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The Work of Vladimir Bonačić: A Temporary Realization of the New Tendencies' Program

Vladimir Bonačić (1938–1999) worked at the Croatian national research center Ruđer Bošković Institute in Zagreb from 1962 to 1973. There, he headed the Laboratory for Cybernetics from 1969 to 1973. He earned his Ph.D. in 1968 in the field of pattern recognition.¹ Vladimir Bonačić's artistic path is inseparable from the international New Tendencies movement and its world view of the synergy between science and art.

Inclusion of Science in Art and Vice Versa

The Galerija suvremene umjetnosti [Gallery of Contemporary Art] organized five New Tendencies exhibitions in Zagreb from 1961 to 1973; in addition, international exhibitions were held in Paris, Venice, and Leverkusen, West Germany. A group exhibition of European artists in 1961 developed into an international movement that was referred to as "NT." NT provided a gathering place for artists, gallery owners, and theoreticians during the Cold War, initially from Eastern and Western Europe and South America, and, from 1965 onwards, from the USA, the Soviet Union, and Japan. This unique situation was enabled by the cultural and geopolitical position of Zagreb, in the former non-aligned Socialist Federal Republic of Yugoslavia.

In the catalog of the first New Tendencies exhibition in 1961, the artist François Morellet, a member of the Paris-based Groupe de Recherche d'Art Visuel [Visual Art Research Group], wrote: "Imagine that we are at the eve of a revolution in the arts that is as great as the revolution that exists in science. Therefore, the reason and the spirit of systematic research has to replace intuition and individualist expression."²

Further New Tendencies ideas – that can be wholly applied to Bonačić's work – were presented in the 1963 catalog of the second New Tendencies exhibition in a text by the Croatian art critic, theoretician, and co-founder of the New Tendencies movement, Matko Meštrović. Tellingly, the text was later republished under the title "Ideologija Novih tendencija" [The Ideology of the New Tendencies], which it surely is from its programmatic and theoretical structure. The demythicization of art and demystification of the creative process were also proclaimed through a positive ap-

proach to the industrial production of works of art (the possibility of multiplication was essential), collective work, and a rational approach. Meštrović called for the speeding up of the evolution and synthesis of science and art within the framework of rendering humanities and art more scientific, as part of the long-term utopian process of rendering all human activity scientific. In Meštrović's view, this process could be actively begun within the framework of art immediately, as well as the development of a global model, undertaking efforts to act in the sphere of culture at a smaller scale, for example, through appropriation of scientific methods, such as the experiment. There is the issue of distributing all material and spiritual assets in equal measure, as well as of returning the achievements of science to the public domain. Meštrović did not consider artworks as unique commodities for the art market, but as "plastic-visual research, with the aim of determining the objective psychophysical bases of the plastic phenomenon and visual perception, in this way a priori excluding any possibility of including subjectivism, individualism, and romanticism [...]."³

Further, the thesis was advanced that ultimately, art as we know it will be transcended through developing the consciousness of the world using a metamorphosis of the social into the artistic act, which actively transforms the entire world.⁴

We can trace such developments in the practices of numerous New Tendencies artists and researchers in the early 1960s, which formed the context for the inclusion of scientist-artists later, such as Bonačić.

During the first half of the 1960s, the New Tendencies attained a noteworthy international reputation as a leading international platform for avant-garde visual art that favored rationality, social engagement, and interactivity with the user, which was achieved through scientific methods of experimentation and algorithmic programming of visual elements in creating objects, as well as environments made of industrial materials, movement, and light. Whereas, in Matko Meštrović's words, "at the beginning of the movement artists intuitively oriented towards science, often lacking a notion of what it implied,"⁵ this situation changed radically in

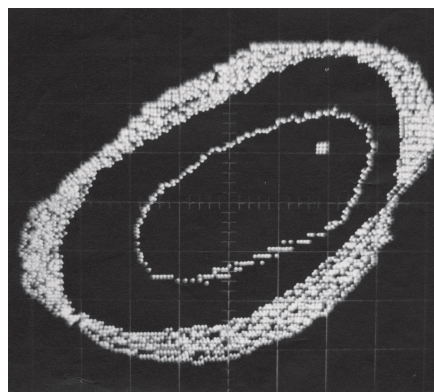
1968 when the program “Kompjuteri i vizuelna istraživanja”/ “Computers and Visual Research” began, and a greater number of scientists began to participate actively in the New Tendencies. At the conferences and exhibitions, which were a part of the program, a number of scholars, who had left the realm of pragmatic scholarly work by using computers creatively, participated alongside the artists.

In addition to his academic work at the Ruđer Bošković Institute in Zagreb, Vladimir Bonačić participated actively in all parts of “Computers and Visual Research” within *tendencies 4*, and during this short and obviously intense period he started to realize a wide range of artworks and to develop his own theory of computers and visual research. Bonačić participated in both conferences related to computers and visual research: the colloquy in 1968 and the symposium in 1969, the papers of which were published in the journal *bit international* which was launched by the Galerija suvremene umjetnosti in 1968.⁶ Within the two exhibitions of 1968 and 1969, Bonačić exhibited one coproduced work, a collaboration with the artist and designer Ivan Picelj (this volume, p. 364), as well as twenty-one own works. He also presented a large, 36-meter computer-controlled light installation, *DIN. PR18* (this volume, p. 370), in a public location.

