*Claudia Giannetti*

# Media Sculpture

## The Cybernetic Condition

**Abstract**
In the twentieth century, sculpture underwent radical changes both aesthetically and technically as a result of several factors, including the influences of new scientific theories. In this text I explore synthetically some of these changes in the field of sculpture and in particular the influence of cybernetic theory on sculpture using electronic and digital technologies. I briefly analyze the impact of these transformations on aesthetic theories.

**Key Words**
Media sculpture, cybernetics, media art, art, science, technology, contemporary aesthetics, cybernetic aesthetics, Moholy-Nagy, Schöffer, Paik, Bense, Cordeiro, Palatnik

Matter, form, and space have been central concerns for sculptors, along with the techniques, content, and aesthetics pertaining to each historic moment. The way that artists have interpreted and worked through them has varied enormously. After thousands of years dominated by techniques involving sculpting, engraving, modeling, or carving, sculpture underwent radical, paradigmatic changes in the twentieth century. Among them, emerging twentieth-century scientific theories had a considerable influence on the arts in general and on sculpture in particular. Along with quantum physics and Einstein's spatial-temporal relativity emerged another theory, which was one of the most significant from the late 1940s onward: cybernetics. In this text, I synthetically explore some of these influences in the field of sculpture, and more specifically on sculpture that makes use of electronic and digital technology. Due to the limited length of the text, I have to refrain from in-depth analyses and interpretations of the artworks mentioned as examples. The selection of artists cited is also rather restricted, chosen according to the criterion of exemplarity. I would nonetheless like to apologize for the many and rather evident omissions in this brief essay.

The thought of Michelangelo Buonarroti was paradigmatic for various generations of sculptors. According to the Renaissance artist, sculptural form was virtually contained within the block of stone, making it necessary to liberate it from material excess, allowing it to emerge. The sculptor's work was carried out with and as a function of the material, whose final form, whose solid, three-dimensional volume, was in dialogue with space and the artist's iconological conception.

This gesture is the translation of the idea to matter mediated by manual labor. The sculptor's gesture seeks to reveal information hidden in the matter. This is the gesture that traditionally accompanies the act of sculpting.

In the twentieth century, certain sculptors introduced a fourth fundamental factor: spatial-temporal dynamism. Notions derived from physics, namely simultaneity, energy, and mobility, were explored in the visual arts. Meanwhile, conventional sculptural concepts, such as line, volume, and mass, lost some of their prominence, as is made explicit in Naum Gabo and Antoine Pevsner's 1920 manifesto of Constructivist practices.[1] They sought, rather, rhythm and depth with their new spatial-temporal forms.

Starting in the 1920s, apart from Gabo, László Moholy-Nagy had the pioneering vision to consider the play of movements and effects of light and shadow, projected into space by kinetic-luminous objects, as key motifs of the sculptural piece, quite beyond the object in itself, its materiality, and mechanics. The dynamism and fluidity of the forms derived from the projection of sculptural features in motion onto the walls over time and space became essential to the work. Rather than proposing a model, Moholy-Nagy put forth a kinetic-constructive system to allow for the "recognition of a space condition which is not the result of the position of static volumes, but consists of visible and invisible activities of forces, e.g., of phenomena of movement and the formations that movements take; and may thus under certain conditions consist of fields of force."[2]

His positions were constituted as an essential starting point for the process of the dematerialization of the sculptural object. Like the scientific theory that establishes the equivalence between mass and energy, Moholy-Nagy defended the substitution of arts of the mass—the inert physical object—for relational fields or spatial relationships. The rigid separation between exterior and interior, which was part and parcel of finished, permanent pieces, had to be subjugated by simultaneous interpenetration, enabled by latent relational forces in the materials. This new occupation of space was not only intangible, but also

1 Naum Gabo with Antoine Pevsner, *Realistic Manifesto* (Moscow: Second State Printing House, 1920).

2 "Der Anerkennung eines Raumzustandes, der nicht das Ergebnis der Lagebeziehungen von starren Volumen ist, sondern von sichtbaren und unsichtbaren Wirksamkeiten der Bewegungstatsachen und Bewegungsformationen, unter Umständen also aus Beziehungen von Kraftfeldern besteht." László Moholy-Nagy, "Von Material zu Architektur – Der Weg zum Erlebnis von Plastik und Architektur," *Bauhausbücher*, no. 14 (Munich: Albert Langen Verlag 1929), p. 202. Facsimile available at: https://digi.ub.uni-heidelberg.de/diglit/moholy_nagy1929/0208. English translation from: László Moholy-Nagy, *The New Vision: Fundamentals of Bauhaus Design, Painting, Sculpture and Architecture* (New York: Dover Publications, 2012).

processual, interrelational, transitory, and ephemeral in time. Equally revolutionary was the introduction of the parameter of performativity in the context of sculpture.

Three decades later, Jorge Oteiza revived the principles of physics and the relation between mass and energy to propose a further step toward "trans-sculpture." For the Basque sculptor, in artistic terms, time was terrified by space. Therefore, the arts always sought to spatialize time by trapping, immobilizing, and appropriating it. The result was a work that would be increasingly concerned with physical space. In contrast, for Oteiza, the sculptor's work meant the creation of a void through the liberation or de-occupation of space, experimenting with the negative, leading to the very renouncement of the classic spatial conception of sculpture.[3] His posture made it possible to open up another path altogether.

The gesture of liberation is the gesture of exploration. Hands renounce being transformed into a medium, into an instrument of the prolongation of the idea in the material (volume and mass). It is a gesture whereby, rather than extracting form from matter, one wields the concepts of noninformation and information.

