

Computer Scientists as Early Digital Artists

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Computer graphics and early computer art are practically of the same age as computers. Since the moment when graphical output devices became available people started to use them for experiments in art. This paper attempts to analyze the early computer art in context of its authors' opinions. There are outstanding examples of collaboration between computer scientists, software programmers and 20th century artists. Some recent media art events in Latvia are mentioned from this viewpoint.

Keywords: computer graphics, computer art, digital art.

1 Introduction

The first visual examples created by using an analogue computer appeared in the mid-1950s in the United States and Germany. We can find some experiments with oscilloscope images even before the stage of electronic graphics. The point of interest is why anybody dares to call these pieces the art. We can prove it from the viewpoint of the history of art of the 20th century. Art forms, such as cubism, Dada, futurism, naïve art, primitivism, constructivism, suprematism and kinetic art, had already emerged before and were widely considered to be the art forms in the middle of the century. Abstract expressionism was one of the major stylistic approaches in the US at that time. Therefore, three things characterising the first examples of computer art are: art as a process not only as a result (Dada), non-professional artists (naïve and primitive art) and abstract, non-representative art forms (suprematism, constructivism, abstractionism) have been already accepted by art theoreticians, gallery and museum curators, as well as by general public in the Western world.

The first authors of the computer images are mathematicians, computer scientists and engineers. It seems to be self-understandable considering the availability of computer time being extremely expensive at that time and necessity for high-level technical skills. It has to be mentioned that the first computer artists had their own theoretical viewpoint on the style and aesthetics of their newly created art form.

Almost ten years later, the informal communities consisting of professional artists (visual artists, as well as musicians, filmmakers, etc.) of the one part and scientists, engineers of the other part began to spread out in order to combine the creative potential of art with computer technologies. Some well-known examples of cooperation in such countries as the United States, Japan and the United Kingdom will be analyzed. Despite the political system and official politics in Soviet Latvia, some kinetic and even conceptual art examples emerged in 1970ties. They were often marked as design proposals and implemented in cooperation with engineers and programmers.

The very first examples of computer drawings in Soviet Latvia can be found in the late 1960s. Undoubtedly, this had been made possible thanks to the appearance of better output devices and more appropriate printing possibilities for graphics. The political background dictates a completely different approach to the style and aesthetics of this art form. Nobody, including the authors of computer drawings, accepted them as art. They are anonymous, and only a very small part of them has survived till nowadays.

Nevertheless, in the Soviet Union, particularly in Soviet Russia, papers covering the topics of computer aesthetics and computer music appeared in the 1970s and 1980s.

After 1990, new media art (now computer art is often a part of it) began to develop in Latvia. Some Latvian contemporary artists had successful cooperation with our computer scientists and physicists in developing their art projects.

2 Computer Graphics and Computer Art Pioneers

The term “computer art” was coined in BOEING Company by its designer William Fetter (1928-2002) who first used it in 1960 to describe his 3D renditions (computer-generated orthographic view) of aircraft cockpits and pilots.

Benjamin Francis Laposky (1914-2000) is being considered as a pioneer of computer art. Shortly after World War II, he began working with oscilloscopes due to his longstanding interest in geometry, curves and Lissajous figures. At the very beginning, he even did not use a computer in his artworks which he called “Oscillons”. We can note his works as some kind of predecessors to the computer art because of the use of algorithmic signals to control artwork producing devices. In 1950, Laposky used a cathode ray oscilloscope with sine wave generators and various other electrical and electronic circuits to create abstract art.

“My work in computer art is a form of oscillography, the results of which I have called ‘Oscillons’ or ‘Electronic Abstractions.’ These are composed of combinations of basic electronic wave forms as displayed on a cathode ray oscilloscope and photographed. Colour compositions are achieved by means of special filter arrangements. The resulting art works are presented in photographic exhibitions, kinetic oscilloscope displays, light boxes, or movies.

The relationship of the oscillons to computer art is that the basic waveforms are analogue curves, of the type used in analogue computer systems. I got into oscillographic art through a long-time interest in art or design derived from mathematics and physics. I had worked with geometric design, analytic and other algebraic curves, ‘magic line’ patterns from magic number arrangements, harmonograph machine tracings, pendulum

patterns, and so on. The oscilloscope seemed to me to be a way of getting a wider variety of similar kinds of design and with controlled effects to produce even newer forms not feasible with previous techniques.” [1]

His “Oscillons” was exhibited and published in America and abroad (over 216 exhibitions and 160 publications since 1952). The permanent collection of Laposky’s artworks is to be found at the Sanford Museum, the United States.

