrivée d'un train en gare le ciotat* (1897) was, as R. M. Hayes has pointed out,[31] actually the first 3-D film to be screened in public, although it is unlikely that the optical aids really did enable the images to be seen in three dimensions. Like the panorama before it, film began by replicating what could actually be experienced to establish its potential as a medium. The audience reacted to the approaching train in this film, its "brutal reality,"[32] with screams of panic, by running away, and, according to many contemporary sources, by fainting.[33] These reactions resulted from the fact that for the first time, the camera lens angle and the observer's eyepoint corresponded. James Gibson has described this effect and its influence on film in his outline of an ecological theory of perception.[34]

The immersion experienced by early cinemagoers is described by Siegfried Zielinski: a "darkened room, where the spectators, like Plato's cave-dwellers, are virtually held captive between the screen and the projection room, chained to their cinema seats, positioned between the large-size rectangle on which the fleeting illusions of motion appear and the devices that produce the images of darkness and light. Cinema as an environment for the enjoyment of art, for immersion in traumatic experiences, for hallucination, for irritation of real experience; and, what is more, with films constructed in deliberate opposition to the experiences of those who pay to enter the dark womb and be at the mercy of the play of light and sounds."[35]

Early cinemagoers' reactions to silent black and white films tax our imagination and seem explicable only in terms of the novelty of the medium of illusion and its then unknown potential for transitory suggestive effects. Film greatly affected an audience whose perception was unprepared and not habituated to processing moving, simulated images. However, this effect must be regarded as relative in view of the similar drastic reactions of the public to the first panoramas and the long historic chain of innovations in illusionist image production. At first, the audience is overwhelmed by the new and unaccustomed visual experiences, and for a short period, their inner psychological ability to distance themselves is suspended. This contention needs to be tested by comparative research on immersion, which as yet is only just beginning. The connection between innovations in technologically produced illusions and putting the inner ability to distance oneself under pressure, may, for a period of time (the length of which is dependent on the illusion potential of the given new medium) render conscious illusion unconscious and confer the effect of something real on that which is merely appearance.[36] When a new medium of illusion is introduced, it opens a gap between the power of the image's effect and conscious/reflected distancing in the observer. This gap narrows again with increasing exposure and there is a reversion to conscious appraisal. Habituation chips away at the illusion, and soon it no longer has the power to captivate. It becomes stale, and the audience are hardened to its attempts at illusion. At this stage, the observers are receptive to content and artistic media competence, until finally a new medium with even greater appeal to the senses and greater suggestive power comes along and casts a spell of illusion over the audience again. This process, where media of illusion and the ability to distance oneself from them compete, has been played out time and again in the history of European art since the end of the Middle Ages.

Film, or cinema, is such a heterogeneous media complex that it resists being subsumed under a general definition. Here, I shall follow the Russian director Andrey Tarkovsky's characterization of film as "emotional reality," which allows the viewers to experience a "second reality."[37] Cinema is intended for direct sense and emotional perception, and this inevitably gives the director "power" over the feelings of the audience, even leading some filmmakers into the aberrant self-deception of being a demiurge. For Tarkovsky, these highly sensitive and suggestive components of film that, for a period of time, allow the audience to believe in an artificial reality created by technology, impose a heavy responsibility on the director.[38] This perspective, Tarkovsky's iconic understanding of film, allows us to interpret and comprehend the recurrent forays attesting to film's polysensory aims. Their basic trend is toward extending the system of illusion beyond the visual to include the other senses. Essentially a reproductive and psychological art form, the medium of film has seen many attempts in the last century to advance beyond two-dimensional screen projection in order to intensify its suggestive effect on the audience.

Teleview (1921) introduced the 3-D film to the United States.[39] Colorful light projections, viewed with two-color glasses, created impressions of space and depth.[40] Like the panorama, the subjects of these films were distant and, for the average urban American, exotic places: a Hopi camp in Arizona, scenes from the Canadian Rockies, or a main feature entitled *M.A.R.S.* Abel Gance also planned to include 3-D sequences in his epochal film *Napoléon* (1926–1927). However, at private previews, the 3-D scenes were felt to be too overwhelming, even more powerful than the panoramic effect of three simultaneous screen projections. Gance decided to remove the 3-D sequences in order not to risk compromising the effect of the rest of the film, which was in 2-D.[41] Zeiss-Ikon put their 3-D color *Raumfilm* system on the U.S. market at the end of the 1930s, but, apart from a few short films, it was hardly used during World War II.[42] For the cinema newsreel Wochenschau in Germany and the lavish color productions of the German UFA film company, the standard format in the latter war years remained 2-D.

Sergei M. Eisenstein was one of the visionaries of new media of the art of illusion (fig. 4.8). In the late 1940s, he described a symbiosis of art and utopian technology. An influential Soviet film director and theorist, he interpreted the history of art as an evolutionary process inseparable from

Figure 4.8 Sergej Eisenstein. ⟨http://www.fdk-berlin.de/forum98/gesichter.html⟩.

the development of technology. From the perspective of the 1940s, Eisenstein considered film the most advanced developmental stage of art. In his essay "*O Stereokino*" (1947), he stressed the long continuity in the dialectical relationship of art, science, and technology.[43] The ultimate synthesis of all art genres would culminate the imminent realization of Stereokino, stereoscopic cinema,[44] which Eisenstein believed humankind had been moving toward for centuries and represented a further expression of a deeply human urge to create images.[45] Then, the image, experienced as "real three-dimensionality" (Eisenstein offered no technical details about stereoscopic cinema) would "pour" from the screen into the auditorium.[46] Further, stereo sound would be "absolutely essential."[47] This would enable the director to "capture" the audience and the audience to "immerse themselves completely in the powerful sound."[48] Stereokino would have the power "for the first time ever, to 'involve' the audience intensely in what was once the screen and to 'engulf' the spectator in a manner no less real and devastating with what was formerly spread across the screen."[49] Eisenstein is not sketching a blueprint of virtual reality here, in the sense of panoramatic images; his reflections revolve around rendering images so powerful, with plasticity and movement, that they can tear the audience psychologically out of their actual surroundings and deliver them into the environment of the stereoscopic film. His use of language, such as "immerse," "engulf," "capture," and so on, is a clear indication of what lies at the heart of this idea: the expectation of soon having a medium at his disposal that, at an advanced technological level, would have the capability to amalgamate image and spectator psychologically. These film images would have a suggestive power with hitherto unknown potential and effects: "That which we were accustomed to see as an image on a screen will suddenly 'swallow' us in the distance that opens up behind the screen, which has never been seen before, or 'get into' us through a 'tracking shot,' which has never been realized before with such expressive power."[50]

Obviously, Eisenstein is not looking to facilitate inner distance in the spectator or to construct an arena of manageable, controlled reception and subjectivity. He saw Stereokino as a tool for "getting into" the audience and "sucking them into" the images.[51] The essay "About Stereoscopic Cinema" documents Eisenstein's will to take possession of this future high-tech medium of illusion as an instrument for exercizing a great deal of control over the emotions of the audience. He seeks to infer the inevitable development and phenomenology of this medium of illusion from art history and anthropology:[52] Stereokino is rooted in the ritual union of actors and audience, an archaic urge to reconcile "show and mass audience" to form "an organic whole."[53] Eisenstein saw this new image machinery as the goal of a teleological development and justified his intention to utilize it with arguments invoking art history and anthropology. It goes without saying that he desired to further the aims of Socialism in this way.[54] Yet his formulation of the intent to control audience emotions and his supporting arguments did not proceed from any Communist party directives. These visions and arguments are the product of an analytical thinker and went far beyond what the Party expected of filmmakers. Irrespective of how one judges the politics, they are a true reflection of Eisenstein's personal endeavors as a politically thinking artist and aesthetician.

Of the many projects to expand the Silver Screen in the United States during this period, Fred Waller's Cinerama, with its 180° screen (fig. 4.9), occupies a salient position. Compared with the idea of 360° images and the short-lived attempts at projecting circular images at the turn of the

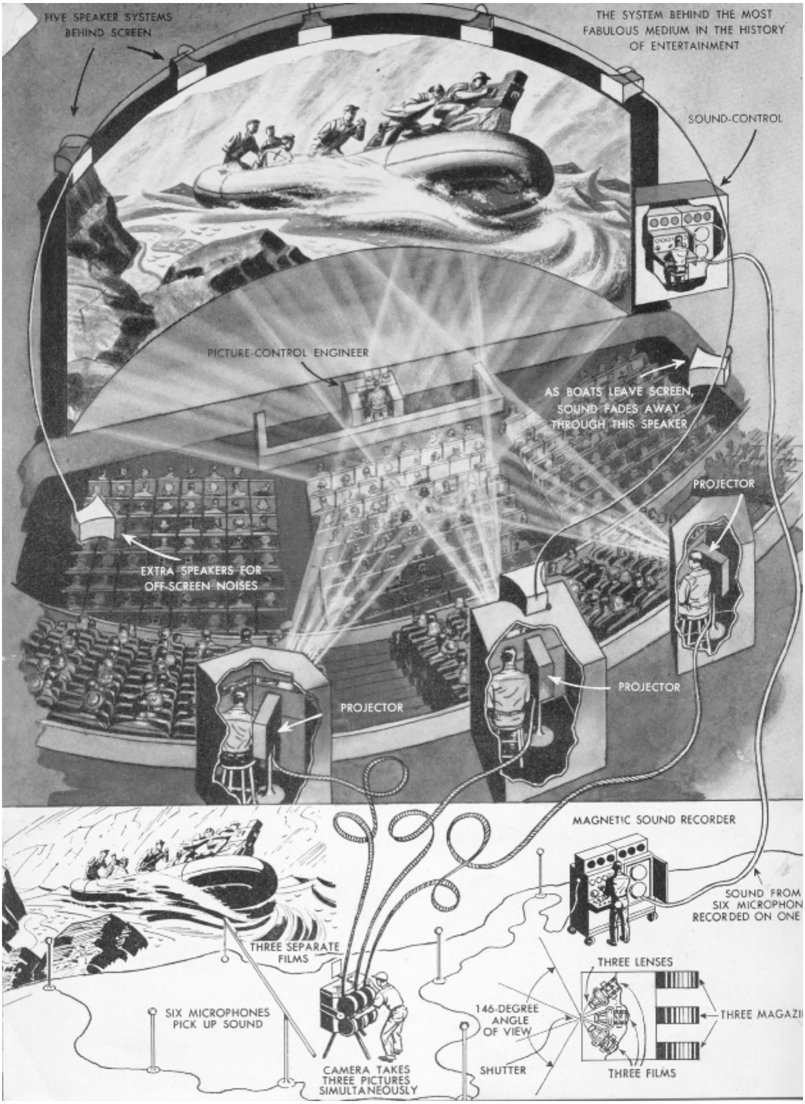


Figure 4.9 The Cinerama. From the private collection of John Mills.