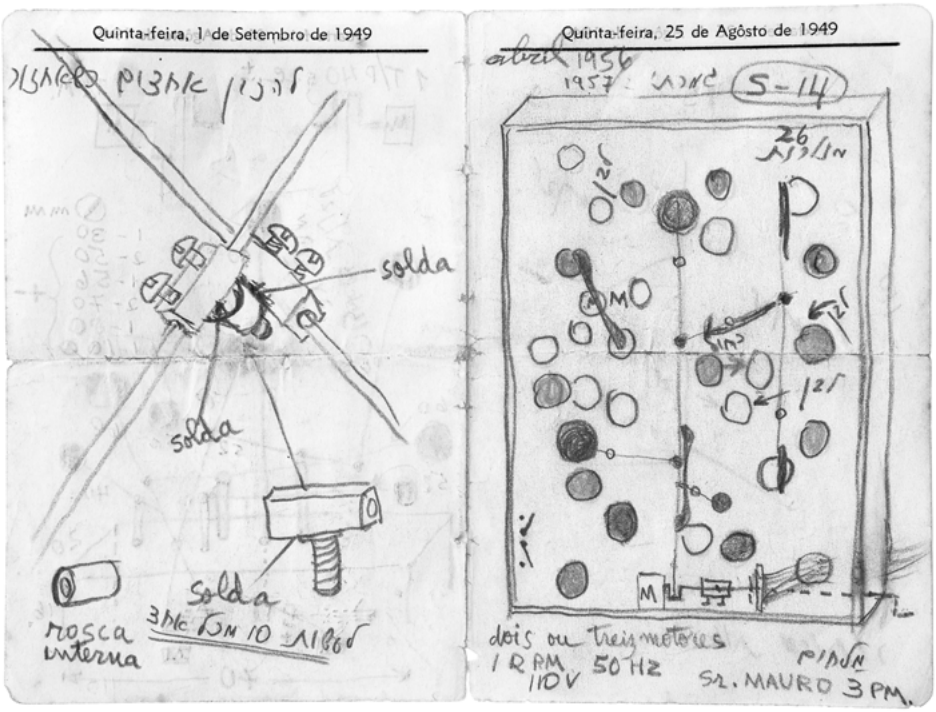
These are just three different examples of possible ways to approach the phenomenon of sculpture.

Another fundamental shift was driven by the incorporation into the arts of period-specific electronic and digital resources, as well as their corresponding materials, artifacts, techniques, and methods. The changes in artistic productions were diverse and profound. Here I will focus solely on the influence of cybernetic theory, and especially on its notion of open systems, on new sculptural conceptions including technological resources, starting in the 1950s.

Cybernetics, as a cross-science that considered the interrelation of various forms of knowledge that, until the 1950s, had been isolated in different scientific specializations, was a factor driving processual and transdisciplinary practices. What most attracted the attention of various artists from the period were factors such as indetermination, feedback, experimentation, and pluri-mediality.

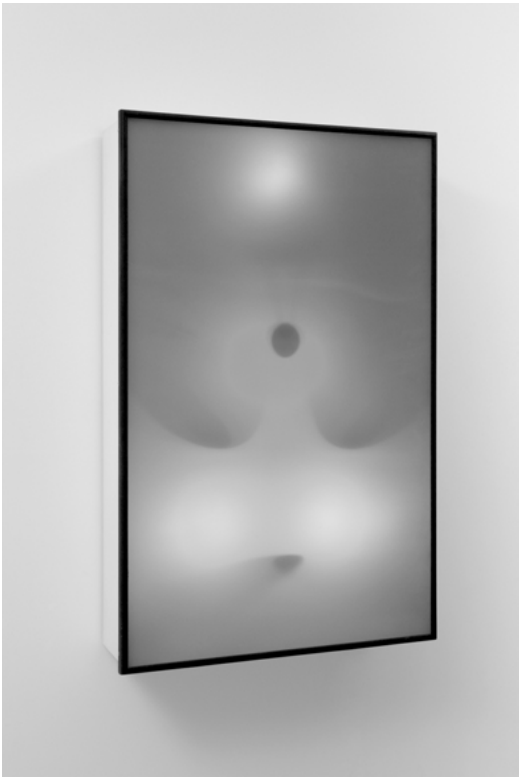
*Information* became a key parameter for the understanding of aesthetic processes and for the structuring of those new artistic positions, influenced mainly by the cybernetic theories of Norbert Wiener. From the mid-1950s on, artists inspired by cybernetic approaches, such as Abraham Palatnik, Nicolas Schöffer, Nam June Paik, Gustav Metzger, and Les Levine, appropriated its methods and revolutionized the field of sculpture.

3 Txomin Badiola, *Oteiza: catálogo razonado de escultura* (San Sebastián: Nerea, 2016). See also the interview with Jorge Oteiza, "El espacio y el tiempo en la escultura" (ca. 1988), Museo Oteiza, https://www.museooteiza.org/jorge-oteiza/ also "Jorge Oteiza: El espacio y el tiempo en la escultura," YouTube video, April 3, 2013, uploaded by Museo Oteiza, https://www.youtube.com/watch?v=dXFUYyo3KRc&t=128s (accessed February 10, 2023).




1 Abraham Palatnik, Desenho para o projeto de peça *Cinecromática 02*, Item 29 (Drawing for the piece project Cinecromatic 02, Item 29), April 1956. 110 × 70 × 20 cm.