Herbert W. Franke (1927) produced similar art work in Germany (Erlangen) by creating “Lightforms” (in cooperation with Andreas Hübner, 1953-1955) and “Oscillogramms” (1956). Unexpected coincidence of the time and a method used by Laposky and Franke should be mentioned.

Herbert W. Franke studied physics, mathematics, chemistry, psychology and philosophy in Vienna. He received his Ph.D. in Theoretical Physics in 1950 by writing a dissertation about electron optics. In 1956, he started his experiments with oscilloscope-type images, then – electronic graphics, and in 1969 – with computer art. He actively used the new form of art throughout many years.

- “DRACULA Series”, 1970-1971, computer graphics based on “Dragon Curves”, a fairly new discovered form of mathematical fractals.
- “Rotations, Projections”, 1970-1971, the images are based on interactively controlled motions in a perspective view. This kind of animation sequences was used in the “Laser” ballet which was performed on the experimental stage of the Bavarian State Opera.
- “Colorraster 75”, 1975, an edition of the pictures was printed with one of the first inkjet printers available in Europe.
- “Cascade”, 1978, live transformation of music into graphics: the underlying program for the Apple II GS converts sounds in relation to the frequencies into pictures.
- “Fourier-Transformations”, in cooperation with Horst Helbig, ca. 1979, the first attempts with planar Fourier transformations already showed that it produced a variety of shapes, which were not inferior to fractals.
- “Virtual Sculptures”, done with two software programs called “Mathematica” and “Bryce”, after 1996. [2]

Franke became a cybernetic aesthetics and computer art lecturer of the University of Munich (1973-1998), and in the Academy of Fine Arts in Munich (1984-1998). In 2008, he was promoted to Senior Fellow by ‘Konrad-Zuse-Zentrum für Informationstechnik Berlin’ (ZIB). His list of publications includes more than 40 books, especially about art-science connections, and also science fiction novels. His second book, “Computer Graphics – Computer Art” (first edition – Bruckmann, München, 1971, second edition – Springer Verlag, Heidelberg, Berlin, New York, 1985), was the earliest comprehensive text on the subject. The works are in the following collections: Abteiberg Museum collection, ZKM, Kunsthalle Bremen, Germany, Victoria and Albert Museum, the United Kingdom. **A. Michael Noll** (1939), **Frieder Nake** (1938) and **Georg Nees** (1926) came as the ‘second generation’ of scientists – computer artists. Nake, Nees and Noll are sometimes called the three capital ‘N’s, generally in the context of history of computer art. Their artworks were often based on originally created algorithms.

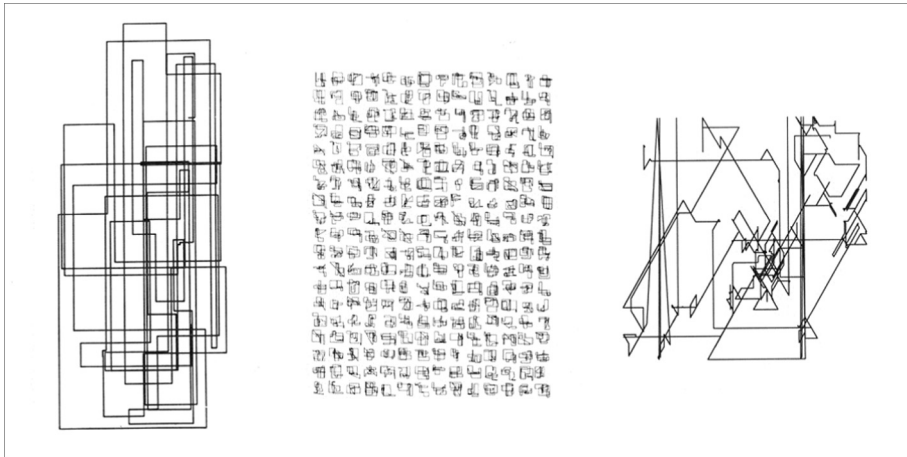


Fig. 1 Random polygons. G. Nees “23 Vertices”, 1965; A.M. Noll “Vertical-Horizontal no. 3”, 1964; F. Nake “Random polygon”, 1965 (© G. Nees, © A. M. Noll, © F. Nake)

Besides being a pioneer in computer art and animation, **A. Michael Noll** has had a varied career as a researcher at Bell Labs in such areas as the effects of media on interpersonal communication, three-dimensional computer graphics and animation, human-machine tactile communication, speech signal processing, cepstrum pitch determination, and aesthetics. He was also a staff member of the White House Science Advisor, AT&T manager and planner, academic professor and administrator, author, columnist, classical music critic, and archivist and biographer.