century, Cinerama represented a step backward; however, it was commercially successful. In company with several other large-scale image projection apparatus, Cinerama originated from an attraction exhibited at the 1939 World Exhibition: the Vitarama, a product of Waller's experiments in the late 1930s for the U.S. air force to improve their flight simulators. At the height of its popularity in the early 1960s, Cinerama films were screened in their own specially equipped cinemas of which there were about one hundred around the world. The films were shot with three cameras and presented with stereophonic sound. Cinerama occupies a paradigmatic place within successful 3-D entertainment cinema of the 1950s and 1960s.[55]

In the same period, Morton L. Heilig developed a far more radical vision of the immersion idea: the Cinema of the Future, offering illusionary experiences to all of the senses, including those of taste, smell, and touch.[56] The screen would not only fill 18 percent of the spectator's visual field, like CinemaScope in 1954, or 25 percent, like Cinerama; Heilig's declared aim was 100 percent: "The screen will curve past the spectator's ears on both sides and beyond his sphere of vision above and below."[57] *The Cinema of the Future* would, Heilig felt, even outdo the "Feelies" envisioned by Aldous Huxley in *Brave New World* and represent an image medium with a unknown suggestive potential: "it will be a great new power, surpassing conventional art forms like a Rocket Ship outspeeds the horse and whose ability to destroy or build men's souls will depend purely on the people behind it."[58] In Heilig's opinion, an artist's powers of expression would benefit considerably through knowledge of the human sensory apparatus and perception—a simple idea, yet remarkable for the period. Along with so many other projects, the Cinema of the Future was destined to remain a futuristic vision. However, its motivation and orientation continued to drive aspirations in the realm of technical development, though tempered by the fact that these are always subject to economic viability and prevailing political interests.

Heilig's pioneering research focused exclusively on immersive image apparatus for the rapidly expanding medium of his day: television. In 1960, he patented the "Stereoscopic televison apparatus for individual use" (fig. 4.10). This consisted of stereo glasses with two miniature TV screens that produced 3-D images and combined the principles of the stereoscope with the technology of television.[59] Only two years later, he developed

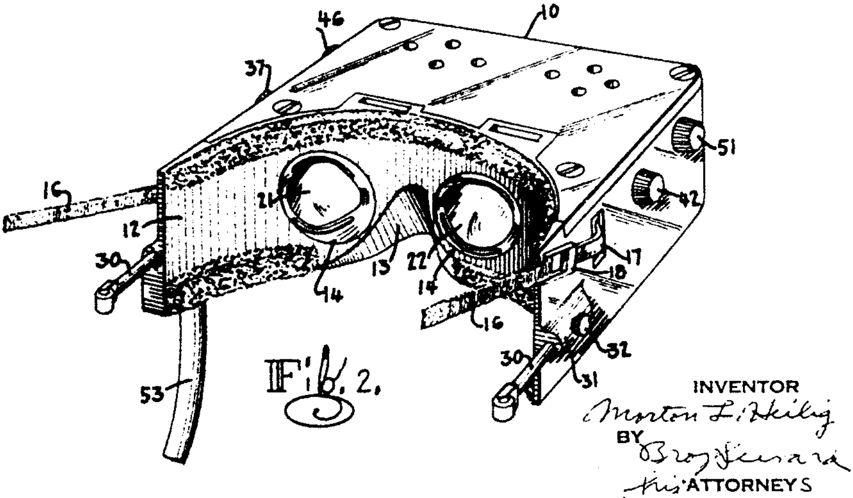


Figure 4.10 Stereoscopic television for individual use. Inventor: Morton Heilig, 1960, patent sketch. Author's archive.

the Sensorama Simulator (fig. 4.11),[60] which soon made its way into the entertainment sector. In addition to 3-D CinemaScope images and stereophonic sound, the audience in the Sensorama were subjected to vibrations and smells simulated by chemicals.[61] The Sensorama was not interactive, but it did succeed in addressing four of our five senses: sitting on an imaginary motorcycle, the spectator saw the streets of, for example, Manhattan whiz past, heard the noise of traffic and the streets, smelled petrol fumes and pizza from snackbars, and felt the vibrations from the road. In this case, the objective of polysensory experience of images is clear. In the 1960s, the Sensorama was found mainly in amusement parks in California but hardly anywhere else.[62]

Besides 3-D cinema, a constant phenomenon but one that never exerted a determining influence on mainstream film production, many other attempts were launched to enhance cinema with tactile elements or smells. Films such as *Earthquake* (Robson 1974) and *The Tingler* (Castle 1959) included haptic sensations: The audience sat in special seats that shook. *Polyester* (Waters 1981) included smells: With the entrance ticket came a card strip which the cinemagoer rubbed during the appropriate film sequences releasing corresponding smells.[63]

Figure 4.11 Sensorama Simulator. Inventor: Morton Heilig, 1962 ⟨http://www.cinemedia.net/CCP/data2.htm⟩.

Parallel to these developments in filmic art, popular and spectacular versions of virtual spaces existed as amusement park and fairground attractions in the 1970s and 1980s, particularly in the form of small immersive circular cinemas. At regular intervals, new concepts were advanced, and some even realized, of how to enhance immersive experiences in the cinema, for example, Omnimax cinema's spherical projection (fig. 4.12).[64] James Gibson has defined these endeavors in terms of the urge to extend the view by banishing all forms of frame from the field of vision:

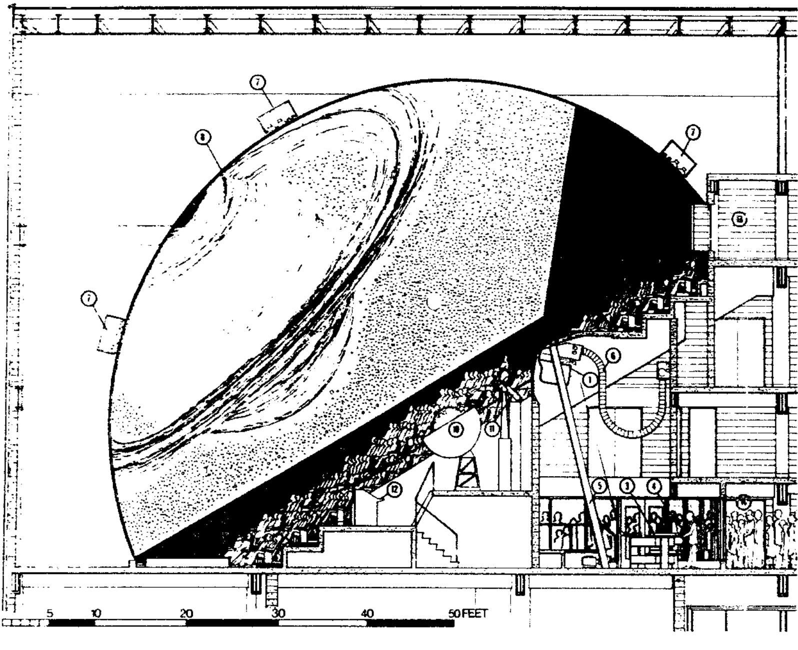


Figure 4.12 Omnimax Theater, 1984. Precursor to the IMAX Dome. By kind permission of IMAX Corporation.

"With a Cinema screen, the virtual window may sample as much as 160° of the ambient array, instead of the mere 20° or 30° of the usual movie theatre, and the illusion of locomotion may then be compelling, uncomfortably so."[65] From the point of view of illusion, IMAX (Image Maximization), introduced in the 1990s, represents the state of the art. This U.S. company has installed over 150 of their spectacular cinemas in more than 20 countries. With curved screens of up to 1000 m^2, spectators are literally in the images. For 3-D IMAX films, the audience wears special glasses with lenses that are opened and closed in rapid succession by high frequency infrared light. Each eye sees the images of the two film projectors separately and the brain combines the slightly different images into one, producing an impressive effect of spatial depth. Commercially, the IMAX cinemas are highly successful;[66] thematically, the films' subjects follow a pattern prefigured by the panorama: IMAX takes the spectators to inaccessible, far-off foreign places. Today, this means the depths of the oceans, the wreck of the Titanic, the summit of Mount Everest, or outer space. The distant places that beckon us now have shifted to the most extreme zones the planet has to offer. Frequently, IMAX films show spectacular locations, such as the Grand Canyon in the United States, which are of such vast dimensions that the human eye cannot take them in at a glance. With edited sequences of takes from inaccessible angles, IMAX expands natural spectacles, and it is to this effect that it owes its millions of visitors.