The Brazilian artist Palatnik carried out pioneering research into the relation between art, science, and technology, as well as in the development of participative art. His research first took on a sensorial form, in his kinetic-objectual series of *Aparelhos Cinecromáticos* (Cinechromatic Devices) from 1949 (figs. 1, 2). Later on, he disarticulated the traditional references of two- and three-dimensional works, implementing the variability and transformation of forms, colors, and visual fields by means of movements created through mechanical, electric, and luminous complexes. In these works, created starting from 1959, he explored viewer participation, such as with magnetic fields in various works from the series *Mobilidade* (Mobility). In 1962, he constructed the object-game *Quadrado perfeito* (Perfect Square), based on the movement of pieces on a chess-like board, with its own rules motivating the intuitive participation of the public. *Objeto Rotativo* (Rotative Object) from 1969 depended on the viewer's intervention for it to work and move, and questioned Newtonian physics. Palatnik applied the principles of cybernetic communication to art, and especially to his kinetic sculptures, following the notion that information exchange between diverse systems encourages feedback. In a world saturated with information, Palatnik understood the positioning of art as follows:

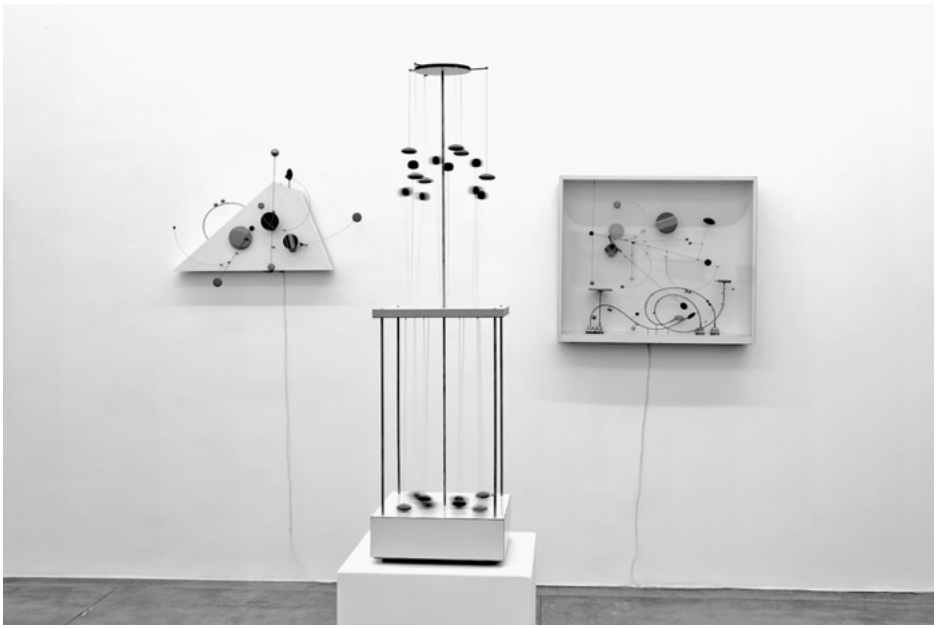


2 Abraham Palatnik, *Aparelho Cinecromático* (Cinecromatic Apparatus), 1969/1986, wood, metal, synthetic linen, light bulbs, and motor. 112.5 × 70.5 × 20.5 cm.

> Its legitimacy lies in our constant adjusting to the exterior world, which we make manifest through our actions in it, either directly or through our extensions and technologies. A kind of "barter." … Likewise, I believe that the form of something is not only its contour, but above all its essence. Reaching this essence is really intriguing. It is the origin of all aesthetic manifestations managed by the artist. It is where sensitivity is brought into play, the improvisation mechanism is liberated and ludic characteristics are presented, once again drawing the human being closer to his condition of participation and integration.[4]

His "sculptures"—which he called at the time *aparelho* (apparatus) or *relevo* (relief), some of which also take on the format of *tableaux-objets*, while others are assemblages—and kinetic-participative objects (fig. 3) are exceptional examples of the way in which the parameter of information plays a decisive role in the conception of the work. They thereby open up a path toward surpassing conventional uses of forms, materials, colors, spaces, and times.

4 Abraham Palatnik, "A evolução do ser humano está ligada diretamente a adoção da tecnologia e da informação" (1977), exh. cat. Instituto de Arquitetos do Brasil (Rio de Janeiro: IAB – Instituto de Arquitetos do Brasil, 1981).