In the late 1960s and early 1970s, Noll constructed interactive three-dimensional input devices and displays and a three-dimensional, tactile, force-feedback (“feelie”) device (US patent 3,919,691 “Tactile Man-Machine Communications System” filed May 26, 1971, issued on November 1, 1975). This device was the forerunner of today’s virtual reality systems. He was also one of the first researchers to demonstrate the potential of raster scan displays for computer graphics. He was an early pioneer in the creation of stereoscopic computer-animated movies of four-dimensional hyper-objects, of a computer-generated ballet, and of computer-animated title sequences for TV and film. [3]

He was very enthusiastic about creating computer simulations after Dutch painter Piet Mondrian (“Composition with Lines”), English painter Bridget Riley (“Ninety Parallel Sinusoids With Linearly Increasing Period”), as well as exploring mathematics for artistic purposes (“Gaussian Quadratic”, “Hypercube Computer Animation”). Noll was one of the first researchers to use a digital computer to create artistic patterns and to formalize the use of random processes in the creation of visual arts. Noll as artist was active till 1980.

Noll’s artworks are in permanent collections of the Museum of Modern Art, the Los Angeles County Museum of Art, the USC Fisher Gallery, the Performing Arts Library at Lincoln Centre, and the Academy of Motion Picture Arts and Sciences, the United States and Victoria and Albert Museum, the United Kingdom.

Frieder Nake is a professor of Computer Graphics at the Department of Computer Science at the University of Bremen. In the early 1960s, his combined interests in probability theory, information aesthetics, and software merged in generating computer art. At first, he used the Graphomat Zuse Z 64 drawing machine to produce four-colour plotter drawings, and later, he worked with computer Standard Electric ER 56. He was active during the 1960s and 1970s working with compositions of abstract geometric lines and shapes. His works are in the collection of the Victoria and Albert Museum, the United Kingdom. **Georg Nees** is a professor at the University of Erlangen, Germany. Nees studied mathematics, physics and philosophy in Erlangen and Stuttgart. In 1969, he received his Ph.D. in "Generative Computer Graphics". His academic advisor was Max Bense (1910–1990), philosopher, mathematician and founder of Information Aesthetics theory. Since 1964, Nees has been working with computer graphics, sculptures and film – both producing and theorizing about it. His first artworks were based on the programming language ALGOL and the Siemens computer system 4004 in conjunction with a tape-controlled plotter 'Zuse-Graphomat'. He is still active as an artist; nevertheless, his artistic style has not changed a lot since the 1960s. The artworks of Georg Nees are held by the Victoria and Albert Museum, the United Kingdom.

In 1965, the computer art by Michael Noll, Frieder Nake and Georg Nees was exhibited at the Howard Wise Gallery in New York, United States, along with random-dot patterns by Bela Julesz.

Béla Julesz (1928–2003) was a visual neuroscientist and experimental psychologist. He was the first creator of random dot stereograms in 1959. Julesz worked at Bell Laboratories on recognizing camouflaged objects from aerial pictures taken by spy planes. At that time, many vision scientists still thought that depth perception occurred in the eye itself, whereas now it is known to be a complex neurological process. Béla Julesz used a computer to create a stereo pair of random-dot images which, when viewed under a stereoscope, caused the brain to see 3D shapes. This proved that depth perception is a neurological process. Later, Christopher Tyler, a former student of Julesz, used the principles of random-dot stereograms to invent autostereograms, which create the same effect using a single image instead of two. [4]

Kenneth C. Knowlton (1931) is to be considered a pioneer of the so-called ASCII (American Standard Code for Information Interchange) art. He received his Ph.D. at M.I.T. in 1962 (thesis: Sentence Parsing with a Self-Organizing Heuristic Program). In 1963, working at Bell Laboratories, Knowlton developed the BEFLIX (Bell Flicks) – the first specialized computer animation programming language for bitmap computer-produced movies, created using an IBM 7094 computer and a Stromberg-Carlson 4020 microfilm recorder. He used it to make experimental film series in cooperation with artists including eight computer-generated animations "Poem Field" together with Stan VanDerBeek (1927–1984).