Highways and Byways to Virtual Reality: The "Ultimate" Union with the Computer in the Image

Ever since the early days of the computer during World War II,[67] there have been attempts to connect, synchronize, or analogize this universal machine with human beings. One of the first to see computers in relation to humans was Vannevar Bush, adviser to Franklin D. Roosevelt and, in his capacity as director of the Office of Scientific Research, decisively involved in the development of the atom bomb. In a classic, highly influential article written in 1945, "As We May Think" for *Atlantic Monthly*, he referred to the computer as a "mind machine." Further, he discussed ideas for the collection, storage, and accessibility of information in a world based increasingly on efficient data processing. Norbert Wiener followed suit in 1948,[68] and Alan Turing in 1950.[69] They both saw analogies between the work processes of humans and computers and thus laid the foundations for later theories of robotics, cybernetics, and research on artificial intelligence. Wiener defined cybernetics as the science of conveying messages between humans and machines. This remarkable conceptualization derived from an idea that later formed the basis of all concepts of interaction and interface design: communication between humans as the model for communication with or between machines. In 1960, when the successful launch of Sputnik into space had also sent shock-wave visions of similar technology in conjunction with nuclear devices through the military establishment, J. C. R. Licklider, who worked on computer networks in defence, sketched a vision of symbiosis between humans and computers.[70] Licklider was interested in simplifying exchange of information between human beings and computers, which would make it possible to give orders and pass them on quickly in wartime, for as he said laconically, "Who can direct a battle when he's got to write the program in the middle of the battle?"[71] As director of the U.S. Defense Department's

Advanced Research Projects Agency (ARPA, later DARPA), which was mainly involved with funding defense-relevant projects rapidly and unbureaucratically, Licklider supported research that led to development of interaction with computers and, ultimately, to the personal computer. For Licklider, the computer was an intelligent partner, which needed to be equipped with attributes of reactive behavior. Then, in 1964, Marshall McLuhan appropriated the term *symbiosis* to describe the future relationship between humans and machines.[72]

Ivan E. Sutherland made probably the most decisive contribution to the human–machine interface in his doctoral thesis, "Sketchpad" (1963), which was supervised by Claude Shannon at the Massachusetts Institute of Technology (MIT). Sketchpad was the first graphical user interface, and it reformed computer graphics. In 1951, the Whirlwind computer had been developed, which allowed direct manipulation of data on a cathode ray monitor—at the time, still a rarity. It was the first dynamic and interactive display. However, Sketchpad enabled the user to draw directly onto the monitor with a hand-held lightpen[73] and thus offered the option of manipulating images directly on the screen: the basic prerequisite for interaction with virtual realities. Sketchpad was the precursor of graphics programs such as Adobe Illustrator or MacDraw, which replaced the abstract *word*-commands, that is, syntax, interface with the interface of pointing at *icons* with a device, that is, physical action, which was also much easier to use.

Sutherland's ideas for an "ultimate computer display" of 1965 were also revolutionary. This display would have the capability to rearrange physical laws optically in "exotic concepts" and even visualize these through computed matter.[74] One remarkable passage recalls Alberti's use of the window metaphor: "One must look at a display screen as a window through which one beholds a virtual world. The challenge to computer graphics is to make the picture in the window look real, sound real, and the objects act real."[75] Sutherland's article, published in the proceedings of a science meeting, opened up a new space for futuristic speculations about this new computer-based medium, which radicalized as-if scenarios. In such an image space communicated directly to the senses, handcuffs can restrain and a shot can kill,[76] depending entirely on the programming. Sutherland's ideas went far beyond mere illusion; the simulation potential of the system ought to have material results, for example, violence, and produce a perfect oneness with the machine-made virtual image.[77]

From 1966, Sutherland and his student Bob Sproull worked on the development of a head-mounted display (HMD) for the Bell Helicopter Company, in retrospect, an important place where media history was written. The HMD represented the first step on the way to a media utopia: a helmet with binocular displays in which the images on two monitors positioned directly in front of the eyes provided a three-dimensional perspective. When connected to an infrared camera,[78] the apparatus made it possible for military pilots, for example, to land on difficult terrain at night. This helicopter experiment demonstrated that merely by using "camera-eyes," a human being could immerse in an unfamiliar environment and be *telepresent*. At one point, a test person panicked when his HMD showed pictures taken from the top of a skyscraper of the street far below, even though he was actually safely inside the building. This amply demonstrated the immersive psychological potential of the technology. In 1966, Sutherland replaced the photographic film images with computer graphics. These were updated many times per second in real time by the system and thus the concept of interactively experienced virtual reality was born.

In 1968, with ARPA funds from the U.S. defense budget,[79] Sutherland developed the first computer-aided HMD. It showed 3-D computer images, and sensors inside tracked the user's head movements,[80] a process known as *headtracking*: "The fundamental idea behind the three-dimensional display is to present the user with a perspective image which changes as he moves."[81] However, the aim of this HMD was not the total simulation of artificial environments; in contrast with today's headsets, visual access to the outside world was uninterrupted. Using two miniature cathode ray tubes, the computer images were projected over the images of the actual environment. The user saw both real and computer images simultaneously, which enabled its utilization as a targeting device.

Sutherland's early virtual spaces were very simple scenes, consisting of at most 200 to 400 polygons. Headtracking and biomechanical feedback produced an impression of immersion. Regular updating made the computer images appear changeable and capable of reacting to the user's movements, limited only by the program's scope: the principle of interaction.

For the first time, the observer was partly responsible for generating the resultant 3-D images. This new potential of the observer's role went so far beyond that of the panorama or Cinerama that they hardly bear comparison.

This new relationship to machines, that is, computers, soon appeared in theoretical discussions of film art. In his book *Expanded Cinema* (1970), Gene Youngblood proposed widening the definition of cinema. Citing many examples, mainly from performance art and the Intermedia movement in the 1960s and 1970s, Youngblood showed that the cinema's two-dimensional screen had entered into a whole range of symbioses with other imaging elements and techniques. Although these were rarely illusionist, they were often multimedia, multisensory, and exclusive, conceived as near-totalities.[82] For example, the Cerebrum, an multimedia event space in late 1960s New York was a mixture of gallery and club, with a psychedelic light show and music, where visitors wore the same uniform of simple white clothes, an uninhibited atmosphere in which to live out "personal realities and anonymous psychodramas."[83] Other contemporary Intermedia artists combined large-format, often abstract film projections with sound effects and sensory stimuli. Particularly innovative were the one-off performances that required audience participation. Jud Yalkut (*Dream Reel*, 1969), for example, used a parachute suspended above the observers as a projection screen for his film images. At the University of Illinois, John Cage and Ronald Nameth (*HPSCHD*, 1969) surrounded the audience with 52 loudspeakers, 8,000 projected slides, and 100 films in an event lasting five hours. Milton Cohen (*Space Theatre*, 1969) projected a mixture of light effects, film, and slide images onto a rotating assemblage of mirrors and prisms. His aim was also "to free film from its flat and frontal orientation and to present it within an ambience of total space."[84] The term "expanded cinema" encompassed video, computers, and lasers, that is, holograms. Well versed in contemporary models of artificial intelligence research,[85] Youngblood envisioned the future human as an amalgamation of organism and computer, a cyborg.[86] With regard to the future development of image production, which he also referred to as expanded cinema, Youngblood projected onto the computer the utopia of a medium where thoughts and mental images would immediately translate into image worlds without interposing processes of communication or code. Theoretically, this predicates a *brain interface*. Youngblood's vision of 1970 was still diffuse, and the consequences were not thought through; nevertheless, he concludes: "the ultimate computer will be the sublime aesthetic device: a parapsychological instrument for the direct projection of thoughts and emotions."[87]

Youngblood's concept of expanded cinema described a trend in the visual arts that sought to extend abstract, technical images and involve as many of the senses as possible for its aesthetic effect. Its ideal was a corollary of the all-inclusive panoramic effect, to which end it was necessary to overcome the traditional boundaries of the film screen. In the future, Youngblood imagined that the relation between observer and fleeting, technologically produced images would be replaced by a physical symbiosis of human and computer image in an ultimate state of osmotic interpenetration. The idea is reminiscent of Sutherland's notion. It is the old idea of merging the human being and the image, but reinvigorated for the computer age. Many of Youngblood's ideas appear to mark him as a utopian, but he was one of the first art theorists with the clarity of insight to point out that the computer would enable the most radical innovations in image illusionism currently possible.

Particularly at MIT, researchers worked intensively on designing immersive computer interfaces. Already in 1970, Nicolas Negroponte[88] had declared that their goal was to combine the visual capabilities of film with computer processing. In 1972, Negroponte stated his vision of a creative human–computer relationship in an even more radical way. Following his argument to its logical conclusion, he declared in his manifesto-like book *The Architecture Machine* that in the future his own profession would be superfluous: The primary functions of an architect could be carried out just as well, if not better, by a computer.[89] By implication, the idea that using a computer can turn an inexperienced user into an architect is applicable to many professions and creative activities. In 1976, the Architecture Machine Group at MIT, also funded by ARPA, focused on the spatial, or hierarchical, distribution of data as an organizing principle.[90] One of the researchers, the psychologist Richard Bolt, supported the idea of an interface that targeted the senses and wrote an account of this research in his book, *The Human Interface*, published in 1984. In company with the majority of treatises on new media technologies, Bolt also tries to ground the principle of spatial distribution of data in established traditions of art history, citing no less an authority than

Francis A. Yeates and her distinguished book *The Art of Memory*[91] in this endeavor.

