

Kunsthalle Wien

Radical Software

Women, Art & Computing 1960–1991

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Rebecca Allen

Rebecca Allen (b. 1953, Detroit, Michigan) has been working with computers as an art medium since the 1970s, collaborating with artists including Nam June Paik and musicians such as Kraftwerk, Mark Mothersbaugh from Devo and Carter Burwell. She was one of the first artists to digitally animate the human body at a time when digital art was dominated by abstraction. Her animations are among the earliest examples of rendered 3-D graphics in music videos.

Girl Lifts Skirt (1974) is Allen's first computer animation, produced from a set of preparatory drawings that were translated into coordinates animated by software. She describes the work as 'a comment on women's sexuality and the absence of the female perspective in technology. At that time, artists working with computers were mostly working with geometric shapes, which is what the computer could do best. I was interested in bringing a different kind of aesthetic, one that would focus on the human body in motion and insert a human and feminine presence into the computer'.

Allen subsequently made *Swimmer* (1981) while working at the Computer Graphics Laboratory at New York Institute of Technology: 'They were considered the best research laboratory in the development of the early software systems for the creation of computer graphics and animation. The first and only 3D model of a female body in the world was made by the lab director, Ed Catmull. It gave me the idea to bring this "frozen model" to life. At that time, making 3D human motion was considered one of the hardest technical challenges. *Swimmer* was the first motion piece that I created from that research and one of the first examples of 3D human motion. I'm a long-time swimmer myself and was keen to work on the movement and fluidity of this "body" within a three-dimensional environment.'

Elena Asins

3 in 3 Perspective Scale 33 newplan (1989) is a computer-generated work by Elena Asins (b. 1940, Madrid – d. 2015, Azpirotz, Spain). Asins attended seminars organised by the Centro de Cálculo (Computation Centre) de la Universidad de Madrid from 1968, where two IBM computers had been purchased for artistic and scientific experimentation. The algorithmic works she produced in the following years show how she was inspired by the inherent logic of computing. Her exploration of mathematical formulations in art resulted in an invitation to attend Columbia University as a researcher in the early 1980s. There she realised her first computer-generated works. *3 in 3 Perspective Scale 33 newplan* shows the evolution of a geometric lattice of Necker cubes that permute slightly from sheet to sheet. The sequence is intended as an extract of an evolving and endless process of potential interconnections and moderations.

Colette Stuebe Bangert & Charles Jeffries Bangert

Land Lines, Black, Brown, Red Earth (1971) is a collaborative artwork made by Colette Stuebe Bangert (b. 1934, Columbus, Ohio) and Charles Jeffries Bangert (b. 1938, Fargo, North Dakota – d. 2019, Lawrence, Kansas). Colette Stuebe Bangert trained as an artist while Charles Jeffries Bangert studied mathematics, arts and statistics. From 1967 they combined their scientific and artistic practices, producing computer-generated drawings that explore the aesthetic properties of algorithms. *Land Lines, Black, Brown, Red Earth* (1971) is emblematic of their formal experiments linked to landscape and specifically, that of Kansas where they moved in 1962. They describe the computer as a support for drawing, like an extension of the artist's physical body: 'We consider each element of the drawing as an independent element. It's artificial. Yet this artificiality is precisely an aspect of using a mathematical attitude – the separation and isolation of the individual elements of a problem. Our efforts in computer graphics have shown us how complex even the simplest manual drawing is.'

Gretchen Bender

In the 1980s Gretchen Bender (b. 1951, Seaford, Delaware – d. 2004, New York City, New York) was linked to the Pictures Generation artists for her video works and installations that appropriate elements from television, films and corporate aesthetics. Her work has been described as using 'media against itself – to have it entertaining and critical simultaneously'. In 1984, through the artist Amber Denker, she gained access to the equipment of the Computer Graphics Lab at the New York Institute of Technology where she started to incorporate computer-generated images into her work.

Wild Dead (1984) brings together the logos of General Electric and AT&T among others, reproducing them alongside contemporary artworks and abstract computer graphics. These are set to a soundscape by Stuart Argabright and Michael Diekmann. Images and sound are edited together at a rapid pace that evokes the disrupted stream of remote-controlled television. 'I think of the media as a cannibalistic river. A flow or current that absorbs everything', Bender stated in an interview in 1987.

The 13-monitor, four-channel video installation *Dumping Core* (1984) is titled after a computer error when a computer programme crashes or terminates uncharacteristically and 'dumps' its record of the working memory (the 'core'). It also alludes to a partial nuclear meltdown at the Three Mile Island Nuclear Generating Station in Pennsylvania in 1979 where part of the reactor core melted and the system became dangerously radioactive. Conceived as an 'electronic theater', the installation mimics and exaggerates the pervasive media culture of American television networks in the 1980s. Bender later described how 'from that equivalent flow [she] tried to force some kind of consciousness of underlying patterns of social control.'

Gudrun Bielz & Ruth Schnell

Plüschlove (1984) is the first collaborative computer-based work by Gudrun Bielz (b. 1954, Linz, Austria) and Ruth Schnell (b. 1956, Feldkirch, Austria). It was made at the University of Applied Arts in Vienna where they were studying in the department of Digital Art (formerly Visual Media Design). They used a Commodore 64 computer and graphic tablet to draw over video footage from films such as Raoul Walsh's *High Sierra* (1941) and Alfred Hitchcock's *The 39 Steps* (1935). Using this technology, they sought to manipulate and deconstruct the normative gender roles they encountered in mass media. Schnell explains: 'I found it all really fascinating because it was basically an extension of video, so we were able to occupy an artistic place which a lot of

people had ignored.'

Elvis (1985) was produced as a teaser video for a theatre production at the Schauspielhaus Wien in Vienna: 'There is a display window at the Schauspielhaus on Porzellangasse, and the idea was to put a video in the window and play it night and day. We didn't work with film, instead we based it on a book about Elvis, drawing and improvising. [...] My rule was never to use special effects, create everything yourself!'