Knowlton also created new programming languages for graphics – EXPLOR, ATOMS and SPHERES. In 1966, together with Leon Harmon (1922–1982) he developed electronic scanning technologies explored in the "Studies in Perception" series. In "Studies in Perception I", they created an image of a reclining nude (the dancer Deborah Hay) by scanning a photograph with a camera and converting the analogue voltages to binary numbers which were assigned to typographic symbols based on halftone densities. It was printed in The New York Times (1967) and exhibited at one of the

earliest computer art exhibitions – “The Machine as Seen at the End of the Mechanical Age” – held at the Museum of Modern Art, New York (1968). [5] It became popular as an example of ASCII art, although Knowlton called this technique a ‘photomosaic’. He is still active as an artist and employee. His current artworks are sometimes mosaics made of seashells.

Table 1

Computer Art Pioneers (using data from [6])

<i>Name, Surname</i>	<i>Country</i>	<i>Enter</i>	<i>Category</i>	<i>Comments</i>
Ben Laposky	United States	1950	Mathematician / artist	Oscilogramms
Herbert Franke	Germany	1956	Mathematician / artist	Oscilogramms, algorithmic art
John Whitney (Senior)	United States	1958	Filmmaker	Made films as an artist in residence with IBM
Charles Csuri	United States	1960	Artist – algorist, computer animated filmmaker	Csuri’s film „Hummingbird” purchased by the Museum of Modern Art (1968)
Michael Noll	United States	1963	Computer scientist / artist	Algorithmic art, Riley and Mondrian simulations
Frieder Nake	Germany	1963	Mathematician	Algorithmic art
Kenneth Knowlton	United States	1963	Computer scientist	Cooperation with 1963 (+ Lillian Schwartz), 1964 (+ Stan Vanderbeek), 1966 (+ Leon Harmon), Lillian Schwartz
George Nees	Germany	1969	Mathematician – computer sculpture	Algorithmic art
Manfred Mohr	Germany	1969	Artist – algorist	World’s first museum based solo exhibition of computer-generated art at Musee d’Art Modern, Paris (France)
Harold Cohen	United Kingdom, moved to the United States	1972	Artist (abstract painter)	Creator of AI program robot AARON
Yoichiro Kawaguchi	Japan	1975	Artist / animator	Japan Pavilion EXPO ,1986, EXPO ,2010
Roman Verotsko	United States	1982	Artist - algorist	Algorithmic plotter / brush- algorist
David Em	United States	1983	Artist	First significant use of 3D

3 Computer Art Founding Fathers' Vision about the Computer Art Theory

The theoretical papers by computer art pioneers such as Frieder Nake, Ben Laposky, Michael Noll show their broad spectrum of interests – starting from mathematics, computer science, physics, engineer sciences and including art, art theory, esthetics, semiotics, psychology. They came into the field of art theory and aesthetics with fresh, innovative and sometimes naive ideas providing a basis for new discussions, conclusions and making the first attempts to define the aesthetics of the new digital age.

The immediate theoretical approach to their newly-created artworks seems to be extraordinary and different from the professional artists, as well as from art historians. Despite the growing role of curators and art marketing in the 20th century, artists were occasionally not keen on self positioning in the context of concrete art movement and style right after the work had been created. We can find some exceptions (Dada, Futurism came to the art stage with written manifests) but they never tried to publish papers within an academic environment.

In 1975, Ben F. Laposky wrote: “My interest in other kinds of art was to some extent in abstract geometric painting, cubism, synchronism and futurism. The oscillons are related to the newer developments of op art, Lumia (light) art, computer art, abstract motion pictures into an academic environment, video synthesizer (TV) art, and laser displays, such as Laserium... The oscillons are intended to be a form of creative fine art.” [7]