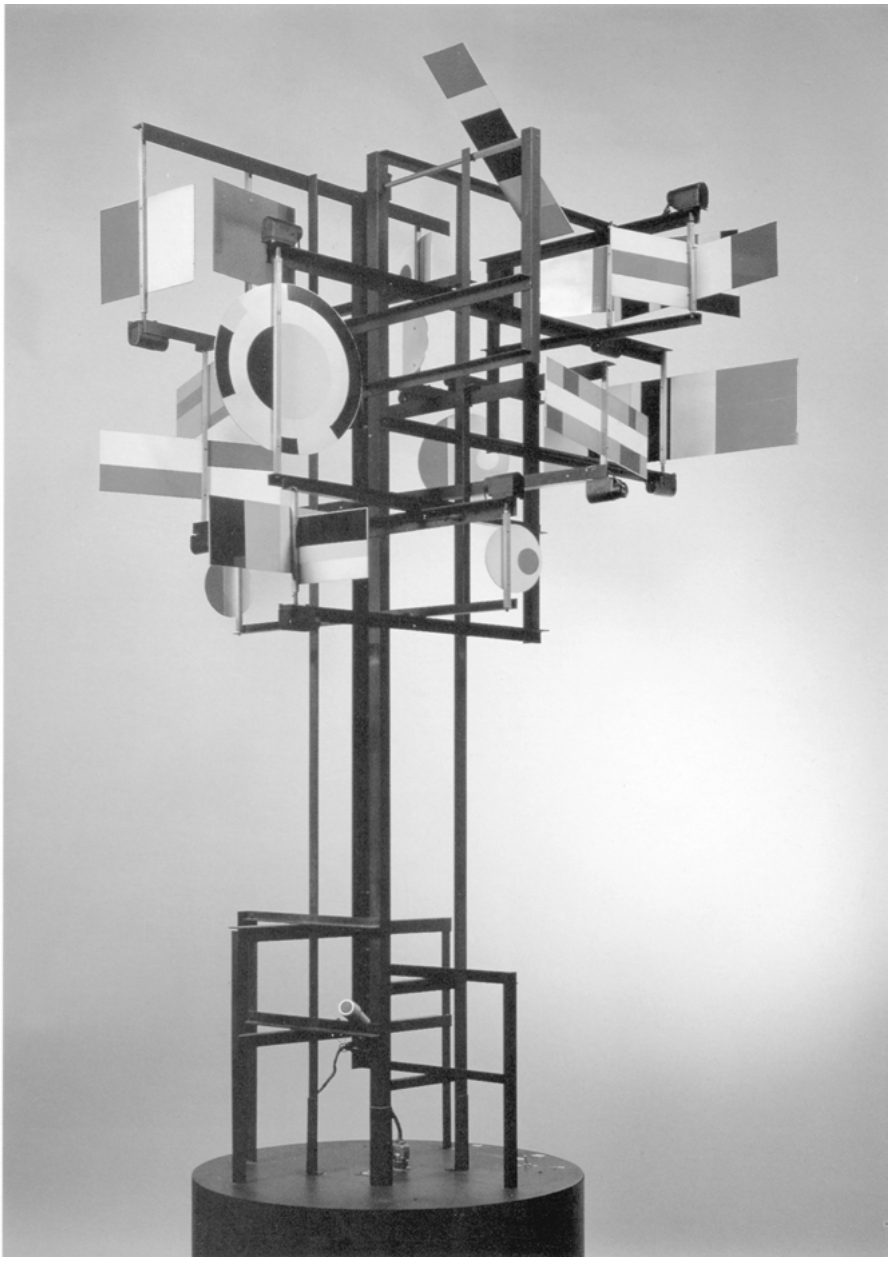


3 Abraham Palatnik, *Objetos Cinéticos* (Kinetic Objects), exhibition view, 2012, curated by Frederico Morais.

For Nicolas Schöffer, works of art should change just as human beings and nature do. Therefore, they should avoid the inert state of matter. With his sculptural shapes, this French-Hungarian artist researched the fourth dimension of time, through real movement, and applied the cybernetic notion of feedback as a dialogical strategy in the work. In striving to achieve this aim, Schöffer programmed indeterminist features, susceptible to influence by natural phenomena (for example, the works responded through electronic sensors to changes in the weather or the presence of humans), or by the action of *performers* (as works which could be manipulated by the viewer). His cybernetic sculptures, such as *CYSP 1* (1956) (fig. 4) were prepared with electronic systems and sensors that converted certain environmental variations around them into kinetic transformations within the piece itself, whether they involved movements, sound, or lighting.

In this position we find the basis—which was highly important in the context of media art—for the objection to the cult of the finished object, as well as the emphasis on open processes and on each work's potential for variability.

Also highly stimulated by cybernetics, Nam June Paik related the concept of freedom to communication problems in art. His first works of cybernetic art, and later his video sculptures, considered communication as a form of free interrelation and interaction between the medium, the public, and the work, and not as a mode whereby purely informational and explanatory messages were transmitted. According to Paik, it is necessary to tran-



4 Nicolas Schöffer, *CYSP 1*, 1956, aluminum and mixed media (computer, traction motor, direction motor, two microphones, two photoelectric cells, nineteen micromotors), height: 2.6 m. This was the first spatial-dynamic sculpture, having total autonomy of movement (traveling in all directions at two speeds) as well as having axial and eccentric rotation (setting in motion its sixteen pivoting polychromed plates).

scend monodirectional experiments with art's randomness.[5] Reflections on indeterminism, variability, transdisciplinarity, communication, and public participation come to the fore in the pieces seen in Paik's first exhibition, held in 1963 at Galerie Parnass in Wuppertal, Germany. In the show, Paik exhibited his first cybernetic sculptures using electronic devices. Just as Palatnik and Schöffer drew from Constructivist sources and the mechanical-luminous kinetics of Moholy-Nagy, Paik had as his starting point certain Dadaist positions regarding the ready-made, Fluxus notions of improvisation, and John Cage's indeterminism to explore the new field of electronic art. Paik structured the exhibition into two parts, made explicit in the very title: *Exposition of Music—Electronic Television*. In the part dedicated to sound objects, Paik showed (among other works) four "prepared pianos," following on Cage, conceived for visitors to be able to touch and manipulate. The five sound sculptures consisted of manipulated audio devices—tape recorders and record players—which encouraged visitors to interact and create sounds. For example, the piece *Schallplatten-Schaschlik* consisted of a record player with the possibility of increasing up to ten vinyl records in movement, and a large pickup allowing visitors to freely place the needle on any of the records and listen, which due to the obvious instability of the arrangement gave out random sounds. The other works, entitled *Participation TV*, were some of the first examples of electronic and interactive audiovisual "sculptural" objects. Paik equipped a television set with an attached switch at its base which, when activated by the viewer, caused a small burst of light on the screen. Another object had an attached microphone that transmuted the vibrations of human voices into visual vibrations on its canvas. Following on the same principle, Paik attached another television set to a working radio whose broadcast intensity enabled a sole point of light in the center of a dark screen to expand or contract in tandem with the radio's acoustic loudness.