XXX (1987) is edited and animated on an Amiga 1000, using video source material that shows movements of flowing water. Layered on top of the wavy imagery are animated shapes, reminiscent of a meadow, but abstracted.

Dara Birnbaum

Kojak/Wang (1980) by Dara Birnbaum (b. 1946, New York City, New York) is part of the artist's Pop-Pop Video series, which uses footage appropriated from television. The artist explains: 'I had been reading a good deal about film semiotics, but it seemed like no one was analysing television, which to me was the dominant cultural vocabulary in America in the late 1970s [...] *Kojak/Wang* was an attempt to see if I could appropriate the stereotypical male voice. The ad from Wang Industries, which was the largest, most dominant seller of computers at the time showed a woman at a computer with laser beams shooting in and out of it. I thought this was an unusual depiction: like the traditional role of a secretary, but now at a computer. And I juxtaposed that with scenes from *Kojak*, a typical violent, shoot-'em-up crime drama. There are two men appearing in it, Kojak as a very strong character, and the man he's questioning as a rather weak figure – and this very commercialised, stereotypical new role for women.'

Inge Borchardt

From 1961, Inge Borchardt (b. 1935, Stettin, Germany, today Szczecin, Poland) worked at the Deutsches Elektronen-Synchrotron (DESY) in Hamburg where she was in charge of the analogue computer centre. In 1966, she used the EAI 231R analogue computer to produce drawings that she exhibited in the Musikhalle in Hamburg (now known as the Laeiszhalle). The drawings presented at Kunsthalle Wien combine differential equations or oscillation equations. They were created by continuously changing variables. Borchardt also applied Lissajous equations to some of these drawings.

Barbara Buckner

Barbara Buckner (b. 1950, Chicago, Illinois) employed analogue image processing tools such as multi-channel keyers and colorizer, as well as a Z-80 microcomputer and analogue-to-digital / digital-to-analogue frame buffer to produce the video *Greece to Jupiter: It's a Matter of Energy* (1982). A combination of several key layers and colorizer channels produced variations in texture, colour and luminosity, as the Z-80 computer digitized and 'drew' the video raster over time. The work suggests a state of transition, a passage through space and time – from the structured forms of Greece – to Jupiter, beyond our terrestrial world.

Millennia (1981) introduces a visual language characterized by universality, symbolism and repetition. The work explores what Buckner has referred to as 'spiritual undercurrents,' whilst appearing distinctly digital. To produce *Millennia*, Buckner used the computer to sequence and arrange the images in grids. The absence of sound is intended to emphasize the rhythmic patterns of the imagery.

Doris Chase

Initially known for her paintings and sculptures, Doris Chase (b. 1923 – d. 2008, Seattle, Washington) first experimented with computers and filmmaking in the late 1960s. Through the Experiments in Art and Technology (E.A.T.) movement, Chase met William Fetter, Communications and Design Director at Boeing. With the support of the company's programmers, she began to produce computer-generated imagery for film. Her first digital animation, *Circles 1* (1970), was programmed on a Boeing company computer. Chase subsequently moved from Seattle to New York where she made *Squares* (1973). The two films extend the principle of modularity explored in her sculptural practice: geometric forms that can permute and be rearranged in different ways, renewing the viewer's point of view. *Circles 1* features an electronic soundtrack composed by Morton Subotnik, which serves to accentuate the effects of repetition in the images.

Analívia Cordeiro

In *M3x3* (1973), Analívia Cordeiro (b. 1954, São Paulo) combines digital technology with dance and video. The choreography performed by the nine dancers is conceived by a computer program, the artist explains: 'For TV, I defined the point of view of the shot, the zoom in or out, the time and the visual effects. The output for the dancers was the body positions drawn according to the television cameras point of view and the time between the positions. The TV team received instructions that included all the takes with time stamps and the visual effects. I used a Digital PDP-11 computer with 5 MB of storage and 256 KB of memory capacity. And the body position output was a vector of six numbers corresponding to the left leg, right leg, left arm, right arm, torso and head. Decoding the numbers for a stick figure was done manually, as there were no graphic plotters in Brazil at the time.'

The piece with its mechanical movement and binary representation (in black and white) was conceived to reflect technological and political change, Cordeiro explains: 'The whole world was under the domination of mass media, and the main subject was what mass media would do with people, transforming people into objects without identity, without individuality. On the other hand, there was a dictatorship in Brazil that was transforming people into non-identities, because people could not have their own opinion – they were instructed to follow the rules of the government.'

Betty Danon

Betty Danon (b. 1927, Istanbul – d. 2002, Milan) created the *Computer poems* series in the early 1990s, initially using her daughter's Macintosh cube computer. Employing an early home-computing graphics program called SuperPaint, Danon created images to illustrate short, humorous verses of poetry. For example, one that uses the computer to reproduce a work by French painter Georges Braque is accompanied by the question: 'Would Braque have liked the computer?' Another depicting a 'shadow' tumbling out of a frame appears with the phrase 'shadow: oh how a shad had a show'. Danon also used the keyboard characters for figurative purposes. In her works, two lateral and adjacent brackets are often used to make a bird motif, an allusion to the subject of migration which is a recurrent topic in her work.

Hanne Darboven

From the late 1960s onwards, artist Hanne Darboven (b. 1941, Munich – d. 2009, Hamburg) adopted a daily practice of writing (*Schreibzeit*). Through a vast body of works that took many

forms – including calendars, musical scores and books – she spatialised and visualised time. *Ein Jahrhundert-ABC* (1970–71) is composed of nineteen panels each containing forty-two sheets of paper, each marked according to Darboven's notational system. The wavy marks or 'writing' describe a 'time-based' principle she named K-value. 2K corresponds to two upward strokes, 3K to three strokes and so on. Darboven's practice can be seen as a performative gesture approximating machine-like labour. During a self-imposed, strictly regimented eight-hour day she generated line upon line and page upon page of handwritten script, recalling the first 'human computers' who filled reams of paper with their longhand calculations charting the trajectories of comets, spacecraft and ballistic missiles.