Herbert Franke suggests on two aspects regarding to computer graphics – computer art. He states that: “Art can be regarded as a special form of communication. It is the task of the artist to provide a message, which in this particular case is also subject to certain aesthetic considerations, however they may be defined. Formerly, colours, sounds and tones were regarded as the raw material of art; today they would be considered information carriers. The elements of art are data, i.e. immaterial components. Even though this statement may sound rather sober, it does imply that art is not a material but rather an intellectual process.” [8] He also draws attention to the fact that having an inventory of all the mathematical branches and an interest in visualization of all forms that come to light, one can obtain plenty of forms, shapes and structures never seen before – an expansion of our treasury of forms. Many of these forms have considerable aesthetic charm. According to the usual criteria we cannot call them original works of art. But they can be considered as elements available for new creations and can be used to develop artworks. [9]

Michael Noll has changed his mind several times regarding the significance of computer graphics and computer art at the stage of the 20th century art history. He has moved from the adoration of a newly-created art form to critics and pessimistic view on its sense and again to positive opinion on the future of this medium. During years 1962–1994, he had had more than ten scientific publications on computer art, digital aesthetics and even an essay on the human perception of computer-generated graphics.

“Composition With Lines” consists of a scattering of vertical and horizontal bars which, at first glance, seem to be randomly scattered throughout the painting. With further study, however, one realizes that Mondrian used considerable planning in placing each bar in proper relationship to all the others. Conceivably, Mondrian followed some

scheme or program in producing the painting although the exact algorithm is unknown. A digital computer and microfilm plotter were used to produce a semi-random picture “Computer Composition With Lines” similar in composition to Piet Mondrian’s painting “Composition With Lines” (1917). Reproductions of both pictures were then presented to 100 subjects whose task was to identify the computer picture and to indicate which picture they preferred. Only 28% of the subjects were able to correctly identify the computer-generated picture, while 59% of the subjects preferred the computer-generated picture. Both percentages were statistically different (0.05 level) from selections based upon chance according to a binomial test.” [10]



Fig. 2 P. Mondrian “Composition With Lines”, 1917; A. Michael Noll “Computer Composition With Lines”, 1965 (© Rijkmuseum, © A. Michael Noll)

Frieder Nake insists on: “Since Shannon and Weaver, it was believed that any message (a sequence or field of perceivable signals) contained information. The information content of a message could be measured. A painting could clearly be considered the carrier of signs. It could, indeed, be viewed as a complex sign composed of subsigns which were in turn composed of subsigns and so on. On each level of such a hierarchy the statistical information content (according to Shannon’s axiomatic definition) could be determined.” [11]

It has to be mentioned that there still exists a gap between contemporary art theory and history, and the computer art theory. Nowadays, when practically everyone, including the artists and art historians, is an everyday user of computers and the term “new media art” is frequently used instead of “computer art”, this art form of the 20th century should be introduced to a wider audience.

4 First Examples of Computer Art in Latvia

The emergence of the computer art was tightly connected with the computer industry development. Latvia, a small state of the Baltic region, was incorporated into the Soviet Union after the Second World War. In former Soviet Latvia, the first generation computer

was constructed by a team lead by Jānis Daube in 1962. Some graphical features became available at the end of the 1960s. In 1969, a second generation computer GE-415 was bought from France to set it at the premises of the Computing Centre in Riga. The Museum of Computer Technique, IMCS UL in Latvia possesses the examples of the first computer drawings from that time.

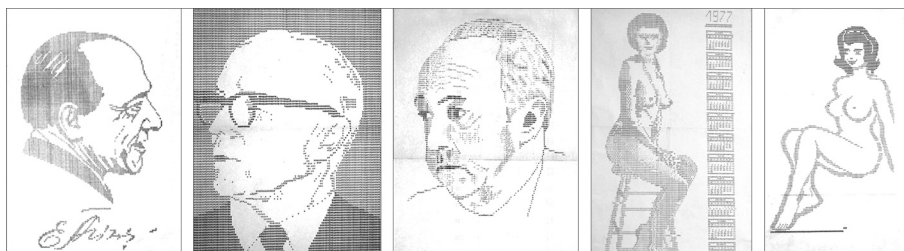


Fig. 3 “ASCII Art Samples”, ca. 1970 (©Museum of Computer Technique, IMCS UL)

Due to the political situation of that time, no connections with the Western modern art were officially allowed. The art forms, such as Dadaism, abstract art (and its variations), etc., were practically unknown to a wider audience. The first authors of computer drawings were computer scientists, engineers. They had hardly any information about the contemporary art forms of the 20th century. The most common were ASCII art forms. These drawings always tended to be realistic. Sometimes they even had features characteristic to caricatures or cartoons. Even some ‘underground’ things like drawings of nudes (no wonder, considering the political status of Latvia at that time) had appeared since 1969. These first examples are not signed at all due to their completely different status in perception of the society, as well as the authors’ own position. The computer scientists and engineers were not tended to position their experiments with data visualization as any form of visual art.