Paik's idea coincided with those of Schöffer and Palatnik on the need to research into strategies to incorporate indeterminist and random information processes into electronic-visual creation to break with the one-directional principles of broadcaster-receiver, opening up the work to public intervention or its interrelation with its surroundings or other media. *Participation Music* and *Participation TV* are noteworthy examples of the articulation of participative art as a system based on "interdependent processes," following on a definition coined by Hans Haacke in 1968, who was likely more influenced by systems theory.[6]

It is important to recall that starting in the early part of the 1960s, a series of artists began to use the television set or frame as an "objectual" feature, to be transcended or intervened upon. This was seen with César, who in 1962 showed *Télévision*, a sculptural television which corresponded to the characteristic proposals of Nouveau Réalisme. Günther Uecker, for his part, in *TV 1963*, covered the casing of a television set with nails. This

5 See Nam June Paik and Edith Decker, eds., *Niederschriften eines Kulturnomaden: Aphorismen, Briefe, Texte* (Cologne: DuMont, 1992).

6 See Hans Haacke and Alexander Alberro, eds., *Working Conditions: The Writings of Hans Haacke* (Cambridge, MA: MIT Press, 2016).

transgressive gesture transformed a status symbol of modern life into a fetish object, like certain African shamanist sculptures done by the Nkisi, from the Congo. In 1963, moreover, Wolf Vostell exhibited *TV Décoll/age*, a clear reference to the deconstruction of mass media's most stellar device.

Starting in 1965, with the first artistic experiments with video, and especially in the 1970s and 1980s, the format of video-sculpture underwent considerable development. The video-sculptures of Paik combined the materiality of found objects with the temporality of audiovisual found footage. They constitute an assemblage of forms and recycled audiovisual information.

In 1969, Les Levine, in *Contact: A Cybernetic Sculpture,* proposed the active inclusion of the public by means of a system of closed-circuit cameras that captured images of the people in the gallery, rebroadcasting them in real time through the televisions found there. The eighteen CRT televisions were combined into a sculptural structure and their screens were covered with acrylic gel in different tones. Sharing in the cybernetic spirit, Levine held that works of art should be established as open systems.[7]

Besides Paik and Les Levine, Shigeko Kubota, who had studied sculpture in Tokyo, was another precursor of video-sculpture. Her emblematic *Nude Descending a Staircase*, from 1976, established a dialogue between audiovisual container and content, moving fully beyond the two-dimensional Duchampian simulation of simultaneous displacement.

Now that we have come to this point, it would seem pertinent for both practical and methodological considerations to reaffirm the need to distinguish between the various formats taken up by media sculpture[8]—such as TV-based sculpture, video-sculpture or monitor-based sculpture (single-channel or multimonitor multi-channel)—and expanded formats closer to environments and installations, such as audiovisual installation, video installation, closed-circuit installation, interactive installation, and many more. Video-sculpture can use one or more monitors and channels, related or not with other features. Its main characteristic is the conception of a work with a delimited three-dimensional format that incorporates video production, which may or may not be closely related to the support. In this way, it is unlike video installation and audiovisual installation, which break with the clearly delimited physical form of the object and put the emphasis on integrating the whole into the space, on ideas of site-specificity, the transitory or ephemeral nature of adapting each intervention to each site, the relationship between context (space, architecture, ambience, surrounding, and so on), time (duration), and the work's component parts, as well as the recourse to a certain degree of "staging."

Some authors do not defend this distinction, although I have not been able to find strong arguments in their writings that might justify the objections to such groupings. In

7 See Gene Youngblood, *Expanded Cinema* (New York: E. P. Dutton & Co., Inc., 1970).

8 The acceptance of the term here is more clearly defined and is differentiated from the meaning Les Levine gave it, where "media sculpture" encompasses a much broader set of possibilities, expanded and independent of its use of technologies, and at other times more related to the question of the mass media.

fact, there is difficulty in certain cases of setting out clear demarcations between formats and ways of presentation, especially in the period when the goal was precisely to break with said limitations and promote hybridism and transdisciplinarity, i.e., "expanded sculpture." The term "expanded" in relation to the arts comes from one of the pioneers of electronic art, Mary Ellen Bute. In the 1930s, she researched the field of expanding cinema and her ideas influenced a posteriori other artists and theorists. However, the use of the term "sculpture" here is associated (without running the risk of recurring to synthopic forms[9]) with various essential and constant characteristics of each artistic expression.

Although they were being broadened and diversified, especially with the use of electronic and digital technologies (as I have observed above), they are implicitly different from the unfolding in space-time that characterized the installation. It is also interesting to mention the approximation of sculpture to what is known as time-based art, which decades earlier would have been considered a contradiction.

Quite independently of formats, the ideas of art as process and as system as well as the dual position of the observer as receiver and emitter came to be constituted as new aesthetic parameters in the realm of media art, and more specifically in media sculpture. Perhaps the main shifts taking place in that first stage of media sculpture, influenced as it was by cybernetic principles, involved overcoming the dichotomy between materiality and immateriality, between the tangible and the intangible, as well as introducing notions of variability and indetermination into the field of sculpture.

One of the effects of these new approaches was the proposal to move beyond aesthetic experience oriented toward subjective, distant fruition, a posture propagated by Romanticism and which would last, to a certain degree, into our century. It is worth recalling what the gnoseological dispossession of the works, which supported aesthetic reflection based on taste with neither concepts nor context, precisely was.[10] We must recognize that the renouncement of this kind of aesthetic discourse in favor of a communicative, even informational, consideration of art, was acutely influenced by phenomenology, hermeneutics, and semiotics. Examples of this current, developed as it was over the entire period encompassing the postwar up to the 1970s, include informational aesthetics, cybernetic aesthetics, and generative aesthetics,[11] all of whose main starting point, as the terms already suggest, was precisely cybernetic theory, with certain notions received as well from systems theory. They deepened the chasm between ontological or metaphysical aesthetics and aesthetics of a rationalist tendency.