Bia Davou

Bia Davou (b. 1932 – d. 1996, Athens) produced serial works in a broad range of media including painting, sculpture, drawing and weaving. The *Serial Structures* (1978) series includes drawings produced by applying dots to a page, following a mathematical system of permutations. *Sail – Odyssey* (1982) is part of a series inspired by the *Odyssey* (c. 8th century BC) an ancient Greek epic poem attributed to Homer. Davou reinterpreted the verses in an abstract geometric alphabet. From one work to the next, the signs are rearranged according to her own sequential logic. The work presented at Kunsthalle Wien displays this within a woven textile, which unfurls in space like a sail. The artist stated: 'The perpetuation of *Serial Structures* can be performed by anyone or begin and progress from all together, as long as there is a given system, a rule, that will associate the sequences and allow the recent ones to be generated from the previous ones.'

Agnes Denes

Agnes Denes (b. 1931, Budapest), primarily known for working with environmental, ecological issues and philosophical concepts, is an early adopter of the computer to engage with scientific and technological subjects. Her *Hamlet Fragmented – Wittgenstein's 'Pain'* (1971) employs two existing texts: an excerpt from *Philosophical Investigations* (1953) by Ludwig Wittgenstein and *Hamlet* (1623) by William Shakespeare, each modified by a computer program. Wittgenstein's text was subjected to his own concepts on the 'logic of language', replacing the word 'pain' with 'pleasure'. Shakespeare's text was programmed into a computer and edited until all connectives, articles and prepositions were removed. The resultant concrete poetry divorces its physical properties from its original meaning opening up new spaces for speculation. According to Denes, 'the technical part may be the least interesting, just basic computer work, deletion and reformation of text. What's important is the result, done by the mind. Using word reversals, a new personality is born: TECHNOLOGY CHANGING PERSONALITY.'

VALIE EXPORT

VALIE EXPORT (b. 1940, Linz, Austria) began a series of 'digital photographs' in 1989, marking a significant shift in her artistic practice by incorporating digital tools within her work. This series explored dichotomies such as culture/nature and masculine/feminine, as well as the positioning of human and female subjects within the constructed social body, often symbolised by urban environments. She explains: 'I photographed body configurations in architecture and in nature and later started processing them using a computer. They were very simple programs. I wanted to connect the representations of the city employing a digital medium as well as a photographic, analogue one. I was interested in drawing on the computer. That was nothing new. But I wanted to combine photography and the computer on the one hand, and my body and the city on the other.'

Concrete Computer Display (1988/1990) by VALIE EXPORT was conceived as a 'computer sketch' for a large, computer-controlled and interactive space-text installation. The monitors are arranged like a grid of a crossword puzzle, using each monitor to display a letter or word. The artist has described the piece as 'a creation of a 'human-machine-language,' as well as a 'text-body.' The work was especially restored for this exhibition and is presented for the first time since the 1990s.

Anna Bella Geiger

Anna Bella Geiger (b. 1933, Rio de Janeiro) produced *Self-Portrait* (1969) during a research trip to London: 'I met some people who were starting to experiment with computers and who invited me to take part in this research, which was an untapped field. It was a new thing, very different to making art, because they were using a computer originally programmed to be used as a possible medium for artists. I didn't continue working with them because I lived in Rio de Janeiro and had a family and four children [...] People's idea and perception of art was changing at the time, and I was feeling the need to experiment with previously unknown media such as video with a Super 8 camera, for instance.'

Isa Genzken

From 1975 to 1985, Isa Genzken (b. 1948, Bad Oldesloe, Germany) used the computer to design a series of sculptures known as *Ellipsoids* and *Hyperbolos*. The artist explains that she wanted to use the 'arts of calculation' to create 'mathematically correct' works. She produced a series of computer-generated drawings of geometric shapes with the technical support of Ralph Krotz, a physics student at the University of Cologne. These were printed at 1:1 scale using a plotter and given to a cabinet maker who produced the sculptures in wood. She first exhibited the drawings alongside these works in 1979. The application of scientific principles and industrial methods of fabrication within these works can be traced to conceptual and minimalist art traditions.

Dominique Gonzalez-Foerster

Ada en ADA (1989) employs the computer programming language ADA to tell the story of Ada Lovelace (b. Ada Byron, 1815 – d. 1852, London), a mathematician now widely regarded as the first computer programmer. The program was developed by the U.S. Department of Defense in the early 1980s and named after Lovelace. Dominique Gonzalez-Foerster (b. 1965, Strasbourg) employed extracts from Dorothy Stein's 1985 biography, *Ada: A Life and a Legacy* to produce the 'packets' or blocks of formatted text executed via the ADA program. Each sequence reveals different aspects of Ada Lovelace's biography: her genealogy, her character traits, her meeting with the mathematician Charles Babbage, her thwarted relationship with motherhood, ill health and death. The accompanying soundtrack is composed by Pierre-André Athané. Gonzalez-Foerster explains: 'I wanted some cinematographic, operatic emotions even, because the computer language was very dry.'

Lily Greenham

Lily Greenham's (b. 1924, Vienna – d. 2001, London) diverse and experimental oeuvre includes sound poetry and lingual music, alongside her works of op, kinetic and computer art. Her radical and restless shifts between media, language as well as places stands in close

connection to her biography: Born to parents of Polish/Ukrainian-Jewish descent, the family fled from Vienna to Copenhagen in 1938 due to the increasingly dangerous political situation. She returned to Vienna in 1952 to study at the Academy of Music and Performing Arts. Shortly after she became involved with the Wiener Gruppe, focusing her work on radio broadcasts and performances of sound and concrete poetry.