Computer scientists, who also considered themselves artists, were already something of a tradition: In 1965, Michael Noll and his colleague Bela Julesz organized the first U.S. exhibition of computer graphics in the Howard Wise Gallery. In Europe, Frieder Nake and Georg Nees had done the same in Stuttgart the year before. Jasia Reichardt's London exhibition, Cybernetic Serendipity, was a milestone in the early history of computer art, which began in the 1950s as a chance by-product of the work of programmers, such as Ben Laposky on the oscillograph. It was the first showcase of creative work with computers in the fields of music, graphics, film, and poetry.[92] In Germany, the exhibitions Computerkunst—On the Eye of Tomorrow and Impulse Computerkunst in the Kunstverein in Munich followed in 1970. This was also the year that computer art became an integral part of the Biennale in Venice, which enhanced the international status of the genre.

In the early 1970s, the computer scientist Myron Krueger began work on developing other forms of integrating human mind and interactive computer images. Krueger experimented with reactive installations, and his work paved the way for interactive, psychologically communicative environments. His oeuvre—he also thought of himself increasingly as an artist—reflects the search for a system where the observers, or users, understand themselves as part of a community of programmed beings and where the artist is a composer of computer-generated space communicated in real time. Krueger called this a "responsive environment." His main work, *Videoplace*, is driven by this idea; the first version dates from 1970 and he developed it further in subsequent years. *Videoplace* is a two-dimensional graphic computer environment; a classic closed-circuit, which records the observer on video and projects his or her digitally manipulated silhouette onto a wall-sized screen. The program offers many levels of interaction, involving the observer in a dialogue-like structure.[93]

In the 1980s, the metaphor dominating interaction with the computer changed radically: Modern graphical interfaces, such as Xerox PARC used in Apple Macintosh computers, began to replace the word-based commands.[94] The metaphor of the desktop created an illusion of a manipulable discretionary symbolic environment on the screen. In essence, virtual environments are an extension of this metaphor into a third dimension, which can be observed and manipulated from exocentric and egocentric perspectives.

In addition to Sutherland, the most important pioneers in the development of virtual reality systems were undoubtedly Tom Furness and Scott Fisher. From the mid-1970s, Furness worked on targeting devices for the U.S. Air Force[95] and founded the Human Interface Technology Lab (HIT) at the University of Washington in 1989. Fisher began working at MIT on stereo optical apparatus and, along with many other researchers, moved to Atari's R&D department in Silicon Valley in 1982.[96] Thomas Zimmerman, who had invented the prototype of the data glove in 1981,[97] was one of the computer scientists who joined him at Atari.[98] There, Zimmerman met Jaron Lanier and together they founded the firm VPL Research. In cooperation with NASA, VPL refined the data glove, which originated from the two-dimensional mouse interface. The data glove became a highly specialized sensor, which registers and transmits the position of the fingers, thus enabling movement and navigation in a virtual space.[99] In most cases, the glove uses optical fibers that run along the fingers from the wrist. The given flexing of the fingers modulates light transmitted through the fibers and the information is relayed to a computer via diodes. The user can touch or move computer-generated objects with the glove. However, feedback effects or tactile obstructions are still difficult to simulate. Sensors positioned on the body allow spatial coordination in the data space and the manipulation of computer-generated objects.[100] Lanier and his company VPL Research were the first to market commercial applications of the data glove and VR. The Atari Lab closed down in the mid-1980s and Fisher moved to the NASA Ames Research Center,[101] where a stereoscopic HMD system with a liquid crystal display (LCD) was constructed within the framework of the VIEW Project (virtual environment workstation). These virtual image spaces allowed up to six users at one time to interact with virtual objects.[102]

NASA was also responsible for further developing the technology of telepresence.[103] Telepresence, for example, allows a user to direct a distant robot's movements by remote control. The user moves in a computer-simulated representation of the robot's actual physical location. Simultaneity of user action and robot reaction together with the graphical representation of the robot's location creates an impression of being present in a different physical location.[104] Thus, telepresence extends the connection between body and machine one step further. It cannot be stressed enough that this is a far cry from "abolishing the body." The goal of telepresence research is to address the senses in a very precise way in order to achieve all-around illusionary deception of the user. In 1988, Scott Fisher and Elisabeth Wenzel succeeded in realizing the first spatiovirtual sound, which, even when the user's coordinates changed, remained located in its own position in the simulated space—a further device for enhancing the illusion. The fastest computers of these years, such as the Hewlett-Packard 9000, were able to render solids, like cubes, more plastically, with shadows on their surfaces in real time. Before, these could be represented only as wire mesh models.

The Rhetoric of a New Dawn: The Californian Dream

When William Gibson published his novel *Neuromancer* in 1984, a gentle satire on utopian dreams, the idea of simulated experiences in computer-generated spaces, in cyberspace, was fast becoming popular. Gibson's understanding of cyberspace was a series of networked computer image spaces, a matrix, which as a "collective hallucination" would attract billions of visitors daily.[105] The subculture that rapidly formed around virtual reality appropriated this new word in the late 1980s. Gibson was rather surprised by the attention scientists and techno-believers paid to his book and the utter seriousness with which his visions were debated and discussed.[106]

In the same period, the price of high performance computers dropped drastically, resulting in a rash of new companies and first commercial uses of virtual reality.[107] Garage firms, such as Autodesk,[108] VPL-Research,[109] Sense8,[110] and W. Industries, with just a few employees,[111] and magazines of the new computer subculture, such as *Mondo 2000*, *Virtual*, *Whole Earth Review*, and *Wired*, plus a series of cyberspace festivals, first spread across California and later to the computer scenes of other industrialized nations. The mood was predominantly euphoric but accompanied by a lot of hype. The conviction that soon there would be a medium capable of spawning image illusions never before experienced gave rise to diffuse individual utopian visions in its protagonists and a collective imagination: the new Californian Dream.[112] Visions of a network spanning the world like a technoid skin, which would allow experience of 3-D space, spread quickly from the subculture to the tabloid press whose reports conformed by and large to their sensationalist credo. Serious business journals were not left untouched by these technological flights of fantasy. An unprecedented investment fever swept the Stock Exchange, and billions of dollars gave a new direction to the worldwide economy.[113] When Jaron Lanier coined the term "virtual reality" in 1989, this was also an attempt to package heterogeneous areas of research on the human–computer interface with different labels together with utopian dreams in one, albeit paradoxical, buzz word with a strong appeal to the public imagination.[114] Terminological fuzziness widens the scope of the imagination and feeds dynamics of development. Rhetoric of this kind often heralds utopian imaginings that are located in a spatiotemporal distance with an appointed redeemer.[115] The hopes placed in a future, as yet nonexistent, technology indicate the presence of religious motifs. Strikingly, expectations are not placed in anything human or divine but in an artificially created apparatus, an artifact.[116] In the mid-1990s, certain Republican intellectuals in the United States discovered cyberspace as a place for projecting the old "westward ho" ideology, which led not only to the conquest of the Wild West but also to the genocide of native Americans. They proclaimed that America's future would lie in the networks.[117]

Virtual Reality in Its Military and Industrial Context

The new alliance of art and technology embodied by virtual reality and its image culture cannot be considered as an isolated phenomenon; it is an integral part of revolutionary developments in the economy and military technology. According to the German ministry of economic affairs (Bundesministerium für Wirtschaft), contemporary developments in new information and communications technology are radically changing both the economic and technological spheres to a degree "that is comparable with the transition from the agrarian- to the industrial-based society, with all accompanying changes."[118] The computer is transforming entire sectors of the economy, production, planning, administration, military operations, and leisure time: Virtually all areas of life are changing rapidly. The degree to which society is dependent on functioning telematic networks and information infrastructures is also increasing rapidly, for which the near-panic concerning the year 2000, or "Y2K," serves as an impressive demonstration. The diversity and speed of communication now possible is influencing the education system, speeding up and expanding the production

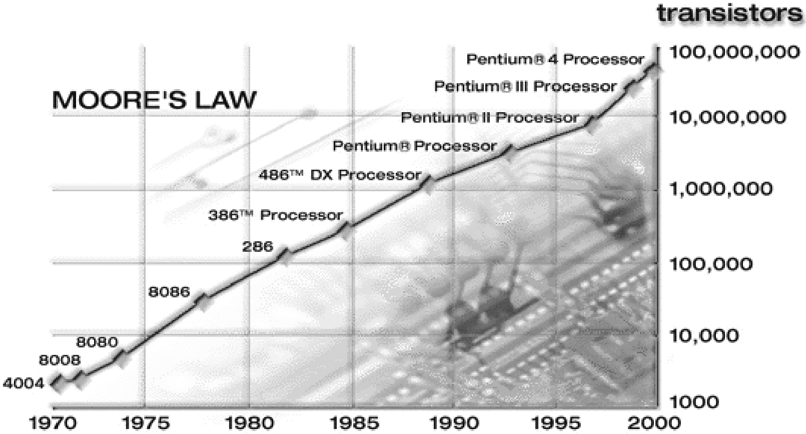


Figure 4.13 Moore's Law. Reprinted by permission of Intel Corporation, copyright 2001 Intel Corporation. ⟨http://www.intel.com/research/silicon/mooreslaw.htm⟩.

of information, and transforming the structures of knowledge. The welfare state and legislature strive to keep up with developments. In brief, in the space of relatively few years, the computer has engineered massive transformations, and the pace is accelerating, rather than slowing down.