Joining the New Tendencies

How did such intensive production and presentation come about?

During the preparation of *tendencies 4*, organizers from the Galerija suvremene umjetnosti sought collaborators at the Ruđer Bošković Institute in Zagreb. Along with other scientists who were to take part in the symposia, New Tendencies organizers met the young scientist Bonačić at the institute, who used visual research in his scientific work. Also at this time, Ivan Picelj, New Tendencies’ chief graphic designer, was asked to design the poster for the *tendencies 4* events. He decided to use punched paper tape of the institute’s computer for a collage. Picelj then had the idea to take his work a step further and to produce a light object following his *Površina* [Surface] series of reliefs in wood and bronze, which he had been developing since 1961. At this point, Vladimir Bonačić came upon the scene, and they began the collaboration that resulted in the electronic object entitled *t4* (this volume, p. 364), the abbreviation of *tendencies 4*. It was presented in 1969. The front panel of the object is made of a grid of round aluminum tubes, each holding a small light bulb. Each tube is cut at an angle. The upper part displays variations of the characters “t4,” moving from the left to the right, for example. The rest of the panel lights up in asymmetric light patterns, and four knobs on the back of the object allow certain manipulations. Bonačić’s experience in physics and electronics helped a great deal, as did the excellent production conditions in the workshops of the Ruđer Bošković Institute.



Vladimir Bonačić
IRB 2-9
 1968
 Computer-generated image
 Photograph
 8.5 × 6.3 cm
 PDP-8, oscilloscope
 Produced at Ruđer Bošković
 Institute, Zagreb
 Archive MSU Zagreb

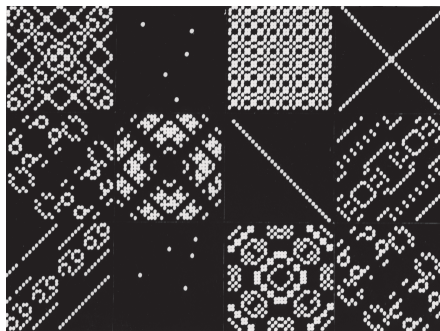
The first exhibition of computer graphics during the colloquy at the Centar za kulturu i informacije [Center for Culture and Information] in 1968 in Zagreb contained eight of Bonačić’s computer-generated pictures titled *IRB*, whereby “IRB” denotes the place where the works were created, the Ruđer Bošković Institute, and the numbers simply distinguish the different exhibits. All the exhibited works were photo reproductions of oscilloscope screenshots in different formats. The oscilloscope was an integral part of a self-constructed light-pen system hooked up to a PDP-8 computer. The programming language used was Assembler. One work marked *IRB 9-9* depicts an outline of a female figure, while other works are abstract. This computer drawing of a human figure, an experiment that in the end was not publicly exhibited, calls into question the author’s repeatedly avowed desire to create “something that has not yet been done”⁷ by using the computer, and the conviction, in concordance with that statement, that the “computer must not remain merely a tool for the simulation of what exists in a new form. It should not be used for painting in the way that Piet Mondrian did, or for composing like Ludwig van Beethoven. The computer gives us a new substance; it reveals a new world before our eyes. In that new world, after many years, scientists and artists will meet again, driven by a common desire for cognizance.”⁸ Bonačić’s reference to Mondrian was a critique of A. Michael Noll’s experiment with a computer-generated Mondrian-like drawing.

The “Galois Field”

The “Galois field,” named after the French mathematician Évariste Galois (1811–1832), whose work marked one of the beginnings of group theory, was a source of general inspiration to Bonačić. In abstract algebra, finite fields are known as Galois fields, and Bonačić studied them in connection with his work on the roots of polynomial equations. First in his scholarly work, and later in his artworks, Bonačić developed his own, original method of studying the Galois field through the way that he visualized it. In his article “Kinetic Art: Application of Abstract Algebra to Objects with Com-

puter-controlled Flashing Lights and Sound Combinations” (1974) he noted: “One of the most interesting aspects of this work [on Galois fields] is the demonstration of the different visual appearance of the patterns resulting from the polynomials that had not been noted before by mathematicians who have studied Galois fields.”⁹

In 1969, using the PDP-8 computer, Bonačić created ten photographic works with oscilloscope screenshots the title of which contains the letters “PLN.” Five works from this series bear titles that consist of exact algebra, but for the other group of five works, a different system of naming was employed. An example of a work with a title containing exact algebra of the Galois field shown in the image is *IR. PLNS. 0044. 7714. 7554. 7744* (this volume, p. 372), where “IR” means irreducible, “PLN” polynomial, “S” symmetry, and the numbers are linked to the polynomial properties. Bonačić described this work in the exact language of mathematics, as a “successive depiction of generating a maximal period in four irreducible polynomials of the tenth degree, $x^{10} + x^3 + 1$ (0044), 7714, 7554, 7744.”¹⁰