After participating in seminars on computer language in 1969 and 1970, Greenham acquired a personal computer in 1982, using it to produce a body of work. She employed a variety of techniques, including programming algorithms and collaging and combining computer graphics on the photocopier. The *Homecomputer Graphics* (1982) on view at Kunsthalle Wien are accompanied by some of her preparatory material (presented in a vitrine). Through the shifting geometric patterns in her collages she negotiates principles of movement and change – aspects consistently featured in her artistic practice.

Samia Halaby

‘In 1985, I said to myself that if I was an artist of my time, I should explore the technologies of my time.’ A year later, painter Samia Halaby (b. 1936, Jerusalem) acquired a Commodore Amiga 1000 computer, on which she began programming abstract kinetic paintings using the BASIC and C languages. ‘I wanted technology to reveal new formal attributes for the language of images’, she explains. The computer allowed Halaby to think of her images in movement and in relation to sound. Some of her kinetic paintings take inspiration from the urban environment, others are formal variations obtained by repeating and superimposing geometric motifs in a variety of colours.

For Halaby, the computer is a means of continuing with the pictorial ideals of the avant-garde of the early twentieth century: ‘The most interesting one is the nature of the pictorial surface. In computing, the surface is luminous and has a memory. Furthermore, shape has the added attribute of sound and motion. Relativity of light and space in abstract painting is accompanied by the relativity of speed. Things appear, disappear, shift and move at different speeds. Also, growth and transformation become new attributes of shape. Shapes can also signal to each other or exude sounds together like a choir. Abstract moving images with sound are vastly different from film, which is moving image dominated by a lens. The lens is perspective and perspective negates the relativity of time and space by always freezing the image into specifics of time and place.’

Barbara Hammer

Created with a 16 mm film camera and an Amiga computer, *No No Nooky C.U.* (1987), by Barbara Hammer (b. 1939, Los Angeles, California – d. 2019, New York City, New York) questions the heteronormative constructs of sexuality. The film uses digital graphics, excerpts from films (including Hammer’s own *Multiple Orgasm*, 1976) and texts on desire or sexual intercourse to create a unique narrative via the computer. Punning on the Spanish word *amiga* (female friend), the artist presents the computer as a potentially liberating tool for women, and an object of eroticism, connecting computing and lesbian sexuality. ‘Radical content deserves radical form’, the artist stated in 1993, as such *No No Nooky C.U.* reflects both the technological and social changes of the 1980s and explores the notions of romance, sexuality and love in the post-industrial age.

Like the earlier film *No No Nooky C.U.* (1987) *C.U. Tart* (1988) combines 16 mm footage and computer graphics that Barbara Hammer (b. 1939, Los Angeles, California – d. 2019, New York City, New York) made on an Amiga computer. The film explores the connection of the food industry, consumerism and televised advertisement – focusing on the development of the increased use of sugar in the populations everyday food intake. The animated shapes in the background of the video remind of a state of being under the influence of a drug: the

psychedelic visuals in combination with the layered words (such as sugar, candy or slave) suggest the addictive effect that sugar as well as consumerism have on society. The soundtrack of the work samples famous pop, soul and electronic songs with the applause of an audience – amplifying the effect of abstraction already initiated by the images.

Lynn Hershman Leeson

Self Portrait as Another Person (1965) by Lynn Hershman Leeson (b. 1941, Cleveland, Ohio) consists of a black wax cast of the artist's face, wearing a wig and red lipstick. The tape recorder underneath plays a recording of Hershman Leeson's breathing. A motion sensor activates the work to 'speak' to viewers, occasionally asking personal questions, such as: 'What is your greatest fear?' or 'Could you tell me about your first sexual experience?' While Hershman Leeson's work is now celebrated for its radical engagement with technology and media, the artist remembers a different reception for the work when it was first shown: 'At the time, people hated it. They wouldn't let it be seen. The show was taken down within twenty-four hours, and it took about fifty-four years before I could show those pieces again. Nobody would display these works back then because people kept saying it wasn't art.'

The mixed-media drawing *X-Ray Woman* (1966) depicts a female figure (resembling the artist). Flesh and machinery are seamlessly interconnected – the torso and upper thighs decorated with a fragmentary, complex interplay of cogs, wheels, conveyor belts, tissues and organs, implying the inner workings of the body. Just a few years after the term 'cyborg' was first coined to refer to a cybernetic organism, Hershman Leeson envisioned this hybrid being in her work, drawing upon her own self-image and using her own voice to make an image that is part human, part machine.

Grace C. Hertlein

Grace C. Hertlein (b. 1924, Chicago, Illinois – d. 2015, Chico, California) is one of the first artists to have used the computer as a tool for art-making and is widely regarded as a pioneer of computer art. Her works are also outstanding for their focus on natural subjects and organic (as opposed to geometric) form. Using the computer programming language, FORTRAN, the artist produced works including the one shown in this exhibition, which is part of a series that variously represent the theme of the forest. This research would lead her to explore the potential application of computer technology in the textile production. Writing in 1977 she ventured: 'The full implication of computer art and computer-controlled textile systems is perhaps the next "industrial revolution," in which computer designs, computer-assisted, produced textiles could enhance private and industrial environments.' Hertlein taught as Associate Professor in the Computer Science Department at the University of California (1970–98) and was editor of the magazines *Computers and People* (1974–88) and *Computer Graphics and Art* (1976–78).