9 I used the concept of "synthopia" in 2000, and after, in Claudia Giannetti, *Estética Digital – Sintopía del arte, la ciencia y la tecnología* (Barcelona: L'Angelot, 2002), p. 15, and *Ästhetik des Digitalen: Ein intermediärer Beitrag zu Wissenschaft, Medien- und Kunstsystemen* (Vienna/New York: Springer Verlag, 2004).

10 For more information, see Giannetti, *Ästhetik des Digitalen*, 2004, ibid., pp. 167–70.

11 For more regarding these theories, see Giannetti, *Ästhetik des Digitalen*, 2004, pp. 29–52; see also a more succinct text in: Giannetti, "Aesthetics of the Digital" (2003), *Media Art Net*, http://www.medienkunstnetz.de/themes/aesthetics_of_the_digital/ (accessed February 10, 2023).

What clearly set apart their different theoretical lines was above all the emphasis given to the information parameter. In his *Informationsästhetik* (informational aesthetics), developed from 1957 on, Max Bense defended the idea, for example, that art should *liberate itself* methodically from objects and forms as the vehicles of aesthetic processes, while reducing aesthetic imitation proportionally to the degree of aesthetic abstraction. This would allow the introduction of an *aesthetic kinetics* characterized by the emancipation of aesthetic medium. "Kinetics" refers to another way of conceiving the work of art as a structure that keeps the possibility of transforming itself, converting itself and diversifying itself as latent, just as what happens with information. His proposal for the objective analysis of the work of art signified, in other words, an explicit split with aesthetic theories for the most part derived from a subjective, metaphysical understanding of art centered on styles and on stable, permanent forms and objects. For Bense, aesthetic objects were not solely physical and inert; their aesthetics had to be addressed as an informational process. Observation and communication technique would, therefore, take the place of previous interpretational aesthetic processes. In other words, works of art would be understood as information mediators (aesthetic information): "It might also be stated that works of art are a special class (that is, created, not given) that are 'carriers' of 'aesthetic information.'"[12]

Something that was indicative of the rapid expansion of cybernetic thought also in the artistic/cultural world is found in the various exhibitions of art and technology organized in various continents throughout the 1960s. These brought together works of art with a clear processual, behavioral, and communicational foundation. To cite a brief selection of these exhibitions: in 1968, *Computer and Visual Research*, held in Zagreb as part of the biennial of new tendencies created in 1961; *Cybernetic Serendipity*, held in London in 1968, which among others featured artists who had taken risks with the sculptural and robotic format, including Paik with *Robot K-456* and his *Participation TV*, and artists who presented interactive kinetic sculptures, such as Schöffer with *CYSP 1*, Edward Ihnatowicz with *Sound Activated Mobile (S.A.M.)*, and Gordon Pask with *The Colloquy of Mobiles*.[13]

In South America, in turn, two exhibitions carried out a vital role in spreading information on the new relationship between art, science, and technology. In 1969, the Buenos Aires-based Centro de Arte y Comunicación – CAyC (Centre for Art and Communication) of the Fundación de Investigación Interdisciplinaria (Foundation for Interdisciplinary Research) organized the first exhibition of *Arte y Cibernética* (Art and Cybernetics), presented at the

12 "Kunstwerke, so lässt sich auch formulieren, sind eine besondere (nämlich hergestellte, nicht gegebene) Klasse von 'Trägern' der 'ästhetischen Information'." Max Bense, "Ästhetische Kommunikation," in "Semiotik: Allgemeine Theorie der Zeichen," *Internationale Reihe Kybernetik und Information*, vol. 4. (Baden-Baden: Agis Verlag, 1967), pp. 18–25. See also Max Bense, *Ästhetische Information* (*Aesthetica II*) (Krefeld/Baden-Baden: Agis Verlag, 1957); *Ästhetik und Zivilisation* (*Aesthetica III*) (Krefeld/Baden-Baden: Agis Verlag, 1958); *Einführung in die informationstheoretische Ästhetik* (Reinbek bei Hamburg: Rowohlt, 1969); *Programmierung des Schönen* (Krefeld/Baden-Baden: Agis Verlag, 1960).

13 Jasia Reichardt, ed., *Cybernetic Serendipity: The Computer and the Arts* (London/New York: Studio International, 1968).

city's Galería Bonino. The exhibition curator and director of the CAyC, Jorge Glusberg, who was also a member of the Argentina Inter-medios program,[14] was one of the early promoters of the potential of cybernetics in implementing the relationships between art and science from a transdisciplinary perspective, focused on the inclusion of technologies into the artistic context. In 1971, Glusberg was likewise a member of the Grupo de los Trece (Group of Thirteen) along with Edgardo Vigo, an Argentine artist who gave an ironic twist to sculpture with his *Máquinas Inútiles* (Useless Machines, developed from 1957 onward), which used rudimentary kinetic mechanisms taken from scrap material. In São Paulo, the exhibition *Arteônica* (1971) brought together, for the first time in Latin America, the leading international artists and researchers in the field at that time, such as Manfred Mohr, Georg Nees, Michael Noll, Herbert Franke, François Morellet, the group from the Centro de Cálculo de Madrid (Madrid Calculus Centre; Barbadillo, Sevilla, Sempere, Delgado, Alexanco, Yturralde), and many more. The initiator and the author of the manifesto that accompanied the exhibition was Waldemar Cordeiro, renowned as one of the most experimental and international artists and theoreticians on the Brazilian scene. Recognized today the world over as a leading figure of Concrete Art, Cordeiro took his place as one of the precursors in the Latin American context of programming and computer art, having done his first pieces in this field in 1968, in collaboration with the Italian physicist Giorgio Moscati. Notions of processual and random art were made patent in his electronic artistic praxis from this early period onward.