Vladimir Bonačić
RS. PLNS. 0374. 1024. 0064
 1969
 Computer-generated image
 Collage of 3 × 4 photographs
 PDP-8, oscilloscope
 Produced at Ruđer Bošković
 Institute, Zagreb

In the visualization of algebra of the Galois field, the calculated algebraic result can be shown in both symmetrical and asymmetrical visual compositions. In the description of the work *RS. PLNS. 0374. 1024. 0064*, which depicts a two-dimensional polynomial of tenth degree, depending on the starting number, Bonačić wrote a note that the case depicted features “a rare symmetrical structure in a polynomial of tenth degree (it cannot be expressed by means of the existing mathematical apparatus) 0374, 1024, 0064. Symmetry cannot be disrupted by a change of starting number.”¹¹ Photographic reproductions show a sharp image of points projected onto the screen of the oscilloscope. In the series of works marked “PLN,” visual representations of Galois fields were used, where visualized numeric combinations, of which there are thousands or millions, depending on the degree of polynomials, are shown within fields (rasters) of 16×16 , 32×32 , or 64×64 elements. Because of the limited size of the oscilloscope screen, some works were photographed and then collaged by hand with other screenshots into a larger format image. In this way, a higher “resolution” was achieved, which means that the number of depicted elements was increased.

In the above mentioned work, *IR. PLNS. 0044. 7714. 7554. 7744*, the collage was made out of 28 photographs of the oscilloscope screen, which enabled simultaneous insight into different stages of visualized algebra.

Bonačić’s entire work is characterized by an innovative and creative approach, as well as an examination of the possibilities of standardized peripheral units (outputs) which show the final result of the work on the one hand, and the utilization of hardware created or adapted by Bonačić on the other.

The next five photographs from the series of works with “PLN” markings have no numerical descriptions of the applied polynomials; they are presented only under the title *PLN* with added numbers 5–9, derived from the sequence of altogether fifteen exhibits displayed at *tendencies 4* in 1969. *PLN 5*, *PLN 6* (both this volume, p. 372), *PLN 7*, *PLN 8*, and *PLN 9* differ from other *PLN* series works in that they do not show sharp contours of points “frozen” in the screenshot. In this series, there is no collaging of photographs, there is only one photograph of the whole screen, so that all the photographs are developed according to one rectangular frame from a 6×6 cm square of the photographic negative. The works *PLN 5–9* resemble experiments with focus and exposure time of photographs, but they were obtained by creative usage of hardware and software parameters, which led to a new dimension in depicting static elements and their spatial relations. The works *PLN 5*, *PLN 6*, *PLN 7*, and *PLN 9* look like a photograph with long exposure time, as the shown elements no longer have a sharp outline. Because of the technical specificity of these works, Bonačić collaborated with Marija Braut, at that time photographer at the Galerija suvremene umjetnosti. The five works selected for display at the exhibition *tendencies 4*, later titled *PLN 5*, *PLN 6*, *PLN 7*, and *PLN 9*, were chosen from a large quantity of photographic material.

Dynamic Objects

Bonačić further elaborated the dimension of time, which in the works described above was achieved through the combination of technologies of computer-generated images and the medium of photography, in a series of computer-generated light objects and installations, which he called “Dynamic Objects.” All of Bonačić’s Dynamic Objects have the possibility of interacting with time dynamics, as viewers (users) are enabled to control the rhythm of images or stop them.

From 1969 to 1971, Bonačić created a series of Dynamic Objects consisting of different computer-programmed light patterns displayed on an originally designed panel made of metal tubes of different shapes and sizes. For all his Dynamic Objects Bonačić made use of the “pseudorandom” algebra of Galois fields (see “GF” in the title of work). The patterns were programmed on a SDS-930 computer in Real-Time FORTRAN, allowing direct usage of Assembler, too, thus providing an excellent tool for various bit manipulation

techniques.¹² The software co-programmer was Miro A. Cimerman.¹³ Bonačić used custom-made hardware for all his Dynamic Objects that were produced or assembled from electronic components by himself and experts at the Ruđer Bošković Institute. The Dynamic Objects were embodied statements of what he later elaborated on in his critique of the influence of commercially available display equipment on the computer-based arts.¹⁴ In his 1974 article “Kinetic Art,” Bonačić emphasized that this was “akin to an artist being limited to the use of only two or three colours in a painting. It is true that much can be done with such equipment, but one can hope that ways will be found to take better advantage of computers.”¹⁵

In 1977, almost ten years after his first artistic experiments, Bonačić stated that a Dynamic Object was a “concept in which impregnable unity is established between the computer system and a work of art.”¹⁶ In 1987 he added: “To integrate computer systems and art, without allowing one to dominate the other, is seen as a step toward the common language. This means that the artist and their work of art are able to communicate; artists and their art use a common language.”¹⁷



Vladimir Bonačić
GF. E32 -S
 1969/1970
 Computer-controlled light object
 Aluminum, electronics, electric lamps
 1024 elements
 68 × 68 × 12 cm
 SDS-930, computer program implemented in special-purpose hardware
 Produced at Ruđer Bošković Institute, Zagreb
 Dunja Donassy-Bonačić, bcd cybernetic art team

The Dynamic Object *GF. E 32 -S* (1969/1970) generates consecutive Galois field elements at maximal distance from each other, and displays them as symmetrical patterns by synchronous selective flashing on the front panel of the object. The object resembles a screen made of a 32 × 32 grid of squared aluminum tubes containing light bulbs. The total “screen resolution” is 1,024 monochrome “pixels.” The Galois field generator is part of a special-purpose computer located inside the object. The unit is self-contained.