Channa Horwitz

Channa Horwitz (b. 1932 – d. 2013, Los Angeles, California) produced drawings, paintings and installations based on a notation system called Sonakinatography – composed of the Greek words 'sound', 'movement' and 'notation' – invented in 1968. Based on numbers from one to eight, each associated with a colour, the Sokinatography system is used by the artist to organise time, space, colour, movement and sound. The two works presented at Kunsthalle Wien, *Sonakinatography Composition #3* (1968/2004) and *Sonakinatography Movement I Sheet C 2nd Variation* (1969), follow precisely this system. Both are produced on graph paper, used to materialise time, with colours that in turn present movement. The artist explains: 'I

wondered if the simple language of “Sonakinatography” could speak to other artists in other disciplines in the same way that it spoke to me in painting.’ Various musical, dance, sound and light installation iterations of *Sonakinatography Composition* have been performed by composers, choreographers and artists who collaborated with her or posthumously, with her work.

Irma Hünnerfauth

In 1968, Irma Hünnerfauth (b. 1907, Donaueschingen, Germany – d. 1998, Kreuth, Germany) abandoned the medium of painting and began creating kinetic works using found objects and the detritus from consumer society. The sculpture *Augen und Glocke* (ca. 1970) is part of the *Vibrationsobjekte* series. In these works, the artist uses materials such as cables, electronic components and plastic objects which are soldered onto computer circuit boards. At the time of their creation, visitors were invited to ‘activate’ these interactive sculptures, causing their components to vibrate and produce electronic sound. In these objects, everything that is ‘fine, precious, like a jeweller’s’ – according to the artist – is meant to waver. She continues: ‘The visitor is confronted with how a composition falls apart – he [or she] is supposed to experience the discomfort of the destruction of the “beautiful”, as an awareness.’

Charlotte Johannesson

Charlotte Johannesson (b. 1943, Malmö) trained as a weaver. In 1978 she traded a tapestry entitled *I’m NO ANGEL* (1972–73) for an Apple II computer. Comparing the computer to the loom she observed: ‘There was a great synchronicity between the two machines, which I thought I could use – on the computer there were 239 pixels on the horizontal side and 191 pixels on the vertical side, and that was similar to what I had in the loom when I was weaving. I was using the same dimensions.’ Together with her husband Sture Johannesson (b. 1935 – d. 2018, Skanör, Sweden), she founded the Digitalteatern (Digital Theatre) in 1981. The first digital arts laboratory in Scandinavia, it was equipped with nine computers, printers, monitors and synthesisers, and remained active until 1985. It was here that Charlotte Johannesson taught herself computer programming languages to reproduce images from the media and popular culture, creating images pixel by pixel. A selection of her weavings and print computer graphic works is presented in the *Software* section of the exhibition.

Alison Knowles

The House of Dust (1967) is a computer-generated poem by Alison Knowles (b. 1933, New York City, New York) created with the assistance of the composer James Tenney on a Siemens 4004 mainframe computer. Knowles supplied the logic for the poem by providing four lists of words and short sentences that are used to produce the stanzas of the poem. Each quatrain begins with ‘a house of’, followed by attributes: its materials, its geographical location, its exposure to light and its inhabitants. Using the computer programming language FORTRAN IV, Tenney programmed the machine to generate the quatrains, finding that it could run four hundred stanzas before a repetition occurred. Here the poem is generated and printed by a dot matrix printer in real time. Different iterations of the work have included public artworks and happenings or events. In 1968, the artist translated the quatrain ‘a house of plastic, in a metropolis, using natural light, inhabited by people from all walks of life’ into a physical structure built in Chelsea, New York and subsequently at California Institute of the Arts (1970–72). The poem was distributed over the house from a helicopter during a *Poem Drop* event in 1971.

Beryl Korot

A founding editor of the influential journal *Radical Software*, Beryl Korot (b. 1945, New York City, New York) made a significant contribution to the nascent discourse on video art and media ecology in the 1970s. The installation *Text and Commentary* (1976–77) comprises woven textiles, drawings, a pictographic score and five channels of video running in a 30-minute loop. The work establishes a dialogue between traditional weaving techniques and the medium of video (first adopted by artists in the mid-1960s), which are both rooted in the encoding and transmission of information.

The videos show the artist working at a loom while the drawings describe the patterns of the weave and the pictographic score illustrates the video editing process. According to Korot, these elements ‘provide varying perspectives on virtually the same information’ yet all within their unique limitations: ‘Weaving in the West was not given the stature it deserved, visually or intellectually. It was relegated to the category of craft as apart from art, a distinction not made in non-Western cultures. It was crucial for me to look at the loom as a sophisticated technology, the first computer, and dispel the demeaning notion of women’s work while shining a spotlight on a tool that impacted all aspects of human industry, commerce and culture.’

Katalin Ladik

Genesis 01-11 (1975) by Katalin Ladik (b. 1942, Novi Sad) is a series of gelatin silver prints made from original slide positives. Ladik used printed circuits from devices such as radios, computers and televisions to generate sound. The work reflects on the rapid obsolescence of twentieth-century communication systems with each technological evolution leaving behind objects that appear archaic. In this work, Ladik interprets printed circuits as sound poems performed through her own voice. The lines within the circuits and spaces between them become abstract phonetic sounds. By associating human and technical languages, Ladik reveals their similarities and central roles within communication. Furthermore, she highlights the material shape of technology which defines how information circulates. Each of the eleven pieces in the series creates an evolving work of processual sound art.

Ruth Leavitt

The work of Ruth Leavitt (b. 1944, Saint Paul, Minnesota – d. 2025, Baltimore, Maryland) employs computation to manipulate and alter abstract forms by virtually stretching, rotating and deforming them across three axes. Her modular structures share a resemblance but are not identical. Leavitt published extensively on the subject of computer art including editing the book *Artist and Computer* (1976). Describing her experience of producing works at the Space Science Laboratories at the University of Minnesota Leavitt recalls: ‘My work in the lab was accomplished from 11 p.m. to 3 a.m. when no one else was working there because science professors regarded time on the computer too valuable to pursue artistic endeavours. However, after a few years, seeing my results and publications, the director of the lab awarded me a grant. The “stretching” program [was] created during this time [...] At the time, unlike the scientific community which eventually came to believe computer art credible, the art world was vehemently opposed to using computers to make art.’