For decades now, the price of graphics hardware has reduced annually by a factor of 4, while performance increases 20 to 100-fold. For example, a supercomputer today can process one thousand million instructions per second (1000 MIPS). If a human were to read just one instruction per second, he or she would take 32 years, without sleeping or resting, for the same amount of data. The popular formula expressing this development is Moore's Law; in 1965, Gordon Moore predicted that the number of transistors per integrated circuit would double every 18 months (fig. 4.13). If this exponential rule still holds, then it will only be a matter of years before the computing power is available to realize high-definition spaces of illusion.

At the beginning of the new millennium, it appears that the computer will amalgamate with telecommunication in a new synthesis, a hypermedium:[119] As soon as the Internet is able to handle greater quantities of data, image spaces will be available in a quality that is currently achieved only in expensive installations, stand-alone systems, at festivals or media

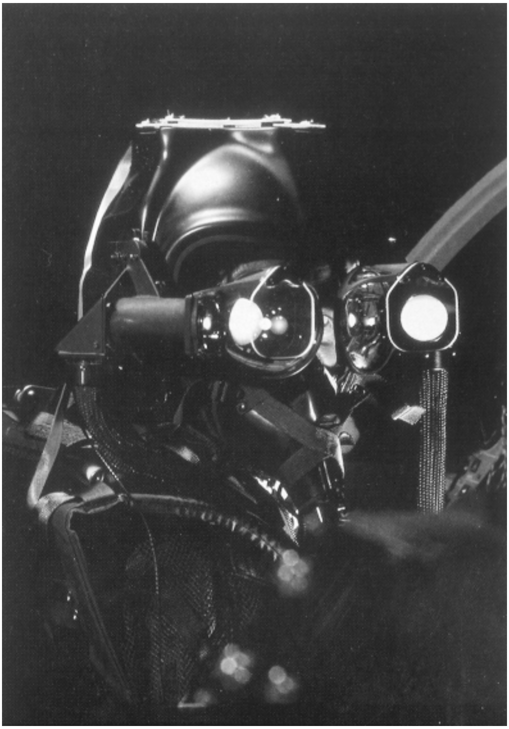


Figure 4.14 A pilot in the Tornado OFT wears a CAE helmet-mounted display. *Military Systems & Trainings News,* no. 1 (fall 1999/winter 2000): p. 7.

museums, which are, on their own admission, future models for the Internet. The majority of exhibitions of interactive art use systems of this kind. However, a precondition for telepresent access to virtual reality applications via the networks is new cables, for example, glass fiber, worldwide.[120] Further, new tools for data compression and standards for bandwidth are needed, as both are important for speed of data transmission and image quality. Currently, telecomunications companies are investing large sums of money to achieve these goals. To put networks in place that will enable high-speed exchange of data on wide bandwidths, companies in the United States, Japan, and Europe have already committed themselves to investments of several hundred billion U.S. dollars.

This close-knit fabric of economic and technological interests, sensation-seeking, and escapism has all but banished the military origins of this

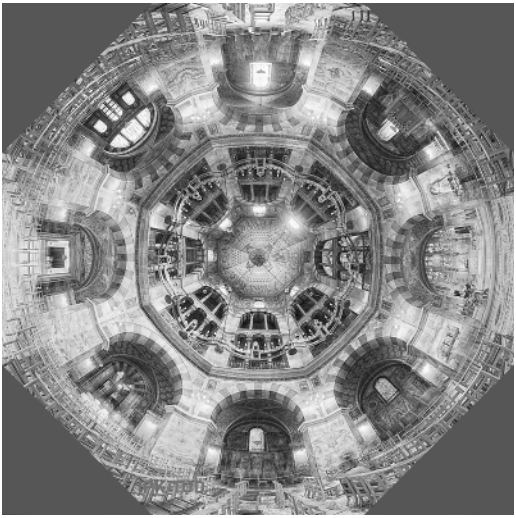


Figure 4.15 Octagon of Aachen cathedral. Photomontage of 20 fisheye shots taken by Dr. Rolf Dieter Düppe. Institut für Photogrammetrie und Kartographie der TU Darmstadt.

technology from public consciousness. To cite but two examples: In the 1980s, the McDonnell Douglas Corporation developed an HMD, which enabled pilots to double their quota of "kills."[121] The U.S. Air Force has used flight simulators for years in pilot training, and even back in 1991, these were capable of such realism that the pilots' adrenalin levels were higher in the simulators than when flying real missions during the Gulf War (fig. 4.14).[122] In addition to this staple application in military aviation, simulation models were also developed for the navy and the army by Bold Beranek and Newman Inc., largely supported by funds from the defense budget: The SIMNET network allows U.S. forces to simulate battles in which over 1000 tanks are deployed. Before combat in the Gulf War and the intervention in Somalia, the armed forces practiced simulated maneuvers. A similar network was installed for the U.S. Air Force, the Aircrew Combat Mission Enhancement Network (ACME). The German Bundeswehr uses the AGPT system, which provides simulations after the manner of SIMNET but with better quality graphics. Installed in mobile containers, it can be transported to anywhere in the world.[123] The U.S. Army works with virtual reality environments for tens of thousands of participants with simulations that are highly realistic.[124] In addition to investments by the military complex and the space industry, in the early 1990s, particularly the electronics and information sectors of civil industry invested heavily. Of particular interest were applications for developing prototypes faster, simulating industrial production processes, constructing walk-in simulations of the built environment from the past, present, and future (fig. 4.15), visualizing scientific research results,[125] and simulation-aided research.[126] Many commercial companies have their own virtual reality research departments that are tailored to their specific requirements. This does not only include telecommunications and software firms[127] or the giants of the entertainment industry, such as Disney, Nintendo, and AOL Time Warner, but also traditional industries, such as automobile manufacturers and civil aviation. Medicine uses the new technological applications in a wide variety of fields. Further, hitherto inaccessible sections of the market are being opened up, not only in more remote regions, by the introduction of e-commerce.[128] Producers and consumers are brought together on a global scale, with all the positive and negative effects for disparate economies that ensue from these encounters. The entertainment sector was the first to develop marketable virtual reality applications.[129] Almost without exception, the leading finance and economics journals have published reports on virtual reality technology; the general drift being that there is hardly an area where this polysensory medium cannot be utilized. R&D of virtual computer worlds has become a globe-spanning project, and a list of the institutes, companies, and organizations involved would fill an entire chapter of this book.[130] Therefore, I shall present a few examples of leading institutes where artists are involved in research, have developed new forms of interaction and interface designs for virtual spaces and telepresence models, and are working on the future of the Internet: a network that will allow access to immersive spaces of illusion.[131]

Art and Media Evolution I

In the mid-1980s, artists of interactive works, such as Jeffrey Shaw, Lynn Hershman, Grahame Weinbren, and Myron Krueger, worked for the most part alone. By comparison, virtual art developed at first in a few research institutions that were equipped with the necessary, very expensive technology. Thirty years after C. P. Snow introduced the idea of two cultures,[132] the distinct contours of the boundaries between technology and art began to break down. Today, a global network of artists work in privileged research institutes on the development of virtual realities.

In the early 1990s, when lower-cost high-performance computers came on the market, it became possible to depict naturalistic three-dimensional bodies with up to 500,000 polygons. Silicon Graphics Workstations introduced the possibility of real-time operations, which also allowed interactive simulations.[133] Installations were created that not only put the observer more intensely *in the image* but, through elaborate interactions, involved the observers in the actual creation of the work itself. Artists working at well-equipped research institutes, such as Monika Fleischmann and Wolfgang Strauss, Christa Sommerer and Laurent Mignonneau, Charlotte Davies, Ulrike Gabriel, Agnes Hegedues, Knowbotic Research, Peter Weibel, Paul Garrin, Christian Möller, Edmond Couchot, Jean-Louis Boissier, and Toshio Iwai, achieved international recognition.

As early as 1991, the Banff Center for the Arts in Canada decided to let artists develop and open up virtual reality technology actively. The result was a program, scheduled for two years, for realizing sections of artistic projects. From 1991 to 1994, virtual installations, such as *The Placeholder* by Brenda Laurel und Rachel Strickland, *Inherent Rights* by Paul Yuxweluptun, and *Archeology of the Mother Tongue* by Toni Dove and Michael MacKenzie, were among the artworks created within this framework.[134]

One of the most important research institutions for virtual reality is Carnegie Mellon University's SIMLAB. Under the directorship of the late Carl Eugene Loeffler, virtual environments were developed that could be experienced simultaneously by several users, for example, via telepresence, "inhabited" by artificial agents, and controlled by A-Life programs. Loeffler enriched technology with artistic concepts as, for example, in the installation *Virtual Ancient Egypt*.[135] In collaboration with the Egyptologist Lynn Holden and the Center for Creative Inquiry team of Carnegie Mellon University, Loeffler created the simulation of an ancient temple, the installation *Virtual Ancient Egypt: Temple of Horus*. According to Holden, this was the first module of a large-scale project, *Virtual World of Antiquity*. Using the latest photographs of the excavations, they reconstructed the 60-foot-high walls and pillars of the Temple of Horus, including the many chambers. By clicking on certain points on the walls, the user could activate animations and in the innermost shrine a statue revealed the chamber's secrets to background music of Egyptian chants.