The clock that controls the rhythm of the appearance of the visual patterns is variable. The rhythm can be adjusted between 0.1 seconds and 5 seconds by the observer. At a frequency range of 2 seconds, the same pattern will be repeated in approximately 274 years’ time. On the rear of the object, the observer finds “manual controls to start, stop, control the speed and for selecting or reading out any of the patterns.

With the binary notation, 32 light indicators and 32 push buttons enable any pattern from the sequence to be read or set.”¹⁸

From a contemporary perspective, Bonačić’s Dynamic Objects are a pioneering example of the use of interactivity in computer-based art. Like many other artworks created within the New Tendencies context,¹⁹ Dynamic Objects by Bonačić are designed both as artworks that can be experienced aesthetically, and as instruments or tools for visual research. Especially the latter aspect could lead us to the cognitive process (visual learning of mathematics and its hidden laws), a possibility mentioned by Bonačić when describing his art production.²⁰ All Dynamic Objects were made to be manipulated either by the author (or someone from his team) or by the observer. Such experimentation and visual research (in the literal sense of the term) can be done within the controlled environment of an artist’s or scientist’s studio or laboratory with the assistance of the artist or his collaborators, or by gallery visitors.

The Dynamic Object *DIN. GF100*

The front panel of the Dynamic Object *DIN. GF100* (1969; this volume, p. 373) is made of a 16 × 16 matrix of luminous elements in 16 different colors, each one appearing 16 times. By using the Galois field generator, *DIN. GF100* can produce 65,535 different pictures or patterns. Depending on the action of the user or observer, the image changes according to the clock either every 200 milliseconds or every 2 seconds, introducing the observer to a pseudorandom process. The object can be set in both “auto-run” mode and interactive mode, as it was exhibited with remote control at the *tendencias 4* exhibition in 1969. The observer can manipulate the light patterns by both the control panel that is on the right side of the object and the remote control that is connected to the object by a four-meter-long wire, a distance that is great enough to experience immediate interaction while observing the object from a distance. The controls enable manipulation of the sequence’s speed rate and to switch on manual operation of the sequences step by step, including the freezing of the chosen pattern.²¹

GF. E(16,4) -NS C M

Bonačić introduced a higher level of interactivity in the Dynamic Object *GF. E(16,4) -NS C M* (this volume, p. 17), which was conceived, developed, and built in Zagreb from 1969 to 1971.²² It is 187 × 187 × 30 cm large and weighs half a ton. The front panel shows a relief structure made of 1,024 light fields in 16 colors. Several Galois field generators operate in order to light the grid in different patterns and to produce the sound played through four loudspeakers, which create a quadraphonic sound system within the installation space. The field of interaction is not confined to the object. The researcher/user/observer can influence both sound and image by using various knobs and switches on the (custom-made) spe-

cial-purpose computer which is positioned next to the object. Sound can be manipulated by excluding some tones. The speed of the visual display can be adjusted by looping the selected sequences. A remote (radio) control can be used by the viewer to manipulate some basic features. However, the observer cannot change the logic. The entire “composition” of this audiovisual spectacle, which consists of 1,048,576 different visual patterns and 64 independent sound oscillators, can be played within 6 seconds or with a duration of 24 days.²³

The bcd cybernetic art team, which was founded in 1971, consisted of Bonačić, his colleague from Ruđer Bošković Institute Miro A. Cimerman, software designer, and Bonačić’s wife, the architect Dunja Donassy. They worked together until Bonačić’s death in 1999. The bcd cybernetic art team continued to develop the Dynamic Object *GF. E(16,4) -NS C M* over a number of years and experimented with different forms of external hardware. *GF. E(16,4) -NS C M* was an instrument that changed interface design, not only by taking advantage of the newest technical possibilities that were rapidly changing between 1969 and 1974, but also by developing original new solutions. Between 1972 and 1974, several upgrades were carried out that extended the interactivity level of *GF. E(16,4) -NS C M* by using an external computer and a light pen: the computer offered a new interface – an interactive monitor – and the light pen enabled more intuitive interaction with its graphic interface. The object was also connected to standard computer industry hardware, such as the GT40 graphic terminal with printer, but the use of human brain-wave activity was also considered as a possible interface of interaction. The object’s tranquil audiovisual output and the transcendental quality of the cognitive and physical experience of higher mathematics led to the object being set up in St. Kilian’s church in Wiesbaden, Germany, from 1983 to 1985, “where it helps the Franciscans to prepare for meditation.”²⁴