Liliane Lijn

Man is Naked (1965) is from a series of *Poem Machines* that Liliane Lijn (b. 1939, New York City, New York) began in 1962. The series is emblematic of her work with kinetic art, light, motion and text. Inspired by research into light refraction by French physicist Augustin Jean Fresnel, Lijn wanted to create a work in which the energy of sound could be seen. In the first *Poem Machines*, a motorised metal drum spins so fast that the viewer is confronted with the vibration of the words rather than a legible text. *Man is Naked* – the first work in the series to employ Lijn's own writing – turns more slowly, allowing the words to float, interfering with the linear syntax of the poem. Created years before she used a computer, the work can be seen to anticipate the interrelation between the machine and language or computers and code. The work also recalls early computation machines that employed a system of wheels to perform calculations.

Vera Molnár

Vera Molnár (b. 1924, Budapest – d. 2023, Paris) was a pioneer of generative and computer art. From the late 1950s, she used simple algorithms to compose abstract paintings and drawings, calling her process an 'imaginary machine'. In 1968, she gained access to a computer and, after learning the FORTRAN computer programming language, produced the *Interruptions* series of works on paper, one of which is presented at Kunsthalle Wien. Taking a grid as her starting point, the artist applied a random rotation to each of the lines from which it is composed, creating an irregular structure of contradictory forces. Molnár then instructed the program to randomly erase certain zones, causing interruptions in the composition. In 1974, she collaborated with her husband, François Molnár to create their own software, *Molnart*. During this time, she produced the *Hypertransformationen Serie* (1974): She substituted the straight lines of a square motif with undulating ones and in that way played with the principles of doubling and repetition.

Lettres à ma mère (1988, displayed in a vitrine) employs a computer to reinterpret the artist's mother's handwriting. Molnár describes it as 'regular, strict, Gothic, but as the line moved towards the side of the page it became more and more nervous, worried, almost hysterical'. Over the years, she noticed that the letters became increasingly tormented. When her mother stopped writing to her, the artist simulated the letters 'for herself', using computer programming to imitate her distinctive handwriting.

Monique Nahas & Hervé Huitric

Monique Nahas (b. 1940, Paris) and Hervé Huitric (b. 1945 – d. 2025, Paris) met at the Centre universitaire de Vincennes, Paris, in 1970. Nahas previously studied physics at the École polytechnique – Huitric trained as an artist at the Fine Arts school in Paris and is among the founders of the Groupe Art et Informatique de Vincennes (GAIV, Art and Computer Science Group of Vincennes, founded in 1969), which Nahas joined in 1970. From 1971, the artists used a computer to compose paintings and drawings, initially employing the programming languages ALGOL and FORTRAN to determine the distribution of colour on works on paper. Once defined, the different colours were applied manually by the artists, they later explained: 'We titled the works produced by this technique the *Séries continues* (continuous series): whatever the colour, its brightness is the same wherever it appears on the surface, in terms of quantity and intensity.', explains Huitric. Later on, they used punched cards as a stencil for paintings, applying the colours with a roller.

Katherine Nash

Katherine Nash (b. 1919 – d. 1982, Minneapolis, Minnesota) began producing computer-generated artworks in the late 1960s. She developed ART1 at the University of New Mexico with electrical engineer Richard Williams in 1968, as a 'computer program for artists'. They also co-authored the article *Computer Program for Artists: ART 1* (1970) introducing different possibilities to use the computer as an artistic tool. Nash collaborated with Ronald Reichenberger to develop a second version of the software, ART 2, at the University of Minnesota in 1970. Its features included a 'polar coordinate generator' system that enabled curves or sine waves to be generated from a fixed point. *Untitled* (1971) is the result of an accumulation of typographical signs, printed in different densities and colours.

Sonya Rapoport

Shoe-Field (1982–89) by Sonya Rapoport (b. 1923, Brookline, Massachusetts – d. 2015, Berkeley, California) uses the computer to record, process and display data that the artist collected about shoes. The work was first presented with a series of computer printouts analysing her own collection of shoes at Berkeley Computer Systems store in 1982. It was accompanied by a participatory performance entitled *A Shoe-In*. Participants had their shoes photographed and were asked questions about their relationship to their shoes (how much they liked them, why they bought them, etc.). Their responses were recorded, entered into a computer and each participant was assigned a 'shoe psyche' charge – from -2 to +2. Through an 'Electric Field Theory' program which translated data into numbers, Rapoport created computer-generated prints and a series of works including artist books and software. Some were also printed as floor tiles that were incorporated within interactive works in 1986 and 1989.

The installation presented at Kunsthalle Wien brings together two artist books from 1983 and 1986, computer printouts and a computer-generated map with polaroids visualising the participants' data from 1982. *Shoe-Field* humorously folds emotions into a quantitative analysis using computing. It combines technology, science and psychology in a singular way to explore the aesthetic potential of data while also anticipating the use of computerised information to monitor consumer behaviour.

A series of activations took place during the exhibition on 8.3., 5.4., 3.5. – all from 2 to 5pm. *Shoe Field: Our Fate is on Our Feet* was a series of special events inviting visitors to interact with the artwork and discover their 'shoe psyche'.