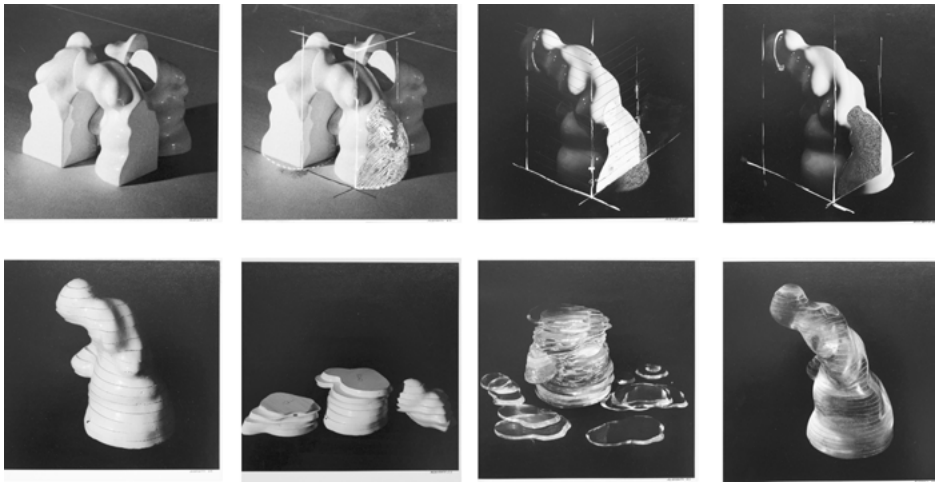
Artistic use of computer systems, as applied to creative processes, was another radical transformation. The production of computer art in its first phase is relatively well known, especially starting in the 1960s, when it was dedicated to generative works, computer graphics, and software art whose output results were in two-dimensional printed pieces. Less would be known, however, of the earliest research by artists into computer-generated sculpture.

One of the innovative proposals in the translation of two-dimensional visuality of computer-generated graphics to three-dimensional materials was conceived by a student of Bense, Georg Nees. This German artist, who studied mathematics and physics, exhibited his first works with computer graphics in Stuttgart in 1965. The most surprising aspect of his *Plastik 1* (Sculpture 1) a relief created from 1965–68 on an aluminum plate, was that he used an automatic milling machine to cut the material. His process of carving the material followed the shapes of images created by a computer by means of an algorithm with random parameters.

In Spain, from 1968 to 1973, the Centro de Cálculo (Calculus Centre) of the University of Madrid developed a series of courses and a research residence program that enabled artists and architects to learn more about the possibilities of computer technologies. The "Seminar in the Automatic Generation of Visual Forms"[15] was of vital importance for the first

14 See Jorge Glusberg, *Argentina Inter-medios* (Buenos Aires: Centro de Arte y Comunicación, 1969).

15 See Manuel Barbadillo, "Hommage to Norbert Wiener" (1975), in Claudia Giannetti, ed., *El discreto encanto de la tecnología: Artes en España/The Discreet Charm of Technology—Arts in Spain* (Badajoz/Madrid: MEIAC/Seacex, 2008), pp. 322–27.



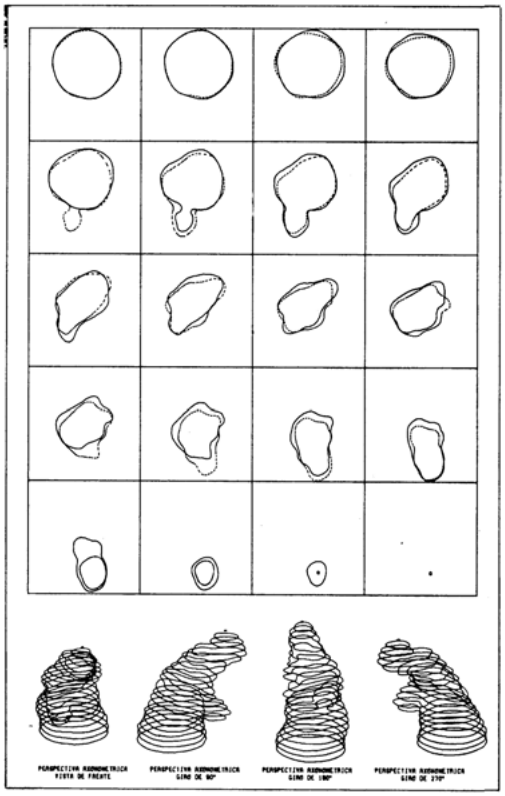
5 José Luis Alexanco, genesis of *Mouvnt*, 1969, eight elements, intervened on photographs on baryta paper, 50 × 100 cm.

generation of Spanish artists to explore the use of computers as tools for art. Participants in the seminar included Manuel Barbadillo, José Luis Alexanco, José María Yturralde, Eusebio Sempere, and Elena Asins.

One of the pioneers in the application of the principles of digital combinatorics to the field of sculpture was José Luis Alexanco. In the period from 1969 to 1973, when he worked in the aforementioned Centro de Cálculo in Madrid, this Spanish artist programmed the algorithm *Mouvnt*, written in Fortran IV. This program made it possible to execute topological transformations on the basis of a three-dimensional form-origin, calculated in functions of data defining forty level curves in an X, Y, Z coordinate system. The algorithm used five different types of methods to transform level curves and a series of parameters for each type. When combined, it was practically impossible for a result to be repeated. The interlinking of the different parameters allowed him to create new forms indefinitely. These forms were applied to methacrylic slices, which were grouped together and juxtaposed to create a sculptural object, as was the case with *Mouvnt XX* (1972) (fig. 5, 6). They also served as molds to create sculptures in resin or cast metal, such as *Plata* (Silver, 1968).[16] The combinatory possibilities were virtually infinite, rendering incalculable the variability of the sculptural results.