Art Installations in Public Spaces

Bonačić also developed computer-based light installations for public spaces which enabled another kind of interaction: interaction at the social level. As part of the *tendencies 4* exhibition in 1969, he set up the large-scale Dynamic Object *DIN. PR18* on the facade of the Nama department store on Eugen Kvaternik Square in Zagreb. The 36-meter-long installation consisted of 18 elements; each element had a 3×5 grid light matrix. The installation performed a light show that flickered 262,143 patterns of the irreducible 18th-degree polynomial $(x^{18} + x^5 + x^2 + x + 1)$.²⁵ The clock was set at 200 milliseconds, but there was a possibility to set it to different rates at “the border of the perception of the observer and frequency clock.”²⁶

At that time, the square was rather dark, with little public lighting, so the installation also acted as additional illumination. In July 1969, the art critic and curator Želimir Koščević

published in the cultural review *Telegram* an affirmative evaluation of the “message” of this public light system, used for an aesthetic rather than a commercial purpose, as opposed to the illuminated signs of companies that had started to appear in Zagreb’s city center.²⁷ Koščević also found that this public installation demonstrated a refinement of the idea of democratization of art within the context of the New Tendencies movement. He observed that Bonačić, “with his ideas, is a part of the front that, within the ‘Tendencies’ movement, attempts to open a path for art that would simply be work, the results of which will be intended for everyone, without the obligation to take our hats off and buy an entrance ticket for the unavoidable museum or gallery before we can confront it. Tomorrow is, as it seems, meant for just that kind of art.”²⁸



Vladimir Bonačić

DIN. PR16

1971

Computer-controlled light installation
Metal construction, electronics, electric lamps, glass

Installed on Nama department store,
Kvaternik Square, Zagreb

SDS-930, computer program implemented in
special-purpose hardware

Produced at Ruđer Bošković Institute, Zagreb

In 1971, the installation *DIN. PR18* was replaced by a more complex installation, *DIN. PR16*, in the same place, at the top of the facade, but in the form of a triple frieze of light elements. A spatial extension was added by new light elements set in the continuation of the frieze on the other side of the building, as well as into the indentation of the front.

A year before, in 1970, another Dynamic Object was set up on the facade of the Muzej savremene umetnosti, Beograd [Museum of Contemporary Art, Belgrade] for the 4. trijenale jugoslavenske likovne umetnosti [4th Triennial of Yugoslavian Art].²⁹ When Bonačić replaced the installation at Nama

in 1971, he also set up another installation on the facade of the Nama department store on Ilica Street, the Dynamic Object *DIN. PRIO*.



Vladimir Bonačić
DIN. PRIO
1969–1971
Computer-controlled light installation
Metal construction, electronics, electric lamps, glass
100 × (88 × 48 × 25 cm)
Installed on Nama department store on the street Ilica, Zagreb
SDS-930, computer program implemented in special-purpose hardware
Produced at Ruder Bošković Institute, Zagreb

Finally, another Dynamic Object was exhibited only several hundred meters away on the facade of the Kreditna banka Zagreb building on Ban Jelačić Square in Zagreb. None of the “outdoor” works mentioned here that were set up in public spaces are still in place, nor can their original elements be traced at present. However, at least, all of Bonačić’s “indoor” Dynamic Objects still exist and are in good condition;³⁰ they belong to the small group of computer-generated interactive objects from the 1960s that are still functioning today.

Critique of True Randomness in Computer Art

“I am especially sceptical of the attempts to produce computer art through play with randomness and the deliberate introduction of errors in programs prepared for non-artistic purposes,”³¹ wrote Bonačić in 1974. He supported art practices where, like in his Dynamic Objects that make use of pseudorandomness, the “feedback loop might be closed with an aesthetic output to an art object, which would then provide semantically relevant information to a viewer. I believe that such interactions will add to cognition, which will be reflected in language and perhaps provide improved means of communication.”³²

In his paper of 1969, Bonačić discussed the notions of information and entropy, and redundancy and originality in the writings of George David Birkhoff, Max Bense, and Abraham A. Moles: “Observing the qualitative relation for the aesthetic measure, we come to the conclusion that the maximal originality (namely, disorder created by random selection of symbols) brings immense aesthetic values. Let us suppose we have created the program in some other way; but it is still the program that will result in an aesthetic object. Using the random generator, we shall carry on with random distribution of the existing information. Although consistent use is made of the random generator, we speak of ‘max-

imal originality,’ no matter what the results of the program might be. The random generator creates the accidental and unique presentation, which has neither value nor importance for human beings. Such information can evoke various associations in the observer. However, a computer used in such a way lags far behind the human being. Even if the expressive potentialities of the computer were equal to those of a human being, the essence of Pollock’s world and creation would not be surpassed, regardless of the complexity of future computers or peripheral units. That, of course, does not mean that a man (or a monkey or other animal) aided by a computer could not create an aesthetically relevant object if they act consciously or unconsciously obeying the law of accident.”³³



Vladimir Bonačić
Random 63
1969
Electronic object
76 × 76 × 7 cm
PDP-8
Dunja Donassy-Bonačić
bcd cybernetic art team

This critique inspired the creation of the object *Random 63*, which used 63 independent true random generators, each of which activated an electric lamp. The geometric pattern of the placement of the light bulbs on the object’s front was calculated with a PDP-8 computer using the pseudorandomness of the Galois fields. This is the only object by Vladimir Bonačić that makes use of true randomness for the dynamic control of the lights.