Deborah Remington

The semi-abstract paintings that Deborah Remington (b. 1930, Haddonfield, New Jersey – d. 2010, Moorestown, New Jersey) produced from the mid-1960s, depict expansive, hieratic forms that lie somewhere between the organic and the technological. Collectively they seem to anticipate the aesthetics of personal computing with their hard-edged, machine-like forms and subtle gradations or backlighting effects that now recall screens. *Merthyr* (1966) is composed of several interlocking elements, like a fictional machine. In contrast to the objective, hopeful nature of Ulla Wigger's work, Remington's machines appear 'ruined [...] blasted and spent [...] opened or cut away' and imbued with 'mask-like shapes' and 'sexual and fetishistic symbols', suggesting 'a machine which is coming to life, or perhaps a life which is becoming a machine'. The artist described her work as follow: 'I am concerned with expressing an intense and personal vision through an imagery which is particularly my own. While I do not completely understand the sources of this imagery, my work contains elements

which, by simultaneously attracting and repelling one another, create a tense balance which has emotional and spiritual meaning for me.'

Sylvia Roubaud

The computer drawings presented at Kunsthalle Wien by Sylvia Roubaud (b. 1941, Munich) were created with the mathematician Gerold Weiss and belong to a series that they produced together in the Computer Graphics group at the German aerospace company Messerschmitt-Bölkow-Blohm (MBB) between 1971 and 1972. The works were produced as part of the cultural program for the 1972 Olympic Games in Munich. Roubaud recalls: 'Based on my ideas and sketches, the mathematician Gerold Weiss would program the IBM 360/50 mainframe computer using the FORTRAN IV language. The program was stamped onto punch cards, transferred to magnetic tape and then realised using the plotter. The drafting machine was a Kongsberg Kingmatic, a high-precision flatbed plotter measuring two by six metres. This drafting machine gave me the opportunity to manually intervene in the visual event during the drawing process, so it was possible to influence and alter the results based on my first impressions.'

Miriam Schapiro

From 1969 Miriam Schapiro (b. 1923, Toronto – d. 2015, Hampton Bays, New York) used computers to create preliminary sketches for a series of hard-edged, abstract paintings. Maddy Henkin describes Schapiro's process: 'Each piece began with a simple hand-drawn shape related to her central core imagery, which an assistant would translate into numbers representing points on a grid. Custom software would use these points to rotate the shape in space, generating fifty views of the original drawing.' *The Palace at 3:00 or A Meander* (1971) is typical of Schapiro's computer paintings in its evocation of female imagery via interlocking forms. It was painted in the same year that Schapiro moved to Los Angeles to run the Feminist Art Program at California Institute of the Arts with Judy Chicago. The following year they opened *Womanhouse* (1972), an artwork that has been credited with signalling 'the beginning of the international feminist art movement'.

Lillian Schwartz

Lillian Schwartz (b. 1927, Cincinnati, Ohio – d. 2024, Manhattan, New York) stated in 1984: 'My art has been nurtured by harnessing the technology that invades our everyday life.' As early as 1968, the artist produced works using the computer. Over a period of thirty-four years, she produced a significant body of work at Bell Laboratories in New Jersey including computer-assisted films, videos, optical effects and animations. Schwartz views the computer as an analytical and creative tool for rethinking the way an image is created.

Pixillation (1970) is the first computer-aided film that the artist produced at the lab. It uses the BÉFLIX language, developed by Kenneth C. Knowlton, which enabled artists and filmmakers to make bitmap films on a computer. The process involved tracing the coordinates of images, punching the information onto a card and feeding this card into a computer. The computer then transferred the information to magnetic tape and printed the graphic shapes onto 35 mm film. This visual essay combines computergenerated images with filmed optical effects, showing paint and pigments poured onto a coloured glass plate. In this way, Lillian Schwartz creates a hybrid work in which painting and computers meet. The images are accompanied by a soundtrack composed by Gershon Kingsley and performed on a Moog synthesiser.

In *Enigma* (1972), geometric shapes such as lines and rectangles are staged in a rhythmic animation with stroboscopic effects. Here again, Schwartz worked manually on the images, colouring the 16 mm film stock. Colour thus appears in different densities through the film, accompanied by a soundtrack composed by F. Richard Moore.

Finally, the monochromatic *Googolplex* (1972) was inspired by Polaroid inventor, Edwin Land's theories on colour perception and retinal persistence. Schwartz alternates positive and negative spaces in computer-generated images at a fast, almost hypnotic pace. The artist produced the sound by mixing found recordings of African music.

Sonia Sheridan

The work of Sonia Sheridan (b. 1925, Newark, Ohio – d. 2021, Hanover, New Hampshire) employs various communication technologies, including computers and copier machines. In 1970 she founded the Generative Systems research programme at the School of the Art Institute of Chicago, providing a platform for a new generation of artists interested in emerging technologies such as reprographics and computer animation. In the mid-1980s she collaborated with John Dunn, using his EASEL software to computerprocess images captured by a surveillance camera on her Cromemco Z-2D computer. The diptychs *Sonia in Time* (1985) show her face surrounded by computer screens featuring her image as recorded by a surveillance camera. Like a virtual *mise en abyme* (where a copy of an image is placed within itself) these portraits suggest infinite space alluding to the numerous possibilities that the computer offers as a tool.

Nina Sobell

The *BrainWave Drawings* were initially developed by Nina Sobell (b. 1947, Patchogue, New York) at the Sepulveda Neuropsychology Laboratory in California, in 1973. Using an electroencephalogram (EEG) to capture and measure electrical activity in the brain, Sobell connected two participants to the apparatus, recording the amplitude and frequency of their respective brain activity. The data was also communicated in real time to a computer so that it could generate curved patterns. The artist explains: 'In 1974, I first began using the computer as a tool in *Interactive BrainWave Drawings* to substantiate the efficacy of non-verbal communication between two people using a Digital Equipment Corporation Programmable Data Processor 12 Lab Computer. The results showed that both participants had at times emitted the same brain wave pattern in amplitude and frequency simultaneously, and that one person could non-verbally influence the brain wave patterns of the other.' By cross-referencing information, Sobell makes visible moments of synergy in the brain activity. Using an Apple II computer, she subsequently produced a series of digital images based on these experiments, using the BASIC programming language in 1980. The documentation presented at Kunsthalle Wien in a vitrine illustrated this multi-faceted project.