Unlike early cybernetic art, which worked above all with feedback and indetermination using factors external to the sculpture, this kind of "permutational art"—a term used

16 See Giannetti, ed., *El discreto encanto de la tecnología: Artes en España*, 2008, pp. 438–39.



6 José Luiz Alexanco, *Mouvnt*, 1969, plotter output print on paper, 100 × 70 cm.

by Abraham Moles,[17] another important supporter of including cybernetic models in art—sought to research the internal resources of the information processor. Through the creation of combinatory algorithms that encompassed diverse possibilities, the machine could systematically analyze the totality of the field, something quite beyond the mental capacities of a person in a reasonable time frame. Using a repertoire as a foundation, the artist created an algorithm in the function of the definition of certain parameters for the manipulation of symbols. Though the artwork was so algorithmically defined, the responsibility for the final work may or may not be assumed by the artist.

In this kind of system, the machine can generate proposals of possible works of art. The artist analyzes and selects them, establishing human-machine co-authorship.[18] The process of actively integrating the machine into the creation of the work gives rise to new que-

17 See Abraham Moles, *Informationstheorie und ästhetische Wahrnehmung* (Cologne: Du Mont, 1971), see also *Théorie de l'information et perception esthétique* (Paris: Flammarion, 1958).

18 For the question of the co-author and the meta-author, see Giannetti, *Ästhetik des Digitalen,* 2004, pp. 102–18.

ries on aesthetic paradigms and the meaning of authorship. Various theoreticians, Douglas Hofstadter[19] among them, propose the figure of the meta-author, i.e., the author of the author of the result. However, it is vital to underline that the relationship between the meta-author and the author—person and machine—cannot be hierarchical in the creation process where the machine is playing an active role. Indeed, their respective contributions are always complementary and grounded in complicity. This point of view contradicts the traditional idea of the machine as a simple, passive, non-mediating tool.

Another highly interesting experimentation was the use of computer processes in the definition of corporeal movements, abandoning the objectification of the body—such as Piero Manzoni's *Sculture viventi* (Living Sculptures, 1961)—and opting for the programming of body dynamics. In 1973, the visual artist and dancer Analívia Cordeiro carried out her first experiments with an algorithm to interrelate dance and audiovisual language, which found its practical application in the audiovisual piece entitled *M3x3* (1973), considered the first work of video art in Latin America. Cordeiro continued her research in the development of a computer program for dance notation in 1982. The resultant software, called Nota-Anna, was programmed in Fortran IV in collaboration with Nilton Lobo. This made it possible to analyze specific body movements, decompose them, and formalize them using spatial lines that schematically symbolize the succession of the dancers' gestures. The objective was to graphically express corporeal action and define its spatial-temporal positioning. This process of codification, of translating an ephemeral movement or sequence of movements into information, allows for the conservation of the gesture's expressive potential.

In the period 2015 to 2017, Cordeiro used Nota-Anna to make a series of smaller computer-aided sculptures with very concrete gestures as their visual leitmotifs. Examples included two Pelé football kicks or a Yoko Geri Kekomi blow by Bruce Lee, both from 1960s audiovisual sources. This program transforms body movement into symbolic coordinates—geometric diagrams in space—which are then formally condensed with extreme exactitude into a single three-dimensional virtual model. The dematerialization of the body takes place through the transformation of mass into energy. The linking of pure dynamic lines present in the trajectory of a specific gesture is thereby conserved. In this way, the memory of the dynamics of the action over time is maintained. The final pieces, as spatial volumes with potentially condensed complex mobility, are modeled and printed in 3D using various materials (figs. 7, 8).

This kind of creative process demonstrates the dual function taken up by the creator regarding computer-assisted sculpture: that of aesthete, and that of manipulator of symbols.[20] The aesthete sets out the artistic criteria (repertoires) that he or she believes must be present in the work, which will be processed and generated by the computer. On the other hand, there is the defining of the algorithm's programming, which must balance the creative necessities of art practice with the formal language of the machine. The algorithm is

19 Douglas R. Hofstadter, *Gödel, Escher, Bach: An Eternal Golden Braid* (New York: Basic Books, 1979).
20 See Giannetti, *Ästhetik des Digitalen*, 2004, pp. 34–42.

7 Analívia Cordeiro, *Materialization of Sight II*, 2015, computer-assisted sculpture, blue polyamide, 28.43 × 22.42 × 21.38 cm.

8 Analívia Cordeiro, *Tribute to Oskar Schlemmer I*, 2016, computer-assisted sculpture, red polyamide, 23.36 x 16.74 x 10.31 cm.

understood as an extension that increases limited human perceptive capacities. Humans, for instance, cannot precisely register a sequence of movements presented at a higher speed than the time required for an impression on the human retina (almost a quarter of a second). In this sense, the exactitude of the forms and the dynamics, regarding the reality of the movement, can only be artistically expressed with the support of technological resources.

Continuing research and technological advancement has opened up new possibilities for art, such as computer-generated sculpture (such as through systems of Artificial Intelligence) or virtual sculpture (from holography to stereoscopic vision techniques), which would be the subject of a different essay. Nevertheless, in essence these formats do not involve changes in the central parameters mentioned previously, while varying the degrees of autonomy of the technological systems wielded. With this in mind, the human-machine relationship (as the co-author or meta-author) as well as the final results regarding the artwork's degree of materiality or immateriality also become far more variable.

Translated from the Spanish by Jeffrey Swartz