Bonačić expressed doubts about information aesthetics, a theory which was important to several participants of *tendencije 4/tendencies 4*. In his book *Science and Technology in Art Today* (1968), Jonathan Benthall, who participated in two Tendencies conferences, observed: “Max Bense writes that mathematical aesthetics is a process which is ‘devoid of subjective interpretation’ and deals objectively with specific elements of the ‘aesthetic state’ of as one might say the specific elements of the ‘aesthetic reality.’ These elements include meanings as well as sensuous or formal qualities. Bense proposes a ‘generic aesthetics’ which would explain how aesthetic states are generated in the same way as generative grammar in linguistics attempts to explain the logical processes by which

sentences are performed and interpreted; but a prior stage of analytical aesthetics is held to be necessary. The main mathematical techniques proposed by Bense are semiotic (the study of signs, originated by Charles Sanders Peirce and others), metrical (concerned with forms, figures, and structures), statistical (concerned with the probability of appearance of elements), and topological (concerned with the relations between sets of elements).³⁴ Benthall pointed out: “Vladimir Bonačić is sceptical about the applicability of information theory to aesthetics, since it takes so little account of semantics. But he approaches visual phenomena in a mathematical and systematic way.”³⁵

Bonačić’s Development after 1972

Contrary to Bonačić’s wishes of 1968 – that computer art should not mimic human-made images – computer-generated art pursued a different path. Computer graphics explored the possibilities of computer-generated figurative visuals and entered – through providing animation and special effects for the mainstream film industry – the commercial world, as well as the military complex, advancing virtual reality techniques that mimic “real life.” Within the context of the dominance of emerging practices of conceptual and non-object art that utilized post-Duchamp ideas of art and representation, this development led to computer-generated art’s almost total exclusion from the contemporary art scene by the mid-1970s. This was propelled by a rising anti-computer sentiment among the majority of the new generation of artists in view of the negative impact of the use of science and technology by the military-academic-industrial complex in the Vietnam War and elsewhere.³⁶

Bonačić was one of the rare artists who found and constantly reinvented a way to use computers and cybernetic art for humanistic purposes. After the period of the first series of Dynamic Objects, Bonačić’s work from 1971 emerged from within the bcd cybernetic art team.

In 1972, Bonačić, Cimerman, and Donassy moved to Israel; in 1973, they founded the “Jerusalem Program in Art and Science,” an interdisciplinary program for study and research at the Bezalel Academy of Arts and Design in Jerusalem, which Bonačić directed until 1977. For this program, he established collaborations with the Hebrew University of Jerusalem and the Israel Museum. In 1974, he organized an international seminar on “The Interaction of Art and Science,” in which several New Tendencies protagonists, including Jonathan Benthall, Herbert W. Franke, Frank J. Malina, Abraham A. Moles, A. Michael Noll, and John Whitney, participated. In 1975, Willem Sandberg, a Dutch typographer and former director of the Stedelijk Museum, received the Erasmus Prize in Amsterdam. On Sandberg’s recommendation, half of the prize was dedicated to “The Jerusalem Program in Art and Science.”

At the beginning of the preparations for *tendencije 6/ tendencies 6*, the “Art and Science team,” which included amongst others Willem Sandberg and the bcd cybernetic art team, was approached by Radoslav Putar.³⁷ The team, represented by Bonačić, proposed the exhibition *Meta Language in Development of Computer Art*.³⁸ Finally, *tendencies 6* began with the conference “Umjetnost i društvo”/ “Art and Society” in 1978 in Zagreb; however, the planned exhibition(s) never took place. The conference was the very last manifestation of the New Tendencies. As the focus had shifted to video, Conceptual, and non-object art, next to the conference a different exhibition was shown presenting Conceptual art only from Yugoslavia, entitled *Nova umjetnička praksa* [New Art Practice], a local synonym for Conceptual and body art and related practices. Bonačić participated at the conference with the paper “Čovjek-jezik-materija ili dematerijalizacija umjetnosti” [Man, Language, Matter – The Dematerialization of Art]³⁹, in which he discussed “an operational relationship between matter and thought,” as well as the relationship of a Darwinian evolution model and artificial intelligence, amongst other subjects. He concluded his paper with the following thought: “The establishment of a common denominator would lead to a greater probability of an ethical evolution and thus, the creation of a new paradigm for society.”⁴⁰

Conclusion: Temporarily Realized New Tendencies Program

From the beginning of his activities as an artist, the work of Vladimir Bonačić drew the attention not only of his colleagues who participated in part of the program “Computers and Visual Research,” but also of the older generation of New Tendencies participants.