In 1967, Gyorgy Kepes, a friend of Laszlo Moholy-Nagy, founded the Center for Advanced Visual Studies (CAVS) at MIT, which aimed at high-level cooperation between art and technology. Having worked at the New Bauhaus, Kepes was firmly committed to interdisciplinarity. This is also reflected in his six-volume work *Vision and Value*, where he outlines an attempt to overcome the specialization of the modern age through integration and synthesis of art and technology. Kepes's intention was to develop a language of vision. To this end, he included findings from biology, experimental psychology, anthropology, communication theory, linguistics, engineering, and relational mathematics. However, the technology-centered Architecture Machine Group at MIT soon eclipsed the CAVS model, both in standing and securing research grants.[136]

Internationally, the University of Geneva's MIRALab, directed by Nadia Magnenat-Thalmann, holds a top position in the field of 3-D animation. This applies particularly to applications such as the simulation of naturalistic body movements in realtime, facial expressions, and the highly complicated animation of materials and objects.[137] Present research focuses on constructing virtual environments populated by avatars, which can be accessed from distant locations via high-performance networks.

In 1986, the Japanese telecommunications corporation NTT and the Japanese government in Kyoto founded together the Advanced Technology Research Institute (ATR) for the purpose of developing virtual reality technology for telecommunication.[138] In the institute's artist in residence program, Christa Sommerer and Laurent Mignonneau work on the design of new interfaces and innovative forms of interaction. Programmatically, the president of the ATR laboratory, Ryohei Nakatsu, stresses that the cooperation of art and technology is focused on developing highly complex methods of communication, including sensitive, nonverbal interaction. In his address at the opening of the ATR-Science-ATR Congress in May 1996 in Kyoto, Nakatsu stated that "It is indispensable to study the mechanism of interaction and to develop technologies that can realize highly human-like communication by integrating communication and interaction technologies as well as interactive arts."[139]

When they applied virtual reality technology to architecture and urban planning, the Berlin association ART+COM, founded in 1988, broke new ground.[140] In addition to interactive installations, such as *Zerseher* (1991) by Joachim Sauter and Dirk Lüsebrink,[141] the same year saw Monika

Fleischmann and Wolfgang Strauss' first virtual reality work, *The Home of the Brain*. In Germany, virtual reality research is concentrated mainly in the Fraunhofer Institutes in Stuttgart (FhG-IGD, IAO), the Zentrum für Graphische Datenverarbeitung (ZGDV)[142] in Darmstadt, German Aerospace in Oberpfaffenhofen (primarily telerobotics research), and the Fraunhofer Institut in Sankt Augustin near Bonn.[143] Fleischmann, who works closely with Strauss, became artistic director of the GMD's Institut für Medienkommunikation in 1992, where the main research focus is to develop interactive virtual scenarios and innovative interface design for human-machine communication.

Roy Ascott, one of the foremost pioneers of interactive art,[144] founded the Centre for Advanced Inquiry in the Interactive Arts (CAiiA) at the University of Wales in Newport, where he established an international joint research program, CAiiA-STAR, which allows media artists to gain a Ph.D. A significant number of internationally important media artists participate in this program, artists who normally work in high-tech institutes on the development of new interfaces, interactive models, and visual strategies and who are playing a decisive role in the design of the high-performance future of the Internet.[145] His position as director of this program, which attracts so many leaders of cutting-edge research in media art, confers on Ascott the role of *spiritus rector*, who gives the younger generation of visualization developers of the new millennium a wealth of new impulses, consolidated further in the series of meetings entitled Consciousness Reframed initiated in 1997 by Ascott.

In addition to the artist in residence programs of the research laboratories, there are the important festivals that have nurtured and promoted interactive art—events such as Ars Electronica,[146] Interactive Media Festival, Siggraph,[147] Imagina,[148] and the Biennales of Kwangju,[149] Lyon, Nagoya,[150] and St. Denis.[151] In Germany, media art has received suppport since the 1980s. With the foundation of the new Kunsthochschule für Medien (KHM)[152] in Cologne, the Hochschule für Graphik und Buchkunst in Leipzig, the Institut für Neue Medien[153] in Frankfurt, and particularly the Zentrum für Kunst und Medientechnologie (ZKM)[154] in Karlsruhe, Germany, along with Japan, is among the foremost pioneers of media art. Japan's institutions include the InterCommunication Center (ICC)[155] in Tokio and the International Academy of Media Arts and Sciences (IAMAS)[156] in Gifu.

Notes

1. See Wheatstone (1838).

2. See Witasek (1910), pp. 167ff.; Kemner (1989); Tokyo (1996b).

3. See Sagner-Düchting (1985), pp. 55ff.

4. Monet worked on this theme for many years, and in 1921, he had over 50 waterlily paintings in his atelier that could be combined in a variety of ways.

5. Dezarrois speaks of visitors being "plongés dans un aquarium lacustre," in "Les Nymphéas de Claude Monet à l'Orangerie des Tuileries," *Illustration*, March 21, 1927, p. 548, cited in Sagner-Düchting (1985), p. 61.

6. "Le panorama se déroule d'une façon interrompue, en cercle autour du spectateur." See M. Elder, *A Giverny chez Claude Monet*, Paris, 1924, p. 79, cited in Sagner-Düchting (1985), p. 60.

7. For the artistic policies of the Futurists, see Falkenhausen (1979).

8. See Prampolini (1924), p. 7: "Questa nuova *costruzione teatrale* per la sua ubiacazione permette di fare sconfinare e *l'angolo visuale* prospettico oltre la linea d'orizzonte, spostando questo al vertice e viceversa in simultanea compenetrazione, verso una irradiazione centrifuga di infiniti angoli visuali ed'emotivi dell'azione scenica."

9. Ibid.

10. See L. Moholy-Nagy, "Theater, Zirkus, Variete," in Wingler (1985), pp. 54ff.

11. Ibid., p. 55.

12. See Schwitters (1973–1981), vol. 5, pp. 39ff.

13. See Prampolini (1924), p. 7.

14. Ibid.

15. “Ritengo quindi che l’intervento dell’attore nel teatro quale elemento di interpretazione, sia uno dei compromessi più assurdi per l’arte del teatro.” Printed in boldface in the original, ibid., p. 7. In his *Magnetic Theatre*, Paris 1925, Prampolini replaced the actors with light effects.

16. “Ogni *spettacolo* sarà un *rito meccanico* dell’eterna transcendenza della materia, una rivelazione magica di un mistero spirituale e scientifico.” Ibid.

17. “Una sintesi panoramica dell’azione, intesa come un rito mistico del dinamismo spirituale. Un centro di astrazione spirituale per la nuova religione dell’avvenire.” Ibid.

18. Arnheim (1933), pp. 129–133.

19. See Kaes (1979).

20. Benjamin (1974). Panofsky had already raised the issue of reproduction in 1930 in his essay, “Original und Faksimilereproduktion.” He wrote a critique of Benjamin’s ideas, first published in the Hamburg journal *Der Kreis*, long before the Nazi movement began to gain in strength. See Panofsky (1930).

21. Panofsky (1936). On this subject, see “Regine Prange, Stil und Medium,” in Reudenbach et al. (1992), pp. 171–190.

22. Nevertheless, all his life as a researcher, Arnheim believed that the tendency of increasingly perfect film images, as a technical illusion that covered the view of our world, possessed a threatening character for the sphere of art. See Arnheim’s preface to the revised 1974 German edition of his (1933).

23. See Arnheim (2000), pp. 167ff. This essay was, as Arnheim put it in our correspondence, “already written with a view to the new millennium, so I was thinking of the coming generation and of your generation.” Letter written in Ann Arbor, dated August 5, 2000, private archive of the author.

24. Friedberg (1993), pp. 84ff.

25. See Bordini (1981), pp. 101ff.

26. For an impressive list of the panoramas shown at the World Exhibition Paris 1900, see Malkowsky (1900), pp. 28, 131–132, 238–240, 474–475.

27. An advertisement for EXPO 2000 reads: “The journey into the fascinating world of the media ‘Planet m—media for people’ begins with a ride in the largest elevator in the world. The ‘Space Lift’ will take you and 200 other visitors into the inside of the planet. In a Multivisions Show you will experience the development of the media speeded up, from cave paintings to the Internet.” See ⟨http://www.expo2000.de/cgi-bin/db4web_c/ibis/sdocs/tn/docs/tn_index.mth?spr_id=2&filter_id=4&tn_id=301028⟩.

28. The description of the EXPO contains the following: “Canvases, above, below, right, left, in front, behind: films in 2 × 360 degrees. Six bridges allow access to the space. Bridges with symbolic character: ‘bridges to the future’.... The film shows pictures from recent German history; however, mainly from the present and the future. The starting point is a neighborhood party in the courtyard of Berlin apartment building. Germany is be experienced ‘at close quarters’.... The 720-degree film event ‘Deutschland mittendrin’ was designed by the Stuttgart Agency of Mila and Partner, in cooperation with KuK Filmproduktion, Munich.” See ⟨www.deutscher-pavillon.de/cont2.html⟩.