Later (during the 1970s), we can find some examples of kinetic art, conceptual and environmental art made by professional artists. Officially, these pieces were stated in the category of design objects. Most of them were never realized. They appeared only a few times in the expositions dedicated to design. Some kinetic objects were built, as well as communication design samples appeared. In 1980, the Riga Central Railway Station’s renovation project was implemented. A multi-program light system at the clock tower and visual communication system inside the station building were developed. In nowadays terms, we can call it a synthesis of communication design and conceptual art.

5 Cooperation of Artists and Scientists

According to Andrea Grover [12], the first publicized cooperation of contemporary artists and scientists working on new technologies started in early 1960s. The NASA Art Program was established in 1962 by the United States to commission artists, including Norman Rockwell and Robert Rauschenberg, for the purpose of recording history of

space exploration through the eyes of artists. The collection now includes 2,500 works by more than 350 artists.

In 1964, Bell Laboratories started an informal artist-in-residence program that later evolved into the greatest art and technology programs in the country. It started with the beginnings of computer graphics, such as the above-mentioned Ken Knowlton's and Leon Harmon's computer-generated "Studies in Perception" series and BEFLIX animation system, which was used to produce dozens of animated films together with artists like Stan VanDerBeek and Lillian Schwartz.

In 1966, a group of New York artists worked with around 30 engineers and scientists from the Bell Telephone Laboratories to create performances that incorporated new technology. On October 13–23, 1966, they organized a major artistic event "9 Evenings: Theatre and Engineering". It has always been mentioned as landmark in the 20th century art history, as well as a starting point of using such technologies as video projection, wireless sound transmission, and Doppler sonar. In 1967, engineers Billy Klüver and Fred Waldhauer, and artists Robert Rauschenberg and Robert Whitman launched a non-profit organization *Experiments in Art and Technology (E.A.T.)* with a main goal to develop collaboration between artists and engineers. Composer and sound artist John Cage, dancer Merce Cunningham, and pop artist Andy Warhol have to be mentioned among the E.A.T. most active members. The best-known E.A.T. activity is the Pepsi Pavilion at Expo '70 (1970, Osaka, Japan) where E.A.T. artists and engineers cooperated to design and implement an immersive dome that included a fog sculpture by Fujiko Nakaya. Twenty-eight regional E.A.T. divisions were established throughout the U.S. in the late 1960s to promote cooperation between artists and engineers. They resulted in expanding the role of artists in social developments related to new technologies. E.A.T. activities lasted till 1989.

The Art and Technology artist-in-residence program (A&T) was launched during 1967–1971 by Maurice Tuchman, curator of modern art at the Los Angeles County Museum of Art (LACMA) in Los Angeles. Tuchman selected industry partners from southern California companies from one side, and American, as well as European artists, who were keen to use the provided new technologies, from the other. More than 70 artists had participated, among them such 20th century and contemporary art icons as Andy Warhol (1928–1987), Robert Rauschenberg (1925–2008), Roy Lichtenstein (1923–1997) and John Baldessari (1931).

This program was followed by many other programs for artists in residence. John Whitney, computer animation pioneer, became IBM's first artist in residence (1967). Since 1985 to this day, Australian Network for Art and Technology (ANAT) supports Australian and foreign artists and creative practitioners engaged within science and technology, including residencies. Similar activities took place in Britain. John Latham and Barbara Steveni established *Artist Placement Group (APG)* in 1966. They tried to engage artists in non-art environments.

Computer Technique Group (CTG) emerged in Japan from 1966 till 1969. Their statement was that a computer is "a medium, neither a tool nor device, and computers could become a medium for art and had a potential to become a medium that unites media through its art works and global activities."

Computer Arts Society (C.A.S.) was born almost at the same time in London. It started by an inaugural exhibition "Event One" in March, 1969. George Mallen, Alan

Sutcliffe and John Lansdown set up C.A.S. as a branch of the British Computer Society to facilitate the use of computers by artists. Its bulletin PAGE almost to this day has featured British and international computer artists, and hosted some fundamental discussions such as about the aims, nature and aesthetics of computer art.