Barbara T. Smith

Outside Chance (1975) is one of several performance-based works that employ technological apparatus by Barbara T. Smith (b. 1931, Pasadena, California). Smith used a mainframe computer to make it 'snow in the desert' in a live event in Las Vegas. Computer scientist Richard Rubenstein helped Smith programme a PDP-10 computer at the Irvine University of California to generate 3,000 unique 'snowflakes'. Smith recalls: 'We made flakes with three to eight points (unlike in nature, where there is a maximum of six points) and using only two characters (1s and 0s).' Smith disguised herself with a wig and sunglasses before checking

into the Union Plaza Hotel in Las Vegas and dropping the snowflakes from a room on the 21st floor. The event was filmed by a local TV company and broadcast on the evening news.

Tamiko Thiel

Tamiko Thiel (b. 1957, Oakland, California) is known for digital media artworks exploring the relationship between space, body and cultural identity. After studying Product Design at Stanford University and Mechanical Engineering at Massachusetts Institute of Technology, she led the product design team at Thinking Machines Corporation (from 1983 to 1985), building Danny Hillis' Connection Machines CM-1 (1986) and CM-2 (1987). The first commercial artificial intelligence supercomputers had 65,536 1-bit processors richly connected in a manner inspired by the human brain. Physicist Richard Feynman proposed a 12-dimensional hypercube as the structure of this internal network. Thiel visualised it as a repeating cube of cubes and implemented it in the traces and cables connecting the processor chips throughout the machine. Her T-shirt design, depicting 'soft' processors forming data connections independently of this 'hard' cube-of-cube wiring, inspired the form of the machine itself: a black cube-of-cubes, with 4,096 processor chip status lights visible through the translucent doors. Thiel explained: 'The form of the machine was to express its function, but also the passions of its creators: the dream of producing a "Machina Sapiens", a new genus of living, thinking machines.' A selection of the artist's preparatory drawings and photographs of the supercomputer prototype were presented at Kunsthalle Wien.

Rosemarie Trockel

Rosemarie Trockel (b. 1952, Schwerte, Germany) works in a variety of media, including sculpture, collage, ceramics, textiles, drawing and photography. In the 1980s, she began using computer technology to produce a series of 'paintings' in knitted wool, some of which are handmade by people she recruited via classified advertising. For others, such as *Untitled* (1985), the artist used computer technology to weave the patterns. With these works, the artist says she 'tried to take wool, which was viewed as a woman's material, out of this context and to rework it in a neutral process of production'. The works in this series feature emblematic logos of famous brands, also playing on the opposition generally established between applied arts and industrial production. Here, the symbol repeated in the composition is a trademark used to identify wool products quality – acquired by the Woolmark company in 1998.

Joan Truckenbrod

A pioneer in the creation of computer-generated drawings, Joan Truckenbrod (b. 1945, Greensboro, North Carolina) learned to use the programming language FORTRAN before producing a series of drawings generated from a geometric motif. These drawings include *Untitled* (1975), shown in one vitrine at Kunsthalle Wien. In her work, digital technologies are understood as spaces of mediation between the physical and the virtual. The artist compares the variables from which she creates her works to 'pebbles on the beach: each time the tide comes in, you get a new configuration of pebbles. Then the water disappears and the whole arrangement is transformed.' From the end of the 1970s, Truckenbrod created textile works using algebraic formulas developed to describe natural phenomena such as wind currents, light reflection and so on. *Energy Surface* (1981) evokes the contours of a valley. To make this work, the artist photographed the coded algorithmic image from her computer screen and printed it on a textile. Using the computer, Truckenbrod translates natural phenomena that are invisible and ephemeral to our senses, into an image of a landscape and renders it tactile through the textile.

Anne-Mie Van Kerckhoven

Message (1988) is a film animation that Anne-Mie Van Kerckhoven (b. 1951, Antwerp) developed from drawings made at the Artificial Intelligence Laboratory at the Free University in Brussels. Van Kerckhoven had been using softcore pornographic images of women in her work since the late 1970s and subsequently began to translate some of her drawings into film animations. In 1983 Van Kerckhoven was invited to the Artificial Intelligence Laboratory by Luc Steels, the scientist who founded it and with whom she first collaborated in 1976. Working at the laboratory offered her the opportunity to access computers and build upon her broader practice of merging the erotic with machine fetishism: 'I'd always been interested in – seduced by – technological solutions. Many new and groundbreaking theories have something sexy about them. I am attracted to these thoughts, words and new worlds [...] the moment I came into this laboratory, I was completely thrilled by the idea that the future is happening here. I was not bothered by all these depressing ideas about art where women had no place – I hardly had examples of women I could relate to in recent art history. When I was in the laboratory, there were women as well as men working – they didn't make a difference between intellectual human beings, whether they were male or female.'

Ulla Wiggen

Ulla Wiggen (b. 1942, Stockholm) began painting electronic components in 1963. Initially working from audio equipment, in 1965 she was invited to see the newly completed TRASK computer at the Royal Institute of Technology in Stockholm: 'I jumped at the opportunity, took my camera and photographed everything I thought was visually interesting in the six tall cabinets with glass doors inside which the computer was held. I felt the charge of optimism for the future in the room, and that I was part of the beginning of something big that would change the world.' *Oändligt variabel* (1968) is the penultimate work in this series, combining components from several machines and referring to the principle of interconnected units in a technological universe. Wiggen explains: 'Engineers would point to my paintings here and there and say that these are short circuits, that these would not be functional but it seems to amuse them to see their world through my eyes.'