29. See Roth et al. (2000), vol. 1, pp. 88ff., and Nouvel (2000).

30. Roth (2000).

31. Hayes (1989), p. 3.

32. Monaco (1980), p. 348.

33. See Brownlow (1997), p. 26; Toeplitz (1979), p. 18; Toulet (1995), p. 17. For a different viewpoint, see Loiperdinger (1996). Maxim Gorki, who had been to shows at the Cinématograph Lumière in Novgorod in the summer of 1896, wrote: “A railway train appears on the screen. Like an arrow, it streaks directly towards you. Watch out! It seems to be heading exactly for the darkness where you are sitting, to turn you into a shredded bag of skin, full of squashed flesh and splintered bone, to reduce the room to ash and rubble, and destroy the building.” See I. M. Pacatus, “Brief notes, Nizegorodskij listok, Niznij-Novgorod,” no. 182, July 4, 1896, cited in *KINtop*, 4 (1995): 13. Decades later, the effect on people who were confronted with the medium for the first time hardly differed. For example, in

1931, a dozen farmers were injured in the Romanian village of Goerovesti in the panic that broke out during the first film show.

34. "The beholder is apt to identify himself with a protagonist to whom he feels sympathy, and this means he puts himself at the point of observation of the protagonist as I have described." Gibson (1986), p. 295.

35. Zielinski (1999), p. 92.

36. At the Paris World Exhibition of 1900, the Lumière brothers revisited the panorama. They exhibited the photorama, where projected images replaced the painted pictures: a panoramic slide projection of a film strip, about 90cm long and 11cm high, in the form of a cylinder approximately 29cm in diameter. Twelve lenses combined with mirrors revolved around the slide and projected the picture piece by piece onto the screen at such speed that the impression of a complete circular image was created. See Zglinicki (1979), p. 106.

37. "A film is an emotional reality, and that is how the audience receives it—as a *second reality*. The fairly widely held view of cinema as a system of signs therefore seems to me profoundly and essentially mistaken." In Tarkovsky (1986), p. 176.

38. Ibid., p. 172.

39. Before the advent of the stereo film, slides were projected in three dimensions. With the laterna magica, these images spread all over the world from the seventeenth century onward. See Robinson (1993); for a more recent view, see Klaus Bartels, "Proto-Kinematographische Effekte der Laterna Magica," in Segeberg (1996), vol. 1, pp. 113–147.

40. See Hayes (1989), p. 5.

41. Ibid., p. 9.

42. Ibid., p. 11.

43. During Eisenstein's lifetime, only a short passage from this essay appeared in the Russian magazine *Iskusstvo kino* (Art of the cinema), 1948, no. 2: 5–7.

44. "To doubt that stereoscopic cinema has its tomorrow is as naïve as doubting whether there will be tomorrow at all." See Sergei Eisenstein, "Über den Raumfilm," in Eisenstein (1988), p. 196. (English translation Eisenstein 1949.)

45. Ibid., pp. 197ff.

46. Ibid., p. 199.

47. Ibid., p. 235.

48. Ibid. Already in 1940, Eisenstein had the idea of surrounding the audience in the cinema with loudspeakers. In the same period, Walt Disney realized this aesthetic effect for his film *Fantasia*.

49. Ibid., p. 207.

50. Ibid., p. 201.

51. Ibid., p. 210.

52. Eisenstein mentions historical attempts (Richard Wagner's multimedia conception of the *Gesamtkunstwerk*, is not included) to remove the barrier between spectator and theatrical action: *The Monodrama* (1910) by Jewreinov, for example, tried to convey the feelings expressed on the stage to the audience as absolutely as possible through an intermediate device, in this case, a moving chorus (pp. 240ff.). Its function as a link is reminiscent of the *faux terrain* of the panorama. Eisenstein emphasizes that this idea is found in many cultures: In Japanese Kabuki theater, for example, there is the *hana michi*, the flower path, which functions as a bridge between the audience and the actors. At decisive moments in the drama, action moves to the *hana michi*. Through bringing his face in close up to the audience, the actor can use this proximity to get through to them; ibid., p. 226.

53. Ibid., p. 208.

54. Shortly before, Eisenstein was awarded the Stalin Prize for the first part of *Ivan the Terrible*. However, in 1946, the Central Committee of the Communist party banned screenings of Part II on ideological and aesthetic grounds.

55. There are dozens of examples; see Hayes (1989).

56. See Heilig (1992).

57. Ibid., p. 283.

58. Ibid., pp. 284ff.

59. See also Comeau et al. (1961).

60. See Halbach (1994a), pp. 231ff.; (1994b), pp. 190ff.; and the detailed account in Lipton (1964).

61. See Fisher (1991), p. 103; Burdea (1994), pp. 5ff. Burdea's view, that the Sensorama marks the beginning of virtual reality's prehistory, is in my opinion too narrow.

62. Krueger (1991a), p. 66.

63. For a detailed history of olfactory cinema, see Anne Paech, "Das Aroma des Kinos: Filme mit der Nase gesehen: Vom Geruchsfilm und Düften und Lüften im Kino, 1999," at 〈http://www.uni-konstanz.de/FuF/Philo/LitWiss/MedienWiss/Texte/duft.html〉.

64. See Max (1982).

65. Gibson (1986), p. 184.

66. The IMAX cinema at the Technisches Museum in Munich counted over a million visitors in 1997, and in the same year, the IMAX cinema in New York was the most successful cinema worldwide. See Wolf (1998); and Donna Cox, "What can artists do for science: Cosmic voyage IMAX film," in Sommerer and Mignonneau (1998a), pp. 53–59.

67. On the early history of the computer, see Pierre Lévy, "Die Erfindung des Computers," in Serres (1994), pp. 905–944, and the excellent exhibition catalog Steyr (1993), used by many histories of the computer as a reference work. For general information on the computer's military origins, see Coy (1994).

68. Wiener (1961).

69. Turing (1950).

70. Licklider (1960, 1968).

71. See R. M. Fano, CBI Interview OH 165, interviewer Arthur L. Norberg, April 20, 1989, Cambridge, Mass.

72. McLuhan (1964).

73. Ivan E. Sutherland, "Sketchpad: A Man–Machine Graphical Communication System," MIT Lincoln Lab, TR 296 (Jan. 1963); also available at 〈http://www.realtime-info.be/encyc/techno/terms/81/83.html〉.

74. Sutherland (1965), p. 508.

75. Ibid.

76. Ibid.

77. Michael Noll, who had worked at Bell Telephone Laboratories since 1961, published in the same year his proposals for 3-D computer films: Noll (1965a), p. 20, and Noll (1965b). Noll had already recognized the possibility of calculating the spatial coordinates for films with 20 images per second without time lag. See also M. Noll, "Computers and the visual arts," in Krampen et al. (1967), pp. 65–79.

78. Head-mounted electromagnetic sensors had already been used by the Philico company in a telepresence system in 1961: See Comeau et al. (1961).

79. Shocked by the success of the USSR's *Sputnik*, ARPA was given the power and means to take fast action in support of projects that would regain the technological lead for the United States in the arms race between the Superpowers. See also Woolley (1992), p. 53.

80. Charles Seitz had just developed the ultrasound sensor at MIT's Lincoln Lab.

81. Sutherland (1968), p. 757.

82. Additionally, there were Wolf Vostell's *Electronic Happening Room* (1968) and Aldo Tambellini and Otto Piene's *Black Gate Cologne* (1968); see also Henri (1974b). In her study of Jeffrey Shaw's work, Söke Dinkla sees his early inflatable

Corpocinema (1967) as belonging to this movement. The *Corpocinema* was a walk-in polyvinyl environment with slides, film, and light projected onto its skin; see Dinkla (1997), pp. 98ff. and Anne Marie Duguet, "Jeffrey Shaw: From Expanded Cinema to Virtual Reality," in ZKM and Klotz (1997), pp. 21–33.

83. See Youngblood (1970), p. 361.

84. Ibid., p. 371.

85. Ibid., pp. 187ff.

86. Ibid., p. 52.

87. Ibid., p. 189.

88. In 1964, the young student of architecture, Nicholas Negroponte, had the idea of developing a machine that would optimize architects' planning operations and thus would need to be in close interaction with the user. In 1967 he founded the Architecture Machine Group at MIT, from which the MediaLab developed later. Their early research made important contributions to the development of CAD technology and other areas in the development of sensory interfaces.

89. See Negroponte (1972).

90. See Negroponte and Bolt (1976).

91. Bolt (1984). Yeates argues that the basis of all memory is the imagination's organization of space, i.e., spatially organized memory, such as in a temple or a theater. Moreover, memory spaces assume the presence of the rememberer or thinker *in* the memory. On the early link-up of the computer with psychology, see Hersh and Rubinstein (1984).

92. Reichardt (1969).

93. See Dinkla (1997), pp. 76ff.; Myron Krueger, "Responsive Environments," in Korfhage and Isaacson (1977), pp. 375–385; and Krueger (1983).

94. See D. C. Smith et al., "The star user interface: An overview," pp. 1–14 in *Designing the Star User Interface*, at 〈http://jupiter.information.umn.se/nijsow/

ucipd/smith.html⟩. See also ⟨http://www.cs.cmu.edu/~amulet/papers/uihistory.tr.html⟩.

95. Under Furness's direction, the technology was developed at the Wright-Patterson airbase. The result was the first VCASS system (Visually Coupled Airborne Systems Simulator) in 1982. See also T. Furness, "The Supercockpit and Its Human Factors, Challenges," in Perlman et al. (1995), pp. 38–42.

96. The Atari Lab, whose philosophy was to develop technological visions for the next two decades, assembled at this time researchers such as Brenda Laurel, Michael Naimark, and Erich Gullichsen, some of whom, e.g., Laurel and Naimark, later made themselves a name as artists.