Another periodical – LEONARDO – should be mentioned as a longstanding and still flourishing science and art project. This journal has achieved international recognition and high scientific level. Its history is a very personal story at the same time. Frank Malina (1912–1981) was a pre-Space Age rocket engineer and second director of the Jet Propulsion Laboratory (1944–1946). However, he became involved in kinetic art. While being an engineer, he had access to an abundance of scholarly Periodicals. There was no equivalent publication place for artists, so he decided to start one. The concept was simple – a publication by serious artists with subject integrity secured by the same kind of peer review of articles that is common in scientific journals. The journal *Leonardo* was founded in 1968 in Paris. *Leonardo* was and still is an international peer-reviewed research journal that features articles written by artists on their own work, and focuses on the interactions between the contemporary arts and the sciences and new technologies.

After the death of Frank Malina in 1981, and under the leadership of his son, Roger F. Malina (astrophysicist, Executive Director of the Centre for EUV Astrophysics at UC Berkeley at that time), *Leonardo* moved to San Francisco, California, as the flagship journal of the newly-founded non-profit organization Leonardo/The International Society for the Arts, Sciences and Technology (Leonardo/ISAST). Leonardo/ISAST has grown along with its community and today it is the leading organization for artists, scientists and others interested in the application of contemporary science and technology to the arts and music. [13] *Leonardo* is covered by Arts & Humanities Citation Index and Current Contents/Arts & Humanities of Thomson Reuters.

In Latvia, the first net art, then new media art, examples spread out in the mid of 1990s. Professional artists were initiators of collaboration between scientists and the IT industry. Annual new media festival in Riga – “Art and Communication” – first organized by RIXC (Centre for New Media Culture in Riga) in 1996 has acquired international recognition amidst worlds digital community. Artists prompted to cover such issues as Transbiotics (2010), Energy (2009), Spectropia (2008), Spectral Ecology (2007), Waves (2006), Media Architecture (2003). In 2007, new media artist Gints Gabrāns (1970) created project “Paramirrors” and presented it in the Latvian pavilion on the 52nd International Art Exhibition of La Biennale di Venezia, Venice, Italy. It was done in collaboration with Elmārs Blūms, Institute of Physics, University of Latvia, Ilze Aulika, Vismants Zauls, Mārtiņš Rutkis, Institute of Solid State Physics, University of Latvia, and Jānis Spīgulis, Institute of Atomic Physics and Spectroscopy, University of Latvia.

References

1. Online: <http://www.atariarchives.org/artist/sec6.php> (accessed December 2010)
2. Online: <http://www.biologie.uni-muenchen.de/~franke/> (accessed December 2010)
3. Online: <http://noll.uscannenberg.org/> (accessed December 2010)
4. Julesz, B. Foundations of Cyclopean Perception. Chicago: The University of Chicago Press, 1971.
5. Online: <http://www.kenknowlton.com/> (accessed December 2010)

6. King, M. Computers and Modern Art: Digital Art Museum. "Proceedings of the 4th Creativity and Cognition Conference", Loughborough University, New York: ACM Press, pp. 88–94, 2002.
7. Laposky, B. Oscillons: Electronic Abstractions. Available online: <http://www.atariarchives.org/artist/sec6.php> (accessed December 2010)
8. Franke, H.W. The Expanding Medium: The Future of Computer Art. "Leonardo", vol.20, No.4, pp. 335–338, 1987.
9. Franke, H.W. and Helbig, H.S. Generative Mathematics: Mathematically Described and Calculated Visual Art, "Leonardo", 25, Nos. 3/4, pp. 291–294, 1992.
10. Noll, A.M. Human or Machine: A Subjective Comparison of Piet Mondrian's '*Composition with Lines*' and a Computer-Generated Picture, "The Psychological Record", Vol. 16. No. 1, pp. 1–10, January 1966.
11. Nake, F. Computer Art. A Personal Recollection. "Proceedings of the 5th Conference on Creativity & Cognition", ACM, New York, NY, USA, pp 54–62, 2005
12. Andrea Grover. Artists in labs, tech industries, or science agencies <http://andregrover.com/category/science/> (accessed December 2010)
13. Online: <http://www.leonardo.info/> (accessed December 2010)