At the *tendencies 4* exhibition in 1969, Bonačić exhibited a total of fifteen works in the gallery, as well as the outdoor installation *DIN. PR18*; for this body of work, he was awarded one of the prizes of the competition that was associated with the exhibition.⁴¹ The jury, consisting of Umberto Eco, Karl Gerstner, Vera Horvat-Pintarić, Boris Kelemen, and Martin Krampen, acknowledged “the harmony between the mathematical consequences within the programming and the visualizing of the processes resulting from the programming. We especially applaud Bonačić’s new approach, which entails solving problems by introducing the image as a parameter instead of the number, and thereby makes it possible to solve far more complicated problems.”⁴²

The statement of Brazilian artist Waldemar Cordeiro at the *tendencije 5/ tendencies 5* conference that “Constructive art belongs to the past, its contents correspond to the Paleocybernetic Period of computer art”⁴³ – that computer art had replaced Constructivist art – found its proof in Bonačić’s artwork. Moreover, with his dynamic objects, especially those set up in public spaces, Bonačić probably managed to make

real the utopia outlined by Matko Meštrović and other New Tendencies theoreticians at the beginning of the 1960s. Bonačić's work is exact research that leads to cognitive insights. Science has been humanized, and art has been scientized. Works have been realized through the use of machines, and their basic materials were time and light. They involve the viewer as an active participant, sometimes in physical interaction with dynamic objects, and they are both socially engaged and democratic. It is possible to multiply the works by programming purpose-built software and constructing hardware.

It seems that Bonačić's work fulfilled and dynamized Meštrović's visions of 1963, introduced at the beginning of this text, which are summarized in the idea that "[a]rt must perform a breakthrough into the extra-poetical and extra-human sphere, because today, without that action the human sphere cannot be enriched."⁴⁴ Bonačić's work has, at least temporarily, realized the program of the New Tendencies that at a certain point in time looked merely utopian. However, today it is being reactualized in a new geopolitical, technological, and cultural climate.

- 1 **Editorial note:** Vladimir Bonačić, *Pseudo-slučajna transformacija podataka u asocijativnoj analizi kompjuterom*, Ph.D. thesis, Faculty of Electrical Engineering, University of Zagreb, Zagreb, 1968.
- 2 François Morellet, "Untitled," in: *nove tendencije*, exhib. cat., Galerija suvremene umjetnosti, Zagreb, 1961; translated from the French.
- 3 Matko Meštrović, "Untitled," in: *nove tendencije 2*, exhib. cat., Galerija suvremene umjetnosti, Zagreb, 1963, n. p.; translated from the Croatian; this volume, p. 116. See also: Matko Meštrović, "Scientifikacija kao uvjet humanizacije," in: Matko Meštrović, *Od pojedinačnog općem*, Mladost, Zagreb, 1967, pp. 221–230.
- 4 See: Meštrović 1963, n. p.; this volume, pp. 114–117.
- 5 Statement at the symposium "Kompjuteri i vizuelna istraživanja" / "Computers and Visual Research," May 6, 1969, Kulturno informativni centar [Culture and Information Center] (KIC), Zagreb, transcript from an audio recording, Archive MSU Zagreb; translated from the Croatian.
- 6 **Editorial note:** See: Vladimir Bonačić, "Mogućnosti kompjutera u vizualnim istraživanjima" / "Possibilities for Computer Applications in Visual Research," in: *bit international 3*, Boris Kelemen and Radoslav Putar (eds.), Galerije grada Zagreba, Zagreb, 1968, pp. 45–58; this volume, pp. 272–274. Vladimir Bonačić, "Umjetnost kao funkcija subjekta, spoznaje i vremena" / "Arts as Function of Subject, Cognition, and Time," in: *bit international 7*, Boris Kelemen and Radoslav Putar (eds.), Galerije grada Zagreba, Zagreb, 1971, pp. 129–142.
- 7 Vladimir Bonačić, lecture given at the colloquy "Kompjuteri i vizuelna istraživanja" / "Computers and Visual Research," August 3–4, 1968, Zagreb, Archive MSU Zagreb, transcript from an audio recording; translated from the Croatian.
- 8 Bonačić 1968, p. 58; this volume, p. 274.
- 9 Vladimir Bonačić, "Kinetic Art: Application of Abstract Algebra to Objects with Computer-controlled Flashing Lights and Sound Combinations," in: *Leonardo*, vol. 7, no. 3, 1974, pp. 193–200.
- 10 Vladimir Bonačić, "Ekspoziti u okviru tendencija 4 Zagreb maj 1969" / "Exhibits within tendency 4, Zagreb May 1969," text of explanatory plaques for the *tendencies 4* exhibition, Archive MSU Zagreb, n. p.
- 11 *Ibid.*, n. p.
- 12 Personal communication of the author with Miro A. Cimerman.
- 13 Cimerman collaborated with Bonačić at the Ruder Bošković Institute from 1968.
- 14 See: Bonačić 1974, p. 193.
- 15 *Ibid.*
- 16 Vladimir Bonačić, "On the Boundary between Science and Art," in: *Impact of Science on Society*, vol. 27, no. 1, January/March 1977, p. 25.