97. See T. Zimmerman et al., "A Hand Gesture Interface Device," in Carroll (1987), pp. 189–192.

98. Brenda Laurel was quick to see the computer's potential for staging virtual experiences in artificial spaces in real time. See Laurel (1991). Laurel's book is already a classic that summarizes contemporary ideas on the interface and interaction.

99. The data glove is basically the further development of the mouse. The input medium could be, for example, a video camera.

100. Their predecessors, today in general use, are the graphic user interfaces (mouse, windows, and menus), which were developed by Doug Engelbart among others in the early 1970s at the Palo Alto Research Center (PARC) and the Stanford Research Center, supported by ARPA grants. Another forerunner of the data glove is the pointer that Daniel Vichers developed for the HMD.

101. On the work of this institution, see Ellis (1991).

102. Fisher and McGreavy et al. (1986).

103. Marvin Minsky envisioned a telepresence system in his (1980).

104. See (1992), pp. 109ff. Potential applications are research and work in dangerous or inaccessible places, such as in space, on the seafloor, the battlefield, and so on.

105. See Gibson (1990 [1984]).

106. Gibson said in an interview, "it never occurred to me that it would be possible for anyone to read these books and ignore the levels of irony." Cited in Guilliatt (1989).

107. In the vicinity of Los Angeles, Autodesk was founded in 1982; VPL Research in 1984, in 1990, Sense8 and the VR game manufacturer W-Industries in England.

108. See Walser (1988); Walker (1988), pp. 9ff.; Bricken (1989).

109. See Lanier (1989).

110. See Gullichsen et al. (1989).

111. According to a report in *Business Week*, October 5, 1992, VPL and Sense8 together employed a mere 33 staff members, a figure that demonstrates the miniscule proportions of these firms compared with the armaments and space industry.

112. Analyzing this new medium, the media theorist Gene Youngblood remarked with millenarian rhetoric: "The 'wonder' before which we stand is not the urban space but the dematerialzed space of electronic sociality in which we shall move at the speed of light. Any praxis that does not set itself the task of investigating this space does not deserve the predicate 'avant-garde.'" In Youngblood (1989), p. 83. Youngblood continues with Futurist jargon: "Entering virtual space is clearly future-oriented and dedicated to the praise of future generations. The new avant-garde is striving to bring about a new Renaissance—a new civilization," ibid., p. 84. In a similar vein, Morgan Russel prophesied a new image of the human being: "Once we human, all too human, beings begin spending much time in VR, we will become new creatures. As we mould ourselves in a way which may not even be discerned until we have already become something manifestly different from what we are now." Russel, "VR everywhere," in Linz (1990) (exhib. catalog), vol. 2, p. 217. Jaron Lanier of VPL expected technological innovation to end racial discrimination: Virtual reality for him means the absolute abolishment of class and racial differences as well as all other forms of pretext for all forms are changeable. See Lanier, "Was heißt 'Virtuelle Realität,'" in Waffender (1991), p. 83. See also Walser (1990, 1991). And the "drugs guru"

of the 1970s, Timothy Leary, managed to hit the headlines once again with similarly drastic ideas: "In the cyberworld, you'll be having competitions, love affairs. . . . Everybody will more and more be communicating with the global language of icons. Literacy will be as quaint as baby talk." See "Timothy Leary in an interview with *UPSIDE*," David Sheff, in Linz (1990) (exhib. catalog), vol. 2, p. 250. These ideas also surface in movies, such as *The Lawnmower Man* by Brett Leonard (1992); *Strange Days* (1995); *The Net* (1995); *Virtuosity* (1995); *Johnny Mnemonic* (1995); and *The Matrix* (1998), all published on the Net. This list is not exhaustive; dozens more could be added.

113. For example, the report in the *Wall Street Journal*, Jan. 23, 1990, pp. 1 and A9.

114. Myron Krueger's term "artificial reality" was less successful; see Krueger (1991).

115. Still of interest in this connection is Doren (1927).

116. An invocation of the age-old myth of creating artificial life; see Bredekamp (1992a).

117. See Alvin Toeffler et al., "Cyberspace and the last American Dream: A Magna Carta for the Knowledge Age," ⟨www.townhall.com/pff/position.html⟩, p. 7, and Toffler and Toffler (1995).

118. Bundesministerium für Wirtschaft, *Info 2000: Deutschlands Weg in die Informationsgesellschaft*, Bonn, February 1996, chap. I.1.

119. Coy (1994), p. 37.

120. See Borchers (1998).

121. See *Aviation Week and Space Technology*, August 15, 1988, pp. 94–96, and Thompson (1987).

122. See *Manager Magazin*, October 1991.

123. Thompson (1993), pp. 142ff.

124. See Macedonia (1994).

125. Gigante (1993a), pp. 8ff.

126. Molecular structures and their specific features, for example, can be simulated as an aid in speeding up research in chemistry and physics.

127. Cf. the activities of Microsoft: 〈http://research.microsoft.com/vwg/〉; for an overview, see 〈http://www.acm.org/sigchi/hci-sites/COMPANIES.html〉.

128. Mirapaul (1998b).

129. Brill (1993); Johnson (1995), pp. 22ff. The goal of a "totally immersive, visual and audio experience" is being pursued in Japan particularly by Sony, Blockbuster, and Sega (see Johnson 1995, p. 22).

130. See *The National Research Agenda for Virtual Reality*, supported by ARPA, the Air Force Office for Scientific Research, Army Research Laboratory, NASA Armstrong Laboratory, NSF, NSA, among many others. See also Durlach and Mavor (1994); IEEE (2001).

131. See Negroponte (1995). This is also the vision of Bill Gates, who is, financially, the most powerful human today; see Gates (1995), pp. 194ff.

132. Snow (1960).

133. Silicon Graphics product literature, Silicon Graphics Inc., Mountain View Calif., 1991; and 〈http://www.sgi.com/virtual_reality〉.

134. Moser et al. (1996), pp. 267–328.

135. Loeffler, "The networked virtual museum," in Loeffler (1994), pp. 31–37; and Loeffler, "Virtual Pompeii," in Breit (1996).

136. Today, MIT has the Media Arts and Sciences Program.

137. See 〈http://miralabwww.unige.ch/〉; Magnenat-Thalmann (1992), Thalmann (1994); and P. Volino, M. Courchesne, and N. Magnenat-Thalmann, "Versatile and efficient techniques for simulating cloth and other deformable objects," in Cook (1995), pp. 137–144.

138. See ⟨http://wwwatr.co.jp⟩. The shareholders, who raise an annual budget of 50 million U.S. dollars, are mainly from the telecommunications industry: NTT, NEC, Hitachi, Toshiba, etc.

139. See Sommerer and Mignonneau (1998a), p. 15.

140. ⟨http://www.artcom.de/⟩.

141. This installation, recipient of several awards, gives the user's gaze an iconoclastic dimension: When the user gazes at a particular point, the initially sharp contours begin to blur and gradually disappear. Technically, this is achieved by a camera within the image that tracks the user's gaze; the computer responds in real time and eliminates the particular sections the user is looking at. See ⟨http://www.artcom.de/projects/zerseher/welcome.en⟩.

142. See ⟨http://www.igd.fhg.de/⟩. For more about the work of this institution, see the Kongress VR '94 and Jörg Vogel, "Haptic Interfaces and Force Feedback in MIS-simulators," at ⟨http://www.robotic.dlr.de/Joerg.Vogel/Medicine/hi.html⟩.

143. ⟨http://www.gmd.de⟩.

144. Roy Ascott has shown at the Venice Biennale, Electra Paris, Ars Electronica Linz, V2 The Netherlands, Milan Triennale, Biennale do Mercosul, Brazil, European Media Festival, and gr2000az at Graz, Austria. He has been Dean of San Francisco Art Institute, California: Professor for Communications Theory at the University of Applied Arts, Vienna: and Principal of Ontario College of Art, Toronto. He is on the editorial boards of *Leonardo, Convergence*, and the Chinese language online arts journal *Tom.Com.*

145. CAiiA-STAR is a multidisciplinary institute that encompasses the following areas: performance, immersive VR, music, transgenics, A-Life, technoetics, telematics, telerobotics, mixed reality, architecture, and other emergent art forms, behaviors, and genres. Artists of international repute who are Ph.D. graduates include Dew Harrison, Joseph Nechvatal, Jill Scott, Bill Seaman, Miroslaw Rogala, and Victoria Vesna; others, who are Ph.D. candidates, are equally well known: Peter Anders, Jon Bedworth, Donna Cox, Charlotte Davies, Elisa Giaccardi, Gromala, Gilian Hunt, Pamela Jennings, Eduardo Kac, Kepa Landa, Jim Laukes, Dan Livingston, Kieran Lyons, Simone Michelin, Laurent Mignonneau, James

Norwood, Marcos Novak, Niranjan Rajah, Gretchen Schiller, Thecla Schiphorst, and Christa Sommerer.

146. ⟨http://www.aec.at⟩.

147. ⟨http://www.siggraph.org/s98/⟩.

148. ⟨http://www.ina.fr/INA/Imagina/imagina.en.htm⟩.

149. ⟨http://www.daum.co.kr/gallery/kwang/han/index.html⟩.

150. ⟨http://www.tocai-ic.or.jp/InfoServ/Artec/arte⟩.

151. ⟨http://www.labart.univ-paris8.fr/index2.html⟩.

152. ⟨http://www.khm.de⟩.

153. ⟨http://www.inm.de⟩.

154. ⟨http://www.zkm.de⟩. For an overview, see ZKM (1997).

155. ⟨http://www.ntticc.or.jp/⟩.

156. ⟨http://www.iamas.ac.jp/⟩.

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