- 17 Vladimir Bonačić, "A Transcendental Concept for Cybernetic Art in the 21st Century," in: *Visions for Cybernetic Art*, exhib. cat., Paris Art Center, Paris, 1987, n. p.
- 18 Bonačić 1974, p. 255.
- 19 For example, *Reljefometar [Relief-Meter] (1964–1967)* by Vjenceslav Richter, manipulable lumino-kinetic works by Gruppo MID, or *Un instrument visuel [A Visual Instrument] (1965)* by Michel Fadat, all exhibited at New Tendencies exhibitions.
- 20 See: Bonačić 1971, pp. 129–142.
- 21 See: Explanatory plaque in: *tendencije 4*, exhib. cat., Galerija suvremene umjetnosti, Zagreb, 1970., n. p.
- 22 This computer sculpture was first exhibited in 1971 at the 7th Biennale in Paris in the section "Interventions" at Parc Floral, Bois de Vincennes, from September 24 to November 1, 1971, followed by exhibition at the UNESCO building in Paris, from November 1971 until November 1972, on the occasion of the 25th anniversary of the UNESCO.
- 23 In his *Leonardo* article, Bonačić elaborates these different kinds of interaction from a practical and theoretical point of view, and also considers the use of brainwaves in artistic practice; see: Bonačić 1974, pp. 195f.
- 24 Raymond Daudel, "The Cybernetic Art of the bcd Team," in: *Visions for Cybernetic Art*, exhib. cat., Paris Art Center, Paris, 1987, n. p.
- 25 See: Vladimir Bonačić, "Ekspoziti u okviru tendencija 4 Zagreb maj 1969" / "Exhibits within tendency 4, Zagreb May 1969," text of explanatory plaques for the *tendencies 4* exhibition, Archive MSU Zagreb, n. p.
- 26 *Ibid.*
- 27 See: Želimir Košćević, "Svjetlost nove urbane kulture," in: *Telegram*, 479, July 4, 1969, p. 17; translated from the Croatian.
- 28 *Ibid.*; translated from the Croatian.
- 29 4. trijenale jugoslovenske likovne umetnosti, Muzej savremene umetnosti, Beograd, July 3 – September 15, 1970; curator: Jerko Denegri.
- 30 In total, eight electronic Dynamic Objects were presented at the *bit international* exhibition: seven objects at Neue Galerie [New Gallery] in Graz, 2007, and three at the ZKM | Center for Art and Media Karlsruhe, 2008/2009. Miro A. Cimerman, Dunja Donassy-Bonačić, and ZKM experts restored *GF. E(16,4) - NS C M* for its first public exhibition since 1985.
- 31 Bonačić 1974, p. 193.
- 32 *Ibid.*, p. 194.
- 33 Bonačić 1971, p. 138.
- 34 Jonathan Benthall, *Science and Technology in Art Today*, Thames and Hudson, London, 1972, p. 59.
- 35 *Ibid.*, p. 62.
- 36 Misuse of technology has been recently described by Richard Barbrook: See: Richard Barbrook, "Imaginary Futures. From Thinking Machines to the Global Village," available online at: www.imaginaryfutures.net, 2005. See also: Anne Collins Goodyear, "From Technophilia to Technophobia. The Impact of the Vietnam War on the Reception of 'Art and Technology,'" in: *Leonardo*, vol. 41, no. 2, April 2008, pp. 169–173.
- 37 **Editorial note:** See: Radoslav Putar, letter to Vladimir Bonačić, October 4, 1978, Archive Dunja Donassy-Bonačić, bcd cybernetic art team.
- 38 See: Art and Science team, "Prijedlog za izložbu meta jezik u razvoju suvremene umjetnosti," enclosure to the letters to Radoslav Putar, January 16, 1978, Archive MSU Zagreb. Vladimir Bonačić, letter to Radoslav Putar, January 22, 1978, Archive MSU Zagreb.
- 39 Vladimir Bonačić, "Čovjek-jezik-materija ili dematerijalizacija umjetnosti," paper read at the symposium "Umjetnost i društvo" / "Art and Society," Zagreb, 1978, Archive MSU Zagreb. An extended version of this text, titled "Dematerialization of Art – A Heuristic Viewpoint," was presented at the symposium "Der modulierte Mensch. Wechselwirkungen zwischen Elektronik, Gesellschaft, Medien, Technik, Medizin und Kunst." [Modulated Man. Interactions between Electronics, Society, Media, Technology, Medicine, and Art] at the Ars Electronica, Brucknerhaus, Linz, September 18–21, 1979.
- 40 Bonačić 1978, n. p.
- 41 Bonačić was honored together with Marc Adrian and the group Compos 68. See: "Computers and Visual Research.' Decision of the Competition Jury," in: *tendencije 4*, exhib. cat., Galerija suvremene umjetnosti, Zagreb, 1970, n. p.; this volume, p. 368.
- 42 *Ibid.*; this volume, p. 368.
- 43 Waldemar Cordeiro, "Analogical and/or Digital Art," *tendencije 5/tendencies 5*, "The Rational and Irrational in Visual Research Today. Match of Ideas," Galerija suvremene umjetnosti, Zagreb, June 2, 1973, conference proceedings, n. p.
- 44 Meštrović 1963, n. p.; this volume, p